Comparative Effectiveness Review
Number 216

Telehealth for Acute and Chronic Care Consultations

Agency for Healthcare Research and Quality

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Key Messages

Purpose of Review

To assess the effectiveness of telehealth consultations and explore supplemental decision analysis.

Key Messages

- Results vary by setting and condition, with telehealth consultations producing generally either better outcomes or no difference from comparators in settings and clinical indications studied.
    - Remote intensive care unit consultations likely reduce mortality.
    - Specialty telehealth consultations likely reduce patient time in the emergency department.
    - Telehealth consultations in emergency services likely reduce heart attack mortality.
    - Remote consultations for outpatient care likely improve access and clinical outcomes.
- More detailed telehealth consultation costs and outcomes data would improve modeling assumptions.
- Future research should employ rigorous methods and standardized outcomes for consistent measurement of telehealth consultation effectiveness.

This report is based on research conducted by the Pacific Northwest Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. 290-2015-00009-I). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

None of the investigators have any affiliations or financial involvement that conflicts with the material presented in this report.

The information in this report is intended to help healthcare decision makers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of healthcare services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

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This report may periodically be assessed for the currency of conclusions. If an assessment is done, the resulting surveillance report describing the methodology and findings will be found on the Effective Health Care Program website at www.effectivehealthcare.ahrq.gov. Search on the title of the report.

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The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of systematic reviews to assist public- and private-sector organizations in their efforts to improve the quality of healthcare in the United States. These reviews provide comprehensive, science-based information on common, costly medical conditions, and new healthcare technologies and strategies.

Systematic reviews are the building blocks underlying evidence-based practice; they focus attention on the strength and limits of evidence from research studies about the effectiveness and safety of a clinical intervention. In the context of developing recommendations for practice, systematic reviews can help clarify whether assertions about the value of the intervention are based on strong evidence from clinical studies. For more information about AHRQ EPC systematic reviews, see www.effectivehealthcare.ahrq.gov/reference/purpose.cfm.

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If you have comments on this systematic review, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

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Prior to publication of the final evidence report, EPCs sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

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Telehealth for Acute and Chronic Care Consultations

Structured Abstract

Objectives. To conduct a systematic review to identify and summarize the available evidence about the effectiveness of telehealth consultations and to explore using decision modeling techniques to supplement the review. Telehealth consultations are defined as the use of telehealth to facilitate collaboration between two or more providers, often involving a specialist, or among clinical team members, across time and/or distance. Consultations may focus on the prevention, assessment, diagnosis, and/or clinical management of acute or chronic conditions.

Data sources. We searched Ovid MEDLINE®, the Cochrane Central Register of Controlled Trials (CCRCT), and the Cumulative Index to Nursing and Allied Health Literature (CINAHL®) to identify studies published from 1996 to May 2018. We also reviewed reference lists of identified studies and systematic reviews, and we solicited published or unpublished studies through an announcement in the *Federal Register*. Data for the model came both from studies identified via the systematic review and from other sources.

Methods. We included comparative studies that provided data on clinical, cost, or intermediate outcomes associated with the use of any technology to facilitate consultations for inpatient, emergency, or outpatient care. We rated studies for risk of bias and extracted information about the study design, the telehealth interventions, and results. We assessed the strength of evidence and applicability, and then synthesized the findings using quantitative and qualitative methods. An exploratory decision model was developed to assess the potential economic impact of telehealth consultations for traumatic brain injuries in adults.

Results. The search yielded 9,366 potentially relevant citations. Upon review, 8,356 were excluded and the full text of 1,010 articles was pulled for review. Of these, 233 articles met our criteria and were included—54 articles evaluated inpatient consultations; 73, emergency care; and 106, outpatient care.

The overall results varied by setting and clinical topic, but generally the findings are that telehealth improved outcomes or that there was no difference between telehealth and the comparators across the settings and for the clinical indications studied.

Remote intensive care unit (ICU) consultations likely reduce ICU and total hospital mortality with no significant difference in ICU or hospital length of stay; specialty telehealth consultations likely reduce the time patients spend in the emergency department; telehealth for emergency medical services likely reduces mortality for patients with heart attacks; and remote consultations for outpatient care likely improve access and a range of clinical outcomes (moderate strength of evidence in favor of telehealth). Findings with lower confidence are that inpatient telehealth consultations may reduce length of stay and costs; telehealth consultations in emergency care may improve outcomes and reduce costs due to fewer transfers, and also may reduce outpatient visits and costs due to less travel (low strength of evidence in favor of telehealth). Current evidence shows no difference in clinical outcomes with inpatient telehealth specialty consultations, no difference in mortality but also no difference in harms with telestroke consultations, and no difference in satisfaction with outpatient telehealth consultations (low strength of evidence of no difference). Too few studies reported information on potential harms from outpatient telehealth consultations for conclusions to be drawn (insufficient evidence).

An exploratory cost model underscores the importance of perspective and assumptions in using modeling to extend evidence, and the need for more detailed data on costs and outcomes when telehealth is used for consultations. For example, a model comparing telehealth to transfers and in-person neurosurgical consultations for acute traumatic brain injury identified that the impact of telehealth on costs may depend on multiple factors, including how alternatives are organized (e.g., if the telehealth and in-person options are part of the same healthcare system) and whether the cost of a telehealth versus an in-person consultation differ.

Conclusions. In general, the evidence indicates that telehealth consultations are effective in improving outcomes or providing services, with no difference in outcomes; however, the evidence is stronger for some applications, and less strong or insufficient for others. However, as specific details about the implementation of telehealth consultations and the environment were rarely reported, it is difficult to assess generalizability. Exploring the use of a cost model underscored that the economic impact of telehealth consultations depends on the perspective used in the analysis. The increase in both interest and investment in telehealth suggests the need to develop a research agenda that emphasizes rigor and focuses on standardized outcome comparisons that can inform policy and practice decisions.

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Appendix I. Exploratory Decision Modeling Methods and Results

Evidence Summary

Background

Telehealth is the use of information and telecommunications technology to provide or support healthcare across time and/or distance. Telehealth's potential benefits are frequently cited,[1,2] and there is a sizable body of research on telehealth, including systematic reviews and reviews of reviews.[3-8] Despite this potential, implementation and spread has been slower than expected,[9,10] though recent trends suggest that use of telehealth may be increasing.

With improvement in technologies,[11] changes in payment policies,[12,13] and evolving models for healthcare in general and telehealth in particular, the possibility exists for a rapid acceleration in implementation and wider use of telehealth. However, targeting, supporting, and sustaining increased use of telehealth requires organized and accessible information on the impact of different uses of telehealth. Specifically, synthesis of existing research evidence can help inform decisions about where, in terms of settings and clinical indications, telehealth is likely to improve access, quality, and efficiency. One approach is to assess the evidence about the different roles telehealth can play in healthcare.

Telehealth for consultations allows medical expertise to be available where and when it is needed, minimizing potential time or geographic barriers to care and maximizing the efficient use of scarce resources. Telehealth for consultations has been studied across a range of clinical situations but not previously assessed in a systematic review.

Objective

The objective of this report is to identify and summarize the available evidence about telehealth consultations. The overarching goal is to maximize the utility of available information by presenting the results in formats that support decision makers at various levels (e.g., regulators, providers, and payers) as they consider policy and practice changes related to telehealth for consultation. To accomplish this we combined a broad systematic review, covering a range of clinical indications, with an exploratory decision model for one selected clinical application. Both systematic reviews and decision analyses have accepted methodologies, but they are not frequently used in tandem. In this sense, this project is experimental as it strives to provide the results of a traditional systematic review of the available research and explore how the addition of decision analysis might be used to increase the utility of evidence for decision makers.

This review focuses on the effectiveness of telehealth for provider-to-provider consultations. ***Telehealth consultations*** are defined as the use of telehealth to facilitate collaboration between providers, often involving a specialist consultant, or among clinical team members, across time and/or distance, on the assessment, diagnosis, and/or clinical management of a specific patient or group of patients. While the patient may or may not be involved in the consultation, the consultation is required to be related to a specific patient or group of patients in order to differentiate this activity from training or education (which would not meet our definition of telehealth). Limited information provided by one clinician to another that does not contribute to collaboration (e.g., interpretation of an electroencephalogram, report on an x-ray or scan, or reporting the results of a diagnostic test) is not considered a consultation for this review.

Systematic Review Key Questions

The Key Questions for the review were:

1. Are telehealth consultations effective in improving clinical and economic outcomes?
   Clinical and economic outcomes may include, but are not limited to, mortality and morbidity, patient-reported outcomes, quality of life, utilization of health services, and cost of services.
2. Are telehealth consultations effective in improving intermediate outcomes?
   Intermediate outcomes include both outcomes that precede the ultimate outcomes of interest (e.g., mediators) and secondary outcomes. Intermediate outcomes may include, but are not limited to, access to care, patient and provider satisfaction, behavior, and decisions (e.g., patient completion of treatment, provider antibiotic stewardship); volume of services; and healthcare processes (e.g., time to diagnosis or treatment).
3. Do telehealth consultations result in harms, adverse events, or negative unintended consequences?
4. What are the characteristics of telehealth consultations that have been the subject of comparative studies?
   These characteristics may include clinical conditions, characteristics of the providers and patients and their relationships, telehealth modalities, and characteristics of settings, including the type of care and healthcare organization, payment models, as well as geographic and economic characteristics.
5. Do clinical, economic, intermediate, or negative outcomes (i.e., the outcomes in Key Questions 1, 2, and 3) vary across telehealth consultation characteristics (Key Question 4)?

Systematic Review Methods

The conduct of this systematic review followed the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*,[14] and it is reported according to the PRISMA checklist. The scope, Key Questions, and inclusion criteria of this review were developed in consultation with a group of technical experts. Detailed methods are available in the full report and the posted protocol (https://effectivehealthcare.ahrq.gov/topics/telehealth-acute-chronic/research-protocol/). The protocol was registered with PROSPERO (CRD42017058304).

A research librarian created the search strategy and another research librarian reviewed it before searching Ovid MEDLINE®, the Cochrane Central Register of Controlled Trials (CCRCT), and the Cumulative Index to Nursing and Allied Health Literature (CINAHL®) to identify studies published from 1996 through May 2018. We also reviewed reference lists of identified studies and systematic reviews, and solicited suggestions through an announcement in the *Federal Register*.

We limited our study inclusion to the use of telehealth for consultations and outcomes that measure clinical and cost effectiveness. Otherwise our criteria were broad, and we included any technology and any comparative study, including before-after and retrospective as well as prospective designs, with quantitative outcomes data. Studies could compare telehealth consultations to consultations done in a different mode (e.g., in-person or telephone), no access to specialty care, or usual care which could be an unspecified mix of these options. We excluded descriptive studies, studies assessing only diagnostic concordance, studies where there was no nontelehealth comparison, and modeling studies that used hypothetical data.

Two team members independently reviewed all abstracts and two reviewers independently assessed each full-text article. Disagreements were resolved by discussion among investigators. For included articles, investigators abstracted key characteristics and data about the studies for quantitative and qualitative synthesis. We were able to conduct meta-analyses for some but not all topics and outcomes due to the heterogeneity of outcome measures, study designs, and telehealth interventions. Two investigators independently rated the risk of bias of each study using predefined criteria consistent with the chapter, "Assessing the Risk of Bias of Individual Studies When Comparing Medical Interventions" in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[14] Risk of bias for economic evaluations were assessed using a modified version of the Consensus Health Economic Criteria.[15,16] Disagreements were resolved by consensus.

Strength of evidence was assessed for each outcome and Key Question as described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[14] We assigned a strength of evidence grade of high, moderate, low, or insufficient for the body of evidence for each Key Question, based on evaluation of four domains: study limitations, consistency, directness, and precision. High, moderate, and low ratings reflect our confidence in the accuracy and validity of the findings and whether future studies might alter these findings (magnitude or direction). We gave a rating of insufficient when we were unable to draw conclusions due to serious inconsistencies, serious methodological limitations, or lack of evidence. We considered applicability and the strength of evidence when making general assessments across the studies and use qualifiers in key messages and conclusions such as 'likely' for moderate strength of evidence and/or some applicability concerns or 'may' for low strength of evidence and/or significant applicability concerns.

Systematic Review Results

The literature searches yielded 9,366 potentially relevant citations. Upon review of the article titles and abstracts, 8,356 were excluded and the full text of 1,010 articles were pulled for review. Of these, 233 articles met our inclusion criteria. The most frequent reasons for excluding an article were that the intervention was not a telehealth consultation (ineligible intervention) or that the study did not compare telehealth consultations to usual care or another intervention (ineligible comparison). A list of the included studies is provided in Appendix C of the full report, and the citations for excluded studies are in Appendix D of the full report.

The included studies are diverse in terms of location, technology, and design. The most frequent geographic location for the included studies of telehealth consultations was the United States (110 articles or 47%); however, more than half of the studies were conducted in other countries. The most common mode or technology used for telehealth consultations was video, which was used in more than half of the studies (55%). The majority of the studies (66%) were observational, including prospective cohorts, retrospective cohorts, and before/after studies in which a group of patients from before the implementation of telehealth consultations are compared to a different group of patients after telehealth implementation. In these studies, the comparator was often usual care, that is, care without telehealth, and the studies rarely provided more detail (e.g., if consultations were in-person, if care was delivered without consultation, or a mix of both). About one-fifth (19%) were randomized controlled trials, 12 percent were economic evaluations, and approximately 3 percent were pre-post studies in which outcomes for the same patients were compared pre (without telehealth) and post telehealth consultations. Table 1 in the full report provides more information on the characteristics of the included studies, and detailed information abstracted from each study is provided in Appendix F of the full report.

We categorized the systematic review results into three patient settings: inpatient, emergency department (ED) or emergency medical services (EMS), and outpatient. We chose to organize the systematic review results by patient setting as the settings are likely to have different telehealth technology and requirements as well as differences in payment structures, staffing, and organization of care delivery. The results are summarized by setting in Tables A, B, and C and in the accompanying text.

Inpatient Telehealth Consultations

Remote Intensive Care Units

- Clinical outcomes: Intensive care unit (ICU) and hospital mortality are lower with remote ICU (moderate strength of evidence).
- Economic outcomes: Not all studies analyzed costs of remote ICUs or their impact on revenue; those that did used differing methods, and conclusions were inconsistent (insufficient evidence).
- Intermediate outcomes: ICU and hospital length of stay (LOS) are not statistically different with remote ICU (moderate strength of evidence).
- Adverse effects: None of the included studies specifically addressed potential harms or unintended consequences (insufficient evidence).

We identified 21 studies reported in 22 articles evaluating the use of telehealth to provide remote ICU services. Remote ICU services involve off site staff (intensivists, critical care nurses, and sometimes administrative assistants) who monitor ICU patients and provide consultation and management assistance with the care of these patients. Thirteen of these studies used before-after designs comparing outcomes from a period before implementation of remote ICUs to the period after this model of care was in operation in the same hospital or hospitals. The remaining studies include four retrospective and two prospective cohort studies, one cross sectional survey, and one pre-post survey. These studies did not provide details on the nontelehealth care, though it likely included a mix of care by clinicians who are not specialists, less frequent care by specialists, and transfers to other hospitals. We reviewed selected key factors that could help explain the differences in outcomes across studies, including information on the hospitals that were the sites for the studies, the coverage and staffing of the remote ICU interventions, and the time periods in which outcomes were measured. For example, the majority of included studies were conducted in larger teaching hospitals or hospitals affiliated with an academic center; and all of the studies included a physician intensivist, most included nursing, and about half included administrative support. However, none of these factors clearly differentiate between studies reporting a clear benefit from remote ICUs and those reporting no benefit or possible benefits. Furthermore, this limitation means we cannot compare the ICUs included in these studies to all ICUs that might consider employing telehealth based on our data.

Inpatient Specialist Consultations

- Clinical outcomes: Mortality or serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability) improve with telehealth consultations across specialties, but differences are not statistically significant in most studies (low strength of evidence).
- Economic outcomes: Cost savings were realized due to avoided transfers or travel, but telehealth did not save money in all studies (low strength of evidence).
- Intermediate outcomes: The impact of telehealth consultations on intermediate outcomes such as hospital LOS, transfer rate or satisfaction of patients, relatives, or healthcare providers is also positive, but not convincing with differences that are close to significant and estimates that are less precise (low strength of evidence).
- Adverse effects: Only studies of surgery explicitly examined harms, but the study limitations were high based on small sample sizes and high risk of bias (insufficient evidence).

We identified 31 studies (32 articles) that reported the use of telehealth to provide specialty consultations for inpatients. Specialty consultations are provided when the input of a specialist is needed for diagnosis, care planning, or treatment, and a physician with the specialized knowledge is not available at the hospital where the patient is located or at the time when the consultation is needed. The studies of inpatient specialist consultations cover a wide range of clinical indications, ranging from neonatal to geriatric care and from care planning to remote proctoring of surgery. Studies of inpatient consultations were predominately cohort studies, including ten retrospective and 15 prospective cohort designs that compare hospitals with and without telehealth. There were also three before-after studies and three randomized trials that studied inpatient consultations. Most of the cohort studies included multiple sites with the largest prospective study including 3,060 patients in 5 intervention and 5 matched comparison hospitals. Overall, inpatient telehealth consultations are not well-described, making it problematic to relate characteristics of the intervention or environment to effectiveness and to assess the generalizability of the study results to either hospitals that may differ in important ways from those included in the studies or to the use for other specialties not studied.

Table A. Inpatient telehealth consultations: strength of evidence

Topic	Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
Inpatient remote ICU	ICU Mortality (KQ1)[a]	11	Lower ICU mortality RR 0.69 (95% CI 0.51, 0.89)	Moderate
	Hospital Mortality (KQ1)[a]	12	Lower hospital mortality RR 0.76 (95% CI, 0.60, 0.95)	Moderate
	Cost (KQ1)	6	Unable to summarize across studies: different methods and inconsistent results.	Insufficient
	ICU LOS (KQ2)[a]	12	No significant difference in ICU LOS Mean difference (days) -0.39 (95% CI -0.99, 0.15)	Moderate
	Hospital LOS (KQ2)[a]	12	No significant difference in hospital LOS Mean difference (days) -0.14 (95% CI -0.96, 0.63)	Moderate
	Harms (KQ3)	0	None reported in identified articles	Insufficient
Inpatient specialty consultations	Mortality (KQ1)	12	No significant difference in mortality	Low
	Other clinical outcomes (KQ1)	6	Clinical outcomes better with telehealth but small differences and most not significantly different	Low
	Cost (KQ1)	7	Cost savings due to avoiding transfers or travel when telehealth is used but not in all studies	Low
	Intermediate outcome (KQ2)	27	Reductions in LOS and waiting time but all not significantly different; satisfaction measures good but not excellent	Low
	Harms (KQ3)	3	Complications from telehealth in surgery was compared with standard procedures in small studies with high risk of bias	Insufficient

CI = confidence interval; ICU = intensive care unit; KQ = Key Question; LOS = length of stay; RR = risk ratio
[a] Based on studies included in the meta-analysis

Emergency Care Telehealth Consultations

We split emergency care into three subtopics, as follows.

Telestroke

- Clinical outcomes: The evidence suggests that telestroke does not result in differences in either in-hospital or 3-month mortality (moderate strength of evidence)
- Intermediate outcomes: Changes in thrombolytic therapy (tPA) use and time to treatment with telestroke were not significantly different (low strength of evidence).
- Adverse events: No increased harms, specifically hemorrhage (moderate strength of evidence).

Specialty consultations in emergency departments

- Clinical outcomes: The impact on clinical outcomes including mortality and functional status is generally positive, though the results are not always statistically significant (low strength of evidence).
- Economic outcomes: Analysis of costs were available only in a few studies, and the results favored savings (low strength of evidence).
- Intermediate outcomes: Teleconsultations have a positive effect on intermediate outcomes such as appropriate triage and transfers and shorter time in the emergency department (moderate strength of evidence).
- Adverse events: No information was available about harms (insufficient evidence).

EMS and urgent care

- Clinical outcomes: Telehealth reduces mortality for heart attack patients (moderate strength of evidence).
- Economic outcomes: Reductions in air transfers and referrals contributed to estimates of lower costs (low strength of evidence).
- Intermediate outcomes: Telehealth led to more timely provision of care and a reduction in air transfers and referrals to higher-level care following urgent care (moderate strength of evidence), and these
- Adverse effects: Information on harms was very limited (insufficient evidence).

Telestroke refers to the use of telemedicine to convey information about a patient to a vascular neurologist/stroke specialist for assessment and diagnosis with a focus on time sensitive treatment and transport decisions. The 29 studies that investigated telestroke all compared outcomes from a prior time period or another hospital without telestroke with those with telestroke. All patients were treated, but in the cases without telestroke, patients received care for their stroke but after a delay, which may have limited their treatment options. Ten studies of EMS evaluated an approach similar to telestroke for patients potentially experiencing heart attacks. Fifteen of the 19 studies of specialist consultations in EDs were before-after or cohort studies that did not provide detailed information on the care without telehealth. In the 21 studies of telehealth consultations for EMS or urgent care, in the groups without telehealth, emergency personnel or clinicians made decisions about transfer or treatment without consultant input.

Table B. Emergency care telehealth consultations: strength of evidence

Topic	**Outcome (KQ)**	**Number of Studies (N)**	**Main Findings**	**Strength of Evidence** (Insufficient, Low, Moderate, High)
Emergency Care: Telestroke	Mortality In-hospital (KQ1)	9	RR 0.89 (95% CI 0.63, 1.43) No difference	Moderate
	Mortality 3-month (KQ1)	7	RR 0.94 (95% CI 0.82, 1.16) No difference	Moderate
	tPA administration (KQ2)	13	Reported tPA use increases; four significant; majority not statistically significant or not tested	Low
	Time to Treatment (KQ2)	23	Time to treatment is shorter but not significant in the majority of studies; a minority report longer times	Low
	Harms (all Hemorrhage) (KQ3)	11	No difference in hemorrhage, the only potential harm reported	Moderate
Emergency Care: Specialty Consultations	Clinical outcomes (KQ1)	13	Lower mortality reported in most studies but not statistically significant; Four studies reporting other clinical outcomes that were better with telehealth; one reported significant differences	Low
	Cost (KQ1)	5	Lower costs with better or no change in clinical outcome in most (4) studies; one study reported higher costs	Low
	Intermediate outcomes (KQ2)	19	Increase in appropriate transfers, decrease in time to decision and time in ED with telehealth compared with standard care	Moderate

Topic	Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
	Harms (KQ3)	0	No studies reported data on harms from telehealth	Insufficient
Emergency Care: EMS or Urgent Care	Clinical Outcomes (KQ1)	10	Telehealth reduced mortality for STEMI patients	Moderate
	Cost (KQ1)	5	Lower costs due to avoided transfers or lower staff costs when telehealth is used	Low
	Intermediate Outcomes (KQ2)	20	Treatment is more timely and fewer air transfers or referrals to higher level of care	Moderate
	Harms (KQ3)	1	One study reported data that could be interpreted as harms, but not defined as such by the authors	Insufficient

CI = confidence interval; ED = emergency department; EMS = emergency medical services; KQ = Key Question; RR = risk ratio; STEMI = ST-elevation myocardial infarction; tPA = tissue plasminogen activator;

Outpatient Telehealth Consultations

- **Clinical outcomes:** Clinical outcomes were reported in just over one-quarter of the studies of telehealth consultations and in 7 of 11 clinical topics. In three topics, there is moderate strength of evidence of the benefits of telehealth (better healing in wound care, higher response to treatment in psychiatry, and improvement in chronic condition outcomes), and in dermatology the findings show no difference in clinical outcomes (low strength of evidence). In three topics (cancer, infectious disease, and multiple specialties) studies were identified, but the results were inconsistent (insufficient evidence).
- **Intermediate outcomes**
    - Access: Telehealth consultations improved access by reducing wait times and time to treatment and by increasing the number of patients receiving indicated diagnostic tests or treatment (moderate strength of evidence).
    - Management and utilization: Telehealth consultations reduced utilization (the number of in-person specialist and hospital visits; number of hospitalizations, and shorter lengths of stay) in most studies. Findings were inconsistent about agreement on diagnosis and management (low strength of evidence).
    - Satisfaction: Patients were generally more satisfied with telehealth consultations, particularly when telehealth saved time or expense compared with the alternative. Clinicians tended to be less satisfied with telehealth than in-person consultations, though differences were rarely statistically significant (low strength of evidence).
- **Costs:** Studies report lower costs and in most cases savings are attributable to reductions in transfers or less transportation. However, the rigor of the measurement, imprecision of estimates and inconsistency in the magnitude of the effects limits confidence in these findings (low strength of evidence).
- **Harms:** Only two of studies explicitly examined harms, reporting lower rates of complications with telehealth (insufficient evidence).

The 106 included articles evaluating telehealth consultations in the outpatient setting are summarized in Table C. Detailed results split into 11 clinical topics are provided in the full report. All of these studies addressed at least one intermediate outcome, and we organized these into three categories: access, management and utilization, and satisfaction.

For the 11 clinical topics, seven reported clinical outcomes (dermatology, wound care, orthopedics, cancer, psychiatry, infectious disease and single specialties). In four of these seven the body of evidence supports better outcomes with telehealth. For 10 topics there were improvements in at least one intermediate outcome. Cost outcomes were identified for nine out of 11 topics, but the conclusions are mixed with lower costs reported across studies for four topics (wound care, orthopedics, cancer, single specialties with diagnostic technology), while for the other five topics the results were inconsistent or cost savings were either minimal or not realized.

Table C. Outpatient care telehealth consultations: strength of evidence

Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
Clinical Outcomes (KQ1): Dermatology	3	No significant different in clinical course	Low
Clinical Outcomes (KQ1): Wound Care	5	Better healing and fewer amputations	Moderate
Clinical Outcomes (KQ1): Ophthalmology	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Orthopedics	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Dental	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Cancer	1	Rate of serious side effects from chemotherapy reported in 1 study.	Insufficient
Clinical Outcomes (KQ1): Psychiatry	3 (in five articles)	Decrease in symptoms and high remission rates	Moderate
Clinical Outcomes (KQ1): Infectious Disease	3	Inconsistent results for virologic suppression across studies	Insufficient
Clinical Outcomes (KQ1):): Single Conditions with Diagnostic Technology	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Single Specialties	6	Positive effects on clinical outcomes such as response to treatment.	Moderate
Clinical Outcomes (KQ1):Multiple Specialties	4	Inconsistent results across studies for unanticipated or avoidable health services utilization	Insufficient
Cost (KQ1)	32	Most studies report cost saving with telehealth but calculations vary and most are dependent on patient avoided travel and loss of time	Low
Intermediate Outcomes: Access (KQ2)	35	Access in terms of time to, or comprehensiveness of, service is improved with telehealth	Moderate
Intermediate Outcomes: Management and Utilization (KQ2)	31	Mixed results with majority finding some benefit in terms of avoiding visits and similar diagnosis or management but a subset of studies report differences in diagnosis and management with telehealth compared with standard care	Low
Intermediate Outcomes: Satisfaction (KQ2)	22	Satisfaction generally the same; patients higher with telehealth if time/travel is avoided. Providers the same or slightly worse for telehealth.	Low
Harms (KQ3)	0	No studies reported data on harms	Insufficient

KQ = Key Question

Exploratory Cost Model for Telehealth Neurosurgical Consultations

The purpose of exploring decision analysis was to address questions the systematic review alone could not answer. We attempted to construct a model to address the following questions for one selected use:

1. What is the predicted impact on clinical, economic, and intermediate outcomes of telehealth consultations?
2. What is the predicted effect of various proposed payment reforms on clinical, economic, and intermediate outcomes of telehealth consultations?

We selected the use of telehealth for neurosurgical consultations by rural or community hospitals for patients with moderate to severe traumatic brain injury (TBI) for this exploratory model. This topic was selected for two reasons: (1) the systematic review did not identify a body of existing evidence that could adequately inform decisions about this use; and (2) neurosurgery is a specialty that is not widely available in all locations (such as rural areas) where people sustain TBIs, making it the type of use often suggested as appropriate for telehealth. We considered the comparison of (1) immediate transfer after stabilization from the community hospital with no access to neurosurgical consultations to a level I or II trauma center (standard care model) and (2) telehealth consultation to determine if the patient can be managed at the local hospital or should be transferred to a level I or II trauma center (telemedicine model).

The model was built as a decision tree. When data were available in the studies included in the systematic review these were used, but the decision modeling team also undertook targeted searches for published data for specific parameters. Data from the literature were used as input parameters to calculate incremental costs for the two different possibilities from the perspective of the healthcare system. The decision analytic model assumed equivalent patient outcomes (details provided in Appendix I). However, the framework was constructed to allow for future inclusion of differences in patient outcomes based on the Glasgow Outcome Scale (GOS) at 6 months: (1) death, (2) persistent vegetative state, (3) severe disability (lost independence) (4) moderate disability, and (5) good outcome (healthy post-TBI) if and when this evidence becomes available.

The model specification and results of this analysis are included in Appendix I of the full report. Insights from our efforts to model cost outcomes are included in the Discussion summary below with more detail in the Discussion section of the full report.

Discussion

This review summarizes a large volume of literature and explores the potential for supplementing systematic reviews with decision models. The 233 included articles cover a diversity of clinical uses and settings for telehealth even when the function is focused only on telehealth consultations. The size, diversity, and other characteristics of these studies of telehealth consultations are important to consider when assessing the utility of the evidence base, potential next steps in research, and what overall conclusion can be drawn from this literature.

Applicability

Our results and synthesis of this large number of studies was organized based on our assessment of the applicability of different subgroups of results. For telehealth consultations we found that the setting is often of primary importance, and we analyzed and presented the studies by setting—inpatient, emergency, and outpatient care. We also made some distinctions within settings. For example, for inpatient care we considered the remote ICU studies separately as remote ICU consultation is a very specialized, specific use, but we combined other specialty consultations for inpatient care as they are similar in terms of the function (e.g., to diagnose a condition or to provide direction during a surgery) of the consultation and the types of outcomes. For emergency care we separated telestroke, specialty consults for ED patients, and EMS/urgent care for similar reasons. The issues of applicability for outpatient consultations and our approach were slightly different. We reported the details separately by specialty to allow readers to see the results in these groupings, as people are often interested in a particular specialty. Then we combined the results across specialties in the strength of evidence assessment by outcomes in grouping that we felt were appropriate in terms of findings that are likely applicable across specialties.

Limitations

There are important limitations to the evidence base on the effectiveness of the use of telehealth for consultations. The most significant is the variation in study designs and the level of rigor of the research methodology. The literature on telehealth consultations consists primarily of studies that are considered weaker designs such as before and after studies without a comparison group and retrospective cohort studies. Very few studies were rated as low risk of bias; most were moderate or high. Importantly, the comparison treatment was poorly described in these studies; such that it was often impossible to know whether usual care referred to in-person care by a consultant, no consultant involvement, or a combination of both. Other limitations are that the outcomes used to evaluate telehealth are inconsistent and the best or most appropriate outcome is not always used when data are limited to what is routinely collected. Also, the studies provide very little information on the context or the environment in which telehealth for consultations was implemented.

There are also limitations to the review process and decision modeling. Searching for telehealth use for a specific function is difficult as the indexing terms in MEDLINE and other citation databases do not exactly match our scope. Also, given the variation in study designs, environments, and outcomes, we completed quantitative synthesis using meta-analysis for some topics, but used qualitative approaches for the majority; we acknowledge that qualitative synthesis is more open to interpretation and judgment.

In exploring the utility of decision models, we modeled the costs of neurological consultation for acute traumatic brain injury, using an analysis that assumes equivalence in patient outcomes. Other assumptions are possible (i.e., that outcomes are better or worse with telehealth), and this model does not help the decision maker consider these possible variations. However, the model was built to allow inclusion of patient outcomes following treatment for cost benefit analyses in the future. When data become available, the impact on mortality or quality adjusted life years could be incorporated into the model and used to inform judgements about the value of additional costs given patient benefits.

Future Research Needs

While we identified 233 articles that evaluated the effectiveness of telehealth consultations, several questions remain to be addressed in future research. A key priority is the need for rigorous, multi-site studies of telehealth consultations in clinical areas and in the types of organizations where the lack of evidence may be a barrier to wider spread implementation.

Future studies are also needed that both expand and standardize outcomes and clarify their objectives. Agreeing on some common metrics across uses of telehealth for consultation would facilitate comparisons across clinical areas and help identify priorities for future expansion of telehealth consultations. Given the wide range of clinical topics, these common metrics may need to be intermediate outcomes, such as measures of access or satisfaction or cost effectiveness. While costs are not the only important outcome, collecting more cost economic data would allow more direct comparisons across clinical topics and both facilitate and inform additional decision analyses, whether these are done for publication of for organizations' internal consideration. At the same time this needs to be balanced with attention to the most important outcomes for a given condition. There are examples, such as telestroke, where the most frequently reported outcome (mortality) may not be the most important, either to patients or in terms of the expected impact of changing care. The assessment of telehealth consultations would also be strengthened by more studies that include contemporary comparison groups, either groups of patients or other organizations, so that the effect of the telehealth consultations could be more successfully isolated from historical changes or the idiosyncrasies of a specific organization. This could involve adding comparison or control sites to pre and post telehealth studies.

The research on telehealth could have more impact if its objectives were clearer. Evaluations of telehealth consultations can consider different perspectives and different levels of implementation and evaluation, but failing to be clear leads to studies with confusing results and lessens the impact of positive results. For example, the work on the decision analyses highlighted the importance of clearly specifying the options being compared, or what is "usual care. In the studies we evaluated for this systematic review, the nontelehealth or "usual care" option consisted of was often not specified and was not always clear what care these patients received.

The decision analysis also highlighted the importance of perspective and the need for better information. Most studies did not clearly state their perspective, though it was often implied that is was a single organization (e.g., a hospital or practice group). This seems unnecessarily limiting, and more studies at higher levels seem warranted. In many ways telehealth consultations could be viewed as a systems-level intervention, more similar to health information exchange and electronic health records, than to a condition-specific treatment.

A major evolution of the research in this area would be to focus on hybrid studies, that is, studies that combine effectiveness and implementation assessments. While the results may be uneven across specific clinical areas, telehealth consultations do generally improve access and clinical outcomes and are likely to improve other outcomes. What is missing is much of the specific information asked for in Key Questions 4 and 5 of this review; that is, what are the characteristics of the context and how do they impact outcomes? A hybrid approach to future research could focus on the information needed to promote successful implementation while still continuing to collect better data demonstrating effectiveness and economic impact.

Reviewing background material for this report and discussing telehealth with the Technical Expert Panel and other experts has convinced us that telehealth consultation are being used, particularly in smaller and rural health systems, and that data are often being collected. However, these organizations and data are not represented in the published literature due to lack of research and analysis capacity. Given the importance to policy and practice issues related to telehealth consultations (e.g., payment, scope of work, cross organization, and state licensing), identifying and facilitating the analysis of these data should be a priority and may help strengthen what conclusions can be made about telehealth consultations.

Also during the time period covered in the review and during our work, policies that facilitate telehealth consultation and the number of publications about telehealth increased. However, many of these are descriptive or less rigorous approaches to research. Continuing in this vein will not contribute to the next level of telehealth expansion. Given that more and more resources are being invested in telehealth, it is reasonable to suggest that research evaluating its effectiveness should both increase and improve. The current situation seems to require an organized effort by telehealth advocates, researchers, and policy makers to identify where there are still gaps in the research base and prioritize these in terms of their potential to move the field forward, toward increasing use of telehealth in those settings and instances where it is likely to be beneficial for patients, healthcare providers, health systems or society.

Conclusions

Although the literature evaluating telehealth consultations is large, it is not possible to make a global, general statement about the clinical and economic effectiveness of telehealth consultations for several reasons. These include the diversity of settings, clinical topics, and outcomes; the limited number of high-quality studies; different approaches to measurement, particularly of costs; and how the perspective may impact the estimation of outcomes. It is possible to conclude it is likely that telehealth is more effective than usual care in several specific situations: Remote ICUs reduce ICU and in-hospital mortality; emergency medical services access to telehealth reduces mortality in patients having heart attacks; remote consultations in emergency care decrease time from presentation to decision, reducing ED time and increasing appropriate transfers and admissions; remote consultations as part of outpatient care improve clinical outcomes in some clinical disciplines and increase access to care in those that have been studied.

For other uses and outcomes the strength of evidence is less definitive. Telehealth consultations may improve inpatient care, emergency stroke care and the management of and satisfaction with outpatient consultations across several specialties. Potential harms or unintended consequences were rarely addressed and future research should address this, if only to confirm they are not significant. Studies of economic outcomes including costs produced mixed results due to major differences in definitions and methods as well as the fact that costs and savings may not accrue to the same organization in an interdependent healthcare system.

Decision models have the potential to build on systematic review results and use evidence in ways that would make it more applicable by tailoring the question, base case, and perspective to the decision maker’s situation. But our experience demonstrates that the literature may not be available to provide all the data needed to fully execute a functioning model for all topics of interest. However, decision modeling can provide some insight by quantifying differences in costs across settings and estimating where savings are likely to accrue in the system. While our exploratory assessment was limited to costs, expansion of this approach could allow more targeted identification of scenarios in which telehealth could improve the range of outcomes including clinical outcomes, access, and cost.

Future research about telehealth consultations needs to be more rigorous if it is to inform policy and practice decisions. Specifically, more studies should include multiple sites, collect information on the context and environment, and consistently measure a more comprehensive range of economic impacts and costs using standard practices.

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Introduction

Background

Telehealth is the use of information and telecommunications technology to provide or support healthcare across time and/or distance. It is a tool with the potential to increase access, improve the quality of care, increase patient satisfaction, positively impact patient outcomes, and reduce the cost of care. Telehealth's potential benefits are frequently cited,[1,2] and there has been a sizable and rapidly growing body of research on telehealth, including systematic reviews and reviews of reviews.[3-8] Despite this potential, implementation and spread has been slower than many expected[9,10] though recent trends suggest the speed and scope of spread may be increasing.

With improvement in technologies and changes in payment policies that are accompanying evolving models for healthcare delivery and payment in general and telehealth in particular, the possibility exists for an acceleration in implementation and wider use of telehealth. Faster internet connections, better hardware, and increasing use of technology by the public as well as by professionals are making telehealth use more and more feasible.[11] Payment policies and delivery models are catching up as demonstrated by recommendations to allow payment for more telehealth services in Medicare[12] and Medicaid[13] and plans for large scale expansions such as the Veterans Administration's "Anywhere to Anywhere" program.[14]

However, these changes are necessary but not sufficient to assure the widespread use of telehealth. This is reflected in several recent initiatives that include proposing a framework for telehealth research and policy[15] and a conceptual framework for developing measures of telehealth use and quality of care.[16] The research and policy framework developed by a committee of experts sought to identify the broad components of the policy context, how telehealth can be used in practice, and potential outcomes in order to support systematic consideration of telehealth expansion and barriers to implementation.[15] The conceptual framework for measurement developed by the National Quality Forum (NQF) identified four domains (Access to Care, Financial Impact/Cost, Experience, and Effectiveness) and several subdomains that could be used to define and categorize the potential impact of telehealth. The NQF's report suggests these domains can be used to develop specific measures of the impact of telehealth that can be used across different modes of delivery (e.g., live video, store-and-forward, remote patient monitoring and mobile health) and clinical indications.[16]

As these efforts illustrate, targeting, supporting, and sustaining increased use of telehealth requires organized and accessible information about the impact of telehealth. While a synthesis of existing research evidence can help inform decisions about telehealth implementation and expansion, it is difficult to produce a meaningful and useful synthesis given the broad scope of telehealth and its use in a wide range of clinical setting for several different indications.

One specific way to address this complexity is to assess the evidence about the different roles telehealth can play in healthcare. This project takes this approach and focuses on one specific role: telehealth for consultations. Telehealth for consultations uses technology to allow healthcare providers to involve other providers, often specialists, in the prevention, treatment, and management of acute and chronic conditions. The technology allows medical expertise to be available where and when it is needed, minimizing potential time or geographic barriers to care and maximizing the efficient use of scarce resources. Telehealth for consultations has been studied across a range of clinical situations, including injuries,[17] burn care,[18] and infectious disease.[19-21] Identifying and summarizing the available evidence about the use of telehealth for consultations will help support the best use of this technology across clinical topics in the future.

The overarching goal of this systematic review is to maximize the utility of available research by presenting the results in formats that support decision makers at various levels (e.g., regulators, providers, and payers) as they consider policy and practice changes related to telehealth for consultation. To accomplish this goal, this project explored combining two evidence synthesis methods: a systematic review of the literature and an extension of the evidence using decision modeling. Both methods have accepted methodologies, but they are not frequently used in tandem. Thus, in this sense, this project is experimental as it strives to both provide the results of a traditional systematic review to identify, organize, and analyze the available research about the use of telehealth for consultations and explore how the addition of decision analysis may be used to increase the utility of evidence for decision makers.

Definitions of Telehealth and Telehealth Consultation for This Project

Telehealth is defined as the use of information and telecommunications technology in healthcare delivery for a specific patient or group of patients, involving a provider across distance or time to address a diagnosis, health condition, or overarching needs of a patient. The information can be transmitted live, be stored and then forwarded, or be a hybrid of these two possibilities. This definition is similar to that used in the previously published Evidence Map,[8] although the inclusion and exclusion criteria have been changed to match the scope of this review.

Telehealth consultation is defined as the use of telehealth designed to facilitate collaboration among providers, often involving a specialist consultant, or between clinical team members, across time and/or distance, on the assessment, diagnosis, and/or clinical management of a specific patient or group of patients. While the patient may or may not be involved in the consultation, the consultation is required to be related to a specific patient or group of patients in order to differentiate this activity from training or education (which would not meet our definition of telehealth). Limited information provided by one clinician to another that does not contribute to collaboration (e.g., interpretation of an electroencephalogram [EEG], report on an x-ray or scan, or reporting the results of a diagnostic test) is not considered a consultation for this review.

Scope and Questions

The Key Questions for the systematic review (SR) are presented below, and the Guiding Questions for the exploratory decision model (DM) are provided later in the report. The Key Questions for the SR were based on questions provided in the scope of work for the Request for Task Order issued by the Effective Health Care program of the Agency of Healthcare Research and Quality. The questions were reviewed, reorganized, and refined by the project team and revised after input from the Technical Expert Panel. There was no formal topic refinement for this project. While the protocol for this review was developed prior to the NQF framework for measurement development, the domains they identified (Access to Care, Financial Impact/Cost, Experience, and Effectiveness)[16] correspond to the outcomes for Key Question 1 (clinical outcomes-effectiveness; economic outcomes- Financial Impact/Cost) or are included in the outcomes for Key Question 2 (intermediate outcomes include Access to Care and Experience).

The Guiding Questions for the DM were also included in the scope of work. The topics, specific questions, and scope for the DM were based on the literature triage and initial findings of the SR.

Key Questions for the Systematic Review

6. Are telehealth consultations effective in improving clinical and economic outcomes?

   Clinical and economic outcomes may include, but are not limited to, mortality and morbidity, patient-reported outcomes, quality of life, utilization of health services, and cost of services.

7. Are telehealth consultations effective in improving intermediate outcomes?

   Intermediate outcomes include both outcomes that precede the ultimate outcomes of interest (e.g., mediators) and secondary outcomes. Intermediate outcomes may include, but are not limited to, access to care, patient and provider satisfaction, behavior, and decisions (e.g., patient completion of treatment, provider antibiotic stewardship); volume of services; and healthcare processes (e.g., time to diagnosis or treatment).

8. Do telehealth consultations result in harms, adverse events, or negative unintended consequences?

9. What are the characteristics of telehealth consultations that have been the subject of comparative studies?

   These characteristics may include:

   a. Clinical conditions addressed. These can include broad categories such as diagnosis and treatment of infectious disease or behavior health as well as specific conditions (e.g., upper respiratory infection, hepatitis C, depression, or addiction) or decisions (e.g., stewardship of antibiotics or antimicrobials, selection of treatments).
   b. Characteristics of the providers and patients involved.
   c. Relationships among the providers and patients involved, including whether these are new or ongoing relationships.
   d. Telehealth modalities and/or methods for sharing patient data and communicating among providers.
   e. Whether specifics in (d) meet Medicare's coverage and Health Insurance Portability and Accountability Act (HIPAA) requirements,
   f. Settings, including:
      - Type of healthcare organization, including the organizational structure (e.g., integrated delivery system, critical access) and the type of care (e.g., long-term care, inpatient, ambulatory care).
      - Country.
      - Geographic and economic characteristics, such as urban or rural areas, or areas with high versus low socioeconomic resources.
   h. Other circumstances (e.g., appropriate transportation, climate).
   g. Payment models, requirements, or limits for payment, including:

- The payer/insurance for the patient (e.g., Medicare, Medicaid, commercial).
- Any parameters for payment (e.g., relative value units) or limits on visits.
- Any eligibility requirements for payment based on patient, provider, setting, or context characteristics.

10. Do clinical, economic, intermediate, or negative outcomes (i.e., the outcomes in Key Questions 1, 2, and 3) vary across telehealth consultation characteristics (Key Question 4)?

PICOTS

The PICOTS framework is used to define the scope of the review. The population, intervention, comparator, outcomes, timing, and setting (PICOTS) for this review are outlined below.

Populations:

- Patients of any age, with medical care needs for prevention, treatment, or management of chronic or acute conditions.
- Providers (clinicians or healthcare organizations).
- Payers for healthcare services (public, private, insurers, patients).

Interventions:

- Telehealth consultations are defined as the use of telehealth designed to facilitate collaboration among providers, often involving a specialist, or between clinical team members, across time and/or distance, on the prevention, assessment, treatment and/or clinical management of a specific patient or group of patients.
- Telehealth consultations can be for any acute or chronic conditions. The literature search focused on both general conditions and specific ones identified as areas of growth and policy interest such as infectious disease, dermatology, and critical care.
- Telehealth consultations can use any technology (e.g., real-time video, store and forward, data transfer).

Comparator:

- Other locations, patients, or time periods that used any alternative to telehealth for healthcare delivery. The alternatives to telehealth could include consultations conducted in another way (e.g., in-person or telephone), care with no access to specialty services, or usual care, which may or may not be defined and could include: 1) consultations conducted in-person, or 2) care delivered without consultation, or 3) a mix of both.

Outcomes for Each Key Question:

- Key Question 1: Clinical and economic outcomes
  - Clinical outcomes such as patient-reported outcomes, mortality, morbidity, such as function, illness recovery, infection.
  - Economic outcomes such as return on investment, cost, volume of visits, and resource use.

- Key Question 2: Intermediate outcomes
    - Access to services
    - Patient satisfaction, behavior, and decisions such as completion of treatment, or satisfaction with less travel to access healthcare.
    - Provider satisfaction, behavior, and decisions such as choice of treatment or antibiotic stewardship.
    - Time to diagnosis, time to treatment, and length of stay.
- Key Question 3: Adverse effects or unintended consequences
    - Loss of privacy or breech of data security.
    - Misdiagnosis or delayed diagnosis.
    - Inappropriate treatment.
    - Increase in resource costs, negative return on investment.
- Key Question 4: Not applicable (this is a descriptive question).
- Key Question 5: Same outcomes as Key Questions 1-3.

Timing:

- Telehealth consultations can be used at any point in the diagnosis, treatment, or management of a patient.
- Outcome measurement needs to occur after the telehealth consultation.

Setting:

- The consultation can involve providers and patients in any location. Settings could include inpatient, outpatient, or long-term care, and could be in civilian, Veterans Administration, or military facilities.

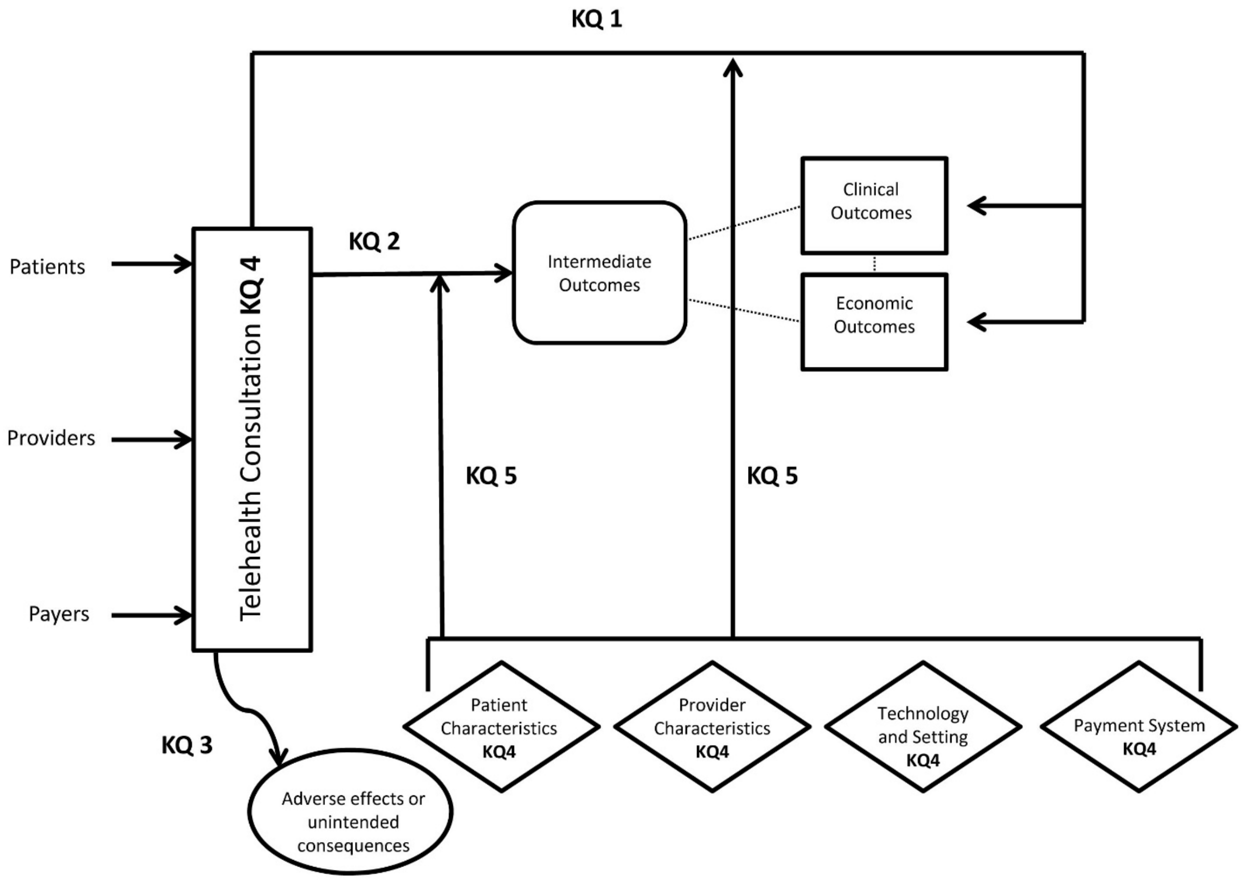
Study Designs:

- Comparative studies, including trials and observational studies.
- Descriptive studies may be used to inform the decision model (DM) as needed but will not be included in the SR.

Analytic Framework

Figure 1 is the analytic framework, which represents the relationships among the elements of the Key Questions for the systematic review.

Figure 1. Analytic framework for telehealth consultations



KQ = Key Question

Methods

The methods for this systematic review follow the Agency for Healthcare Research and Quality (AHRQ) *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (available at http://www.effectivehealthcare.ahrq.gov/methodsguide.cfm) and the PRISMA checklist.[22,23] The full protocol for the review contains a detailed description of the methods and is available at the Effective Health Care website (http://effectivehealthcare.ahrq.gov/index.cfm). The protocol was registered with PROSPERO (CRD42017058304).

As this project includes a systematic review (SR) and a supplemental decision model (DM), the key elements of the methods are outlined separately.

Systematic Review Methods

Literature Search Strategy

The complete search strategies are included in Appendix A.

Publication Date Range: We searched for studies published in a 20-year period, from 1996 through May 2018. This date range captures studies of systems that rely on more current technology. In our evidence tables, we included information on the dates the studies were conducted and the technologies used, as well as the dates of publication.

Literature Databases: Ovid MEDLINE®, the Cochrane Central Register of Controlled Trials (CCRCT), and the Cumulative Index to Nursing and Allied Health Literature (CINAHL®) were searched to capture published literature. The search strategies were developed by a specialist librarian and peer reviewed by a second librarian.

Hand Searching: Reference lists of included articles and selected excluded articles (e.g., systematic and narrative reviews) were reviewed for includable literature.

Supplemental Evidence and Data for Systematic Reviews: The AHRQ Evidence-based Practice Center Scientific Resource Center was asked to notify stakeholders about the opportunity to submit Scientific Information Packets via an announcement in the *Federal Register*.

Grey Literature: Sources for grey (unpublished) literature included reports produced by government agencies, healthcare provider organizations, or others. With the help of AHRQ we contacted the federal government community of practice on telehealth (FedTel), the American Telemedicine Association, and AcademyHealth to make initial inquiries, and we also followed up on any suggestions made by Technical Expert Panel members.

Process for Selecting Studies: Pre-established criteria were used to determine eligibility for inclusion and exclusion of abstracts in accordance with the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[22] To ensure accuracy, all abstracts were independently reviewed by two team members. All citations deemed appropriate for inclusion by at least one of the reviewers were retrieved. Each full-text article was independently reviewed for eligibility by at least two reviewers. We reviewed the full text of any articles suggested by peer reviewers or that arose from the public posting or Supplemental Evidence and Data for Systematic reviews processes. Any disagreements about inclusion or exclusion were resolved by discussion and consensus across the investigators.

Criteria for Inclusion/Exclusion of Studies in the Review

The criteria are based on the Key Questions and are described in detail in Appendix B. Key criteria are described below.

Study Designs: We included comparative studies of any design including trials and cohort studies, as well as pre-post designs (i.e., the comparison can be across time points as well as across different groups). We included economic evaluations that compared two groups and used data derived alongside a primary research study. We reviewed reference lists of existing SRs to identify studies for inclusion. We excluded descriptive studies with no outcomes data or studies that included only outcomes data from one point in time (post only). We also excluded modeling studies that used simulated data, and excluded commentaries, letters, and articles that described telehealth systems or implementations but did not assess impact. We considered whether an excluded article contained information that could be used in the DM even if the study was not included in the SR.

Non–English-Language Studies: We restricted inclusion to English-language articles, but reviewed English-language abstracts of non-English-language articles to identify studies that would otherwise meet inclusion criteria, in order to assess for the likelihood of language bias.

Data Abstraction and Data Management

The following data were abstracted from studies deemed eligible based on inclusion criteria (Included Studies are listed in Appendix C): study design, year, setting, country, sample size, eligibility criteria, population, and clinical characteristics (e.g., age, sex, race, reason for presentation, diagnosis), intervention characteristics (e.g., duration, training/background of personnel engaged in the consultations), and results relevant to each Key Question as outlined in the PICOTS section in the Introduction. Information relevant for assessing applicability of individual studies included the number of patients randomized/eligible for inclusion in an observational study relative to the number of patients enrolled, and characteristics of the population, telehealth intervention, and administrating personnel. Sources of funding for studies were also recorded when reported. All study data were verified for accuracy and completeness by a second team member. A record of studies excluded at the full-text level with reasons for exclusion is provided in Appendix D.

Assessment of Methodological Risk of Bias of Individual Studies

We assessed risk of bias for individual controlled trials and observational studies using predefined criteria consistent with the approach recommended in the chapter, Assessing the Risk of Bias of Individual Studies When Comparing Medical Interventions in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[22] Economic evaluations were assessed using a modified version of the Consensus Health Economic Criteria.[24,25] Our team selected the criteria related specifically to concerns of internal validity and the potential introduction of bias. All studies regardless of design were rated as "low risk of bias," "medium risk of bias," or "high risk of bias." The detailed instructions and criteria used for this evaluation are in Appendix E.

Studies rated "low risk of bias" are considered to have the least risk of bias, and their results are generally considered valid. "Low risk of bias" studies include clear descriptions of the population, setting, interventions, and comparison groups; a valid method for allocation of patients to treatment; low dropout rates and clear reporting of dropouts; appropriate means for preventing bias; and appropriate measurement of outcomes.

Studies rated "medium risk of bias" are susceptible to some bias, though not enough to invalidate the results. These studies may not meet all the criteria for a rating of low risk of bias, but no flaw is likely to cause major bias. The study may be missing information, making it difficult to assess limitations and potential problems. The "medium risk of bias" category is broad, and studies with this rating will vary in their strengths and weaknesses. The results of some medium risk of bias studies are likely to be valid, while others may be only possibly valid.

Studies rated "high risk of bias" have significant flaws that imply biases of various types that may invalidate the results. They have a serious or "fatal" flaw in design, analysis, or reporting; large amounts of missing information; discrepancies in reporting; or serious problems in the delivery of the intervention. In general, observational studies that do not perform adjustment for potential confounders will be assessed as "high risk of bias." The results of these studies are at least as likely to reflect flaws in the study design as the true difference between the compared interventions. We did not exclude studies rated high risk of bias a priori, but high risk of bias studies are considered to be less reliable than low or medium risk of bias studies when synthesizing the evidence, particularly if there are discrepancies among study results.

Each eligible study was independently reviewed for risk of bias by two team members. Any disagreements were resolved by consensus. If the two reviewers could not arrive at a consensus, the principal investigator or the lead for the decision analysis made a final determination. Team members who were involved in the conduct of a study were not involved in data abstraction or risk of bias assessment for that study.

Data Synthesis

Based on the data abstraction we constructed comprehensive evidence tables (Appendix F) identifying the study characteristics, results of interest, risk of bias ratings for all included studies, and summary tables included in the text to highlight the main findings. We reviewed and highlighted studies by using a hierarchy-of-evidence approach, where the best evidence is the focus of our synthesis for each Key Question.

Data are presented in summary tables; ranges, descriptive analysis, and interpretation of the results are provided.

We conducted quantitative synthesis (i.e., meta-analysis) for combinations of similar telehealth interventions and outcomes when there were adequate data from included studies. In cases with few studies, lack of data, or when the use of telehealth or outcomes were different, we used qualitative approaches.

Random effects meta-analysis based on the profile likelihood method was conducted to combine the studies, and this method incorporates the uncertainty related to estimating between-study heterogeneity. Statistical heterogeneity was assessed using the standard χ^2 test and I^2 statistic. For binary outcomes (mortality outcomes), we combined risk ratios. If a study reported adjusted risk ratios, we used the adjusted risk ratio instead of the risk ratio calculated based on the raw data. If a study reported adjusted odds ratio, we converted the adjusted odds ratio to an adjusted risk ratio. For continuous outcomes (length of stay), we combined mean differences. For studies where both the intervention and control groups had a pre- and post-period, we used the mean difference of differences. We conducted sensitivity analyses by comparing results when outlying studies were included or excluded.

All analyses were conducted using Stata/IC 13.1 (StataCorp LP, College Station, TX).

Grading the Strength of Evidence for Major Comparisons and Outcomes

The strength of evidence (SOE) for each Key Question was initially assessed by one researcher for each clinical outcome (see PICOTS section in Introduction) by using the approach described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[22] To ensure consistency and validity of the evaluation, the grades were reviewed by the entire team of investigators for:

- Study limitations (low, medium, or high level of study limitations)
- Consistency (consistent, inconsistent, or unknown/not applicable)
- Directness (direct or indirect)
- Precision (precise or imprecise)
- Reporting bias (suspected or undetected)

The risk of bias for individual studies is provided in Appendix G, while the SOE for each Key Question is in Appendix H. The strength of evidence was assigned an overall grade of high, moderate, low, or insufficient according to a four-level scale by evaluating and weighing the combined results of the above domains:

- High—Very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. The findings are stable (i.e., another study would not change the conclusions).
- Moderate—Confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. The findings are likely to be stable, but some doubt remains.
- Low—Limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). Additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
- Insufficient—No evidence. Investigators are unable to estimate an effect, or have no confidence in the estimate of effect for this outcome. No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Assessing Applicability

Applicability was considered according to the approach described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[22] We used the PICOTS framework to consider the applicability of the evidence base for each Key Question, for example, examining the characteristics of the patient populations (e.g., clinical condition), attrition of participants, telehealth intervention (including personnel delivering the intervention) and study setting (e.g., inpatient or outpatient).

Variability in the studies may limit the ability to generalize the results to other populations and settings. We considered applicability and the strength of evidence when making general assessments across the studies, and we use qualifiers in key messages and conclusions such as 'likely' for moderate strength of evidence and/or some applicability concerns or 'may' for low strength of evidence and/or significant applicability concerns.

Exploratory Cost Model for Telehealth Neurosurgical Consultations

The purpose of exploring decision analysis was to address questions the SR alone could not answer. We attempted to construct a model to address the following Guiding Questions for one selected use:

3. What is the predicted impact on clinical, economic, and intermediate outcomes of telehealth consultations?
4. What is the predicted effect of various proposed payment reforms on clinical, economic, and intermediate outcomes of telehealth consultations?

We selected the use of telehealth for neurosurgical consultations by rural or community hospitals for patients with moderate to severe traumatic brain injury for this exploratory model. This topic was selected for two reasons: 1) the systematic review did not identify a body of existing evidence that could adequately inform decisions about this use; and 2) neurosurgery is a specialty that is not widely available in all locations (such as rural areas) where people sustain traumatic brain injuries, making it the type of use often suggested as appropriate for telehealth.

The model was built as a decision tree. When data were available in the studies included in the systematic review these were used, but the decision modeling team also conducted targeted searches for published data for specific parameters. This approach is common in decision modeling and allows for the inclusion of data from sources that would not meet the inclusion criteria of the systematic review.

The results of the model are reported as costs, and the incremental difference in costs between the two potential treatment scenarios that produce similar outcomes for similar patients. As current evidence on how or whether patient outcomes differ when the consultation is in person or via telehealth is limited for this particular application, the model was constructed as a "what if analysis" assuming equivalent clinical outcomes, facilitating focus on understanding the drivers of cost differences.

The model specification and results of this analysis are included in Appendix I. Insights from our efforts to model cost outcomes are included in the Discussion.

Results

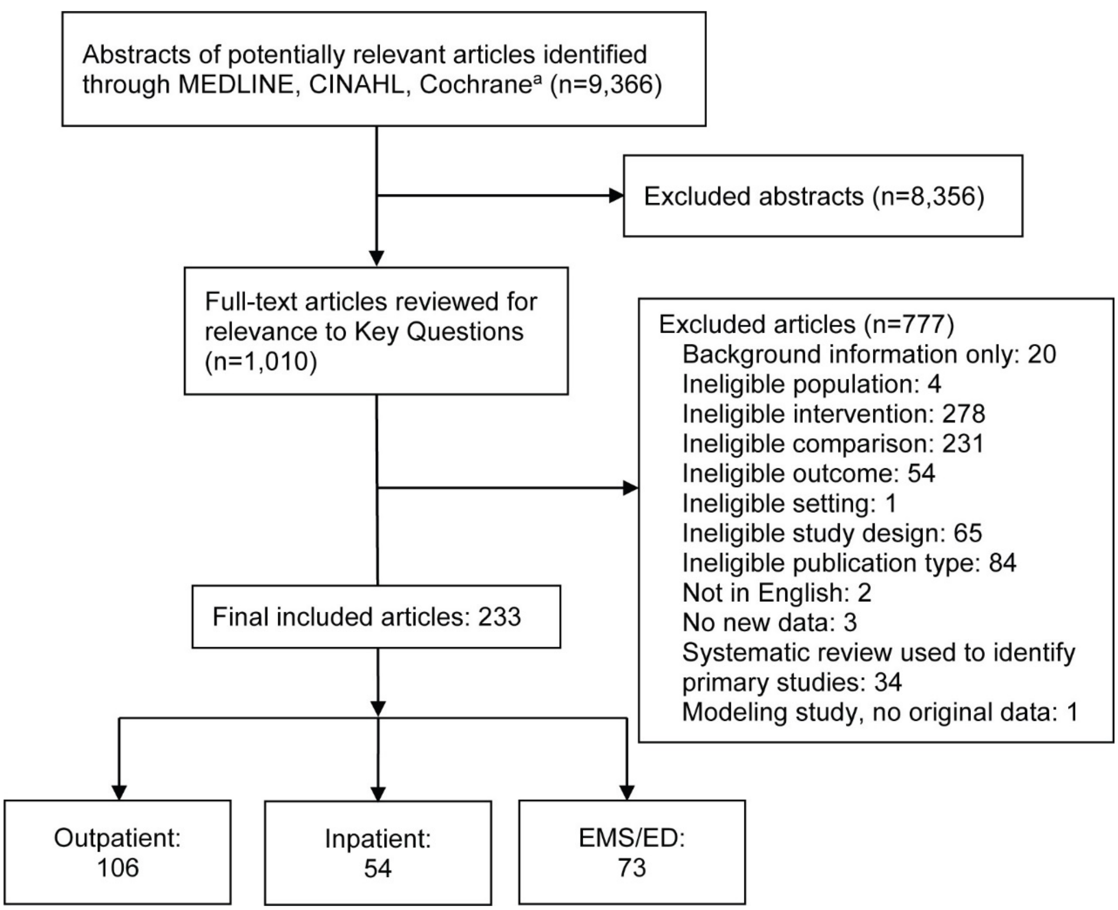
Overview

Literature Search Yield

The results of the literature search, triage of abstracts, and the review of full-text articles is summarized in the study flow diagram (Figure 2). Our searches yielded 9,366 potentially relevant citations after reviewing titles and abstracts, 8,356 were excluded and the full text of 1,010 articles were pulled for review. Of these, 233 articles met our inclusion criteria. A list of the included studies is provided in Appendix C.

The most frequent reasons for excluding an article were that the intervention was not a telehealth consultation (ineligible intervention) or that the study did not compare telehealth consultations to usual care or some other intervention (ineligible comparison). The majority of the excluded studies about telehealth consultations were excluded because they provided only descriptive information. The citations for the studies excluded after full-text review and the primary reasons for exclusion are included in Appendix D.

Figure 2. Literature flow diagram



ED = emergency department; EMS = emergency medical services
[a] Cochrane databases include the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews

Description of Included Studies

Table 1 provides information on selected characteristics of the 233 included articles.

The most frequent geographic location for the included studies of telehealth consultations was the United States (110 articles or 47%); however more than half of the studies were conducted in other countries. Seventy-eight articles (approximately 33%) were conducted in Europe, 15 in Asia, 19 in Australia or New Zealand, three in South America, four in Canada, and one in Africa (Mali).

While the scope of this review is limited to the use of telehealth for consultations, there was substantial variation in the mode and type/timing of telehealth. The most common mode or technology used for telehealth consultations was video, which was used in just over half of the studies (55%). Store and forward of images and information was used in almost 16 percent of the studies; 5 percent studied systems that facilitated review of electronic records, 4 percent involved streaming data, and 10 percent used a variety of modalities simultaneously. Ten percent of studies did not provide enough information to categorize the mode or technology. The mode is closely, but not perfectly, related to whether the consultation was synchronous (real time) or asynchronous. In most of the studies the consultations were in real time (72%), or both real time and asynchronous communications were used (6%). Twenty percent of studies evaluated consultations that involved asynchronous exchanges.

The study designs and sample sizes also varied. Most of the studies (67%) were observational, including prospective cohorts, retrospective cohorts, and before/after studies in which a group of patients from before the implementation of telehealth consultations are compared with a different group of patients after telehealth implementation. In these studies, the comparator was often usual care, that is care without telehealth and the studies rarely provided more detail (e.g., if consultations were in-person, if care was delivered without consultation or a mix of both). Nearly one-fifth (19%) were randomized controlled trials, 12 percent were economic evaluations, and approximately 3 percent were pre-post studies in which outcomes for the same patients were compared prior to and post telehealth consultations. The size of the studies ranged from small (23% with under 100 subjects) to very large (over 10,000 subjects) with most studies of moderate size (41% of studies with 101 to 500 patients and 11% with 501 to 1000 patients). The studies were evaluated for risk of bias (see Methods and Appendix E for details), and 11 percent were rated as low risk of bias, 46 percent as moderate, and 43 percent as high.

The studies also varied in terms of the type of outcomes used in evaluating telehealth. Many studies included more than one outcome. The primary outcomes for this review (Key Question 1) included clinical outcomes (e.g., mortality and morbidity), resource utilization (e.g., length of hospital stay, number of hospitalizations, number of outpatient visits, number of tests), and economic outcomes (e.g., costs of care, costs avoided, and expenditures for telehealth or alternative services). Approximately 40 percent of studies included clinical outcomes, while about a third analyzed economic outcomes. More than 80 percent of the studies included intermediate outcomes, which we defined as patient or provider satisfaction or behavior (e.g., adherence to treatment or frequency in ordering tests). Very few studies (<5%) explicitly considered or reported potential harms.

The identified studies assessed consultations across numerous settings and specialties. Use of telehealth consultations to inform the treatment of patients in hospitals (inpatient setting) included studies of remote intensive care units (ICUs) as well as programs that facilitated consultations for several specific specialties (e.g., neonatal cardiology, pediatrics, geriatrics, psychiatry, and surgeries). Included evaluations in emergency care addressed the effectiveness of stroke assessment and specialist consultations with emergency department physicians or with emergency medical personnel. We also included studies of teleconsultations for several types of outpatient care (e.g., dermatology, wound care, ophthalmology, orthopedics, dentistry, cancer, and infectious disease). While the detailed results in the following sections cover a wide range of topics, the topics are limited to those for which comparative studies were identified; not all possible uses of telehealth for consultations are represented. Based on prior work on a telehealth evidence map,[8] and input from our Technical Expert Panel and other stakeholders there may be topics for which telehealth consultations are used that are not covered in this review. Examples include antibiotic management, pain management, and opioid misuse.

Table 1. Characteristics of included studies

Characteristic	Categories	Number of Articles	Percentage of Articles	References
Geographic Location	United States	110	47.2%	26-135
	Non-UK Europe	56	24%	136-191
	United Kingdom	22	9.4%	192-213
	Australia or New Zealand	19	8.2%	214-232
	Asia	15	6.4%	233-247
	Canada	4	1.7%	248-251
	South America	3	1.3%	252-254
	NR	3	1.3%	255-257
	Africa	1	0.4%	258
Study Design[a]	Observational (Prospective cohort, retrospective cohort, before-after)	155	66.5%	26-33,36-42,44,47,49-51,53,55,60,61,64-68, 70-73,75,76,78-80,82-84,86-94,96,97,101,102, 104-113,115-117,119-125,131-139,141-145,150, 154-156,158,159,161,162,164,165,167,169, 171-174,176-179,182,183,185,188-190,193, 196-199,203,209,214-216,218,219,222,225-227,229,232,234,236-244,246,248-254,256-258
	Randomized controlled trial	44	18.9%	34,35,46,48,56,58,59,63,69,74,98,100,126, 128-130,140,146,149,153,157,163, 175,180,186,187,192,194,195,200-202,207,208, 210,217,220,224,228,233,235,245,247,255
	Economic Evaluation	29	12.4%	45,52,57,62,77,81,85,95,99,103,118,127,147,151, 152,160,166,170,181,184,204-206,211,212,221, 223,230,231
	Pre-post (same patients)	6	2.6%	43,54,148,168,191,213
Risk of Bias[a]	Low	27	11.4%	29,30,47,51,71,80,89,90,94,102,107,137,138,166, 172,173,175,178,180,204,207,208,216,218,236, 246,255
	Moderate	109	46.2%	27,28,36,45,48,56-62,64-68,70,73,76,78,81-88, 91,93,95,96,98-100,108,111-113,117,118, 120,123,125-127,129-135,139-143,145-148,150, 151,155,159,161,162,167-169,171,176, 177,179,181,183-185,189,190,192,195,196, 203,205,206,210-212,214,217,221,223,224, 230-234, 238,240,243,247,248,251,253,254
	High	100	42.4%	26,29,31-35,37-44,46,49,50,52-55,63,69,72,74,75, 77,79,83,92,97,101,103-106,109,110,114-116,119, 121,122,124,128,136,144,149,152-154,156-158, 160,163-165,170,174,177,182,186-188,191,193, 194,197-202,209,213,215,219,220,222,225-229, 235,237,239,241,242,244,245,249,250,252, 256-258

Characteristic	Categories	Number of Articles	Percentage of Articles	References
Sample Size[b]	Under 100	49	22.8%	26,32,39,42,43,48,54,69,74,80,81,92,97,100, 103-105,108,111,115-117,120,139,140, 142, 149,157,163,164,184,185,188,190,191,193,203, 205,206,217,220,226,228,235,239,241,244,250,257
	100-500	88	40.9%	30,34,35,40,45,46,49 ,51,56-59,64,65,67, 68,70,75,76,83-86,88,101,102,112-114,119,121, 122,124,126-130,133,135,136,141, 143,144,148,150-153,156,159-161,168-171, 174,175,178-182,187,189,192,194-196,198-202, 204,210,213,216,222-225,229,231-234,237, 238,240,243,249 ,251,253,255,256,258
	501-1000	24	11.2%	28,38,41,53,60,66,72,96,98,99,107,125,146,147, 158,167,172,209,211,215,218,227,236,242,245-247
	1001-10,000	36	16.7%	27,33,36,44,47,50,62,73,79,87,89-91,94,106,109, 110,123,132,134,137,138,145,154,155,162,165, 166,173,176,177,183,186,207,208,212,214,219, 248,254
	10,001+	9	4.2%	29,55,61,71,77,78,93,95,131,197
	NR/unclear	9	4.2%	31,37,52,63,82,118,221,230,252
Mode of Telehealth	Video	128	54.9%	26,27,30,32,34,35,39,41-44,46-57,59-63,66,68-70, 73,74,76-78,80,81,84-86,88-90,92-96,100,101, 104,105,108,111,116-118,120,121,124,133-135, 139,141,142,149,151,153,155,156,159-161,163, 164,167,169,170,174,178,181,183-185,187,188, 194,196-202,205-208,211,212,214,215,217, 219-221,223,225-227,229-232,234,235, 240,242,245,249,250,252,253,255,256
	Data store and forward	37	15.9%	98,99,113,122,126,128-130,132,146-148, 154,157,158, 166,175,177,180,190,191, 209,213,216,222,228,233,236-239,241,243, 244,251,254,258
	Electronic chart/record review	11	4.7%	28,40,45,65,75,79,127,144,171,186,248
	Mixed modalities	24	10.3%	36,58,71,87,103,106,107,110,112,123,131,137,138, 140,150,152,168,176,182,193,224,246,247,257
	Unspecified/ unclear	24	10.3%	29,31,33,37,38,64,67,82,83,91,97,102,109,115,119, 125,143,145,165,192,195,203,204,210
	Data streaming	9	3.9%	72,114,136,162,172,173,179,189,218
Timing	Real-time	168	72.1%	26,27,29,30,32,34,35,37-39,41-44,46-64,67-74, 76-78,80-97,100,101,103-112,114,116, 117,120,121,123,124,131,133-137,139,141-143, 149-151,153,155,156,159,160,162-164,167-170, 172-174,176,178,179,181-185,187,189, 193,194,196-201,203,205-208,210,212,214-218, 220,221,223,225-227,229-232,234-240,242, 246-250,252-257
	Asynchronous	47	20.2%	31,33,40,45,65,75,79,98,99,118,119,122,125-130, 132,144-148,152,154,157,158,166,171, 175,177,180,186,190-192,195,209,213,222, 224,228,233,244,251,258
	Both	13	5.6%	28,36,66,113,138,140,161,165,188,202,211,243, 245
	NR/unclear	5	2.1%	102,115,204,219,241

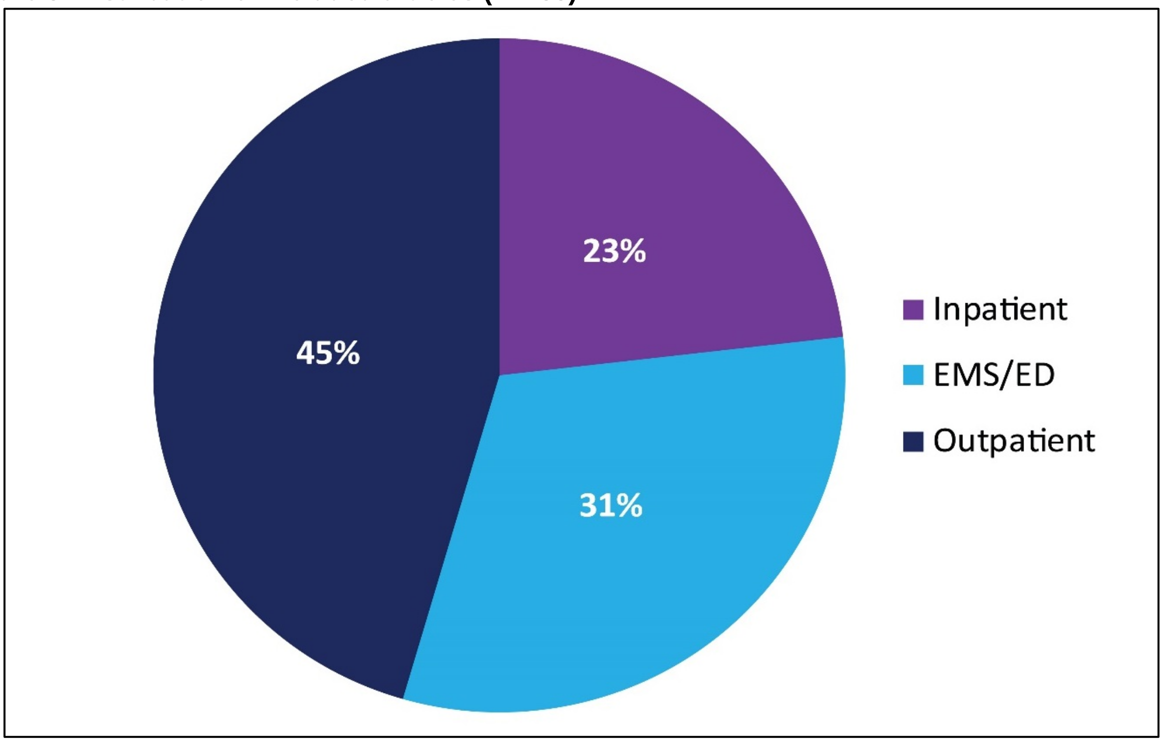
NR = not reported; UK = United Kingdom

[a] Total is more than 233 as some articles analyzed economic and clinical/intermediate outcomes and the risk of bias was different for different outcomes

[b] Total is number of studies (215)

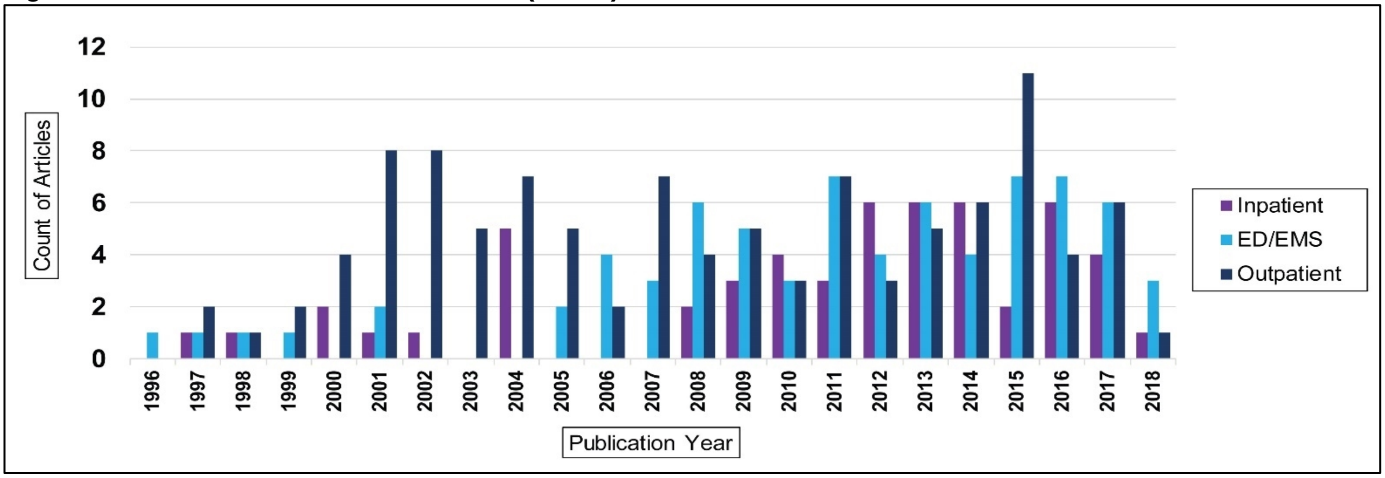
As the volume of the literature is large, we divided it according to the patient setting for both additional description and for presenting the results. We used the three categories: inpatient, emergency department or emergency medical services (ED/EMS), and outpatient. Each study included in this systematic review was assigned to one of these three settings. Figure 3 shows the distribution of the included studies across these three categories. Outpatient is largest, including nearly half the studies, with ED/EMS studies constituting nearly a third and inpatient about a quarter of included studies. Within these categories we have also grouped the studies by clinical indication, condition, or specialty. Summary of evidence tables are included at the beginning of each section that provide the number of studies and citation by setting. Figure 4 presents the year of publication for each article by these categories as well.

Figure 3. Distribution of included articles (n=233)



ED = emergency department; EMS = emergency medical services

Figure 4. Telehealth consultation articles (n=233)



ED = emergency department; EMS = emergency medical services

The tables in Appendixes F (Evidence Tables) and G (Risk of Bias) include the detailed information extracted from each article. Also, the tables later in this Results section provide a summary of study characteristics and outcomes.

Organization of Results

The results for this review are organized into three sections that correspond to the patient settings (inpatient, ED/EMS, and outpatient). We chose to organize the results by the patient setting as the settings are likely to have different telehealth technology requirements as well as differences in payment structures, staffing, and organization of care delivery. Specifically, what is needed to implement telehealth consultations and the nature of the consultation will likely differ if a patient is in a hospital versus treated out of hospital by EMS, in an ED, or in an outpatient clinic. For example, the logistics and technology needed to facilitate a consultation with a specialist differ for EMS in a moving ambulance where the need is emergent and speed is important, compared with outpatient assessments in physician offices which may require larger networks connecting multiple, stable locations (offices or clinics), or consultations for inpatient treatment that may be more urgent than outpatient and involve linking a smaller number of specialists to allow consultations over distance or at times when a specialist is not on site at the hospital. Each of the three sections describe the literature available to address the five Key Questions. Within each of these sections, the studies are grouped by clinical indications, though we attempted to summarize and draw conclusions across indications where we believe it is appropriate.

Systematic Review Results by Patient Setting

Inpatient Results

We divided the research evaluating telehealth for consultations involving inpatient care into two categories: remote intensive care unit (ICU) and specialty consultations. Specialty consultations are further grouped and reported by specific clinical topics. Inpatient care data are shown in Tables 2 through 6 and Figures 5 through 8. Tables 2 and 5 include the number of articles addressing each topic, a summary assessment of key outcomes across studies, and study citations. Figures 5 through 8 and Tables 3, 4, and 6 provide more detail, focusing on key results for each study, and the accompanying text discusses how the studies address the Key Questions for this review. Detailed information we abstracted from each article is provided in Appendix F. The overall rating for risk of bias and the criteria used to assess each article are in Appendix G, and Appendix H contains the strength of evidence assessment for each topic.

Remote Intensive Care Units

We identified 21 studies reported in 22 articles evaluating the use of telehealth to provide remote ICU services. Remote ICU (sometimes referred to as tele-ICU) services involve offsite staff (e.g., intensivists, critical care nurses, and sometimes administrative assistants) who monitor ICU patients and provide consultation and management assistance by alerting onsite staff to issues, recommending treatment, and mentoring onsite staff in care delivery. The purpose is to allow hospitals without 24-hour critical care staff to provide high-quality care to critically ill patients and to avoid transferring them to another facility. Remote ICU systems vary but generally include cameras allowing one-way observation of the patient and care provided, mirroring of bedside monitors, and real-time voice communication. Some studies included access to patient record systems while others required special transmission of records from the hospital to the remote ICU staff location.

Remote Intensive Care Units: Key Points

- Clinical outcomes: ICU and hospital mortality are lower with remote ICU (moderate strength of evidence).
- Economic outcomes: Not all studies analyzed costs of remote ICUs or their impact on revenue; those that did used differing methods, and conclusions were inconsistent (insufficient evidence).
- Intermediate outcomes: ICU and hospital length of stay (LOS) are not statistically different with remote ICU (moderate strength of evidence).
- Adverse effects: None of the included studies specifically addressed potential harms or unintended consequences (insufficient evidence).

Table 2 summarizes the results across the included studies.

Table 2. Remote intensive care units: summary of evidence

Number of Articles	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
22	* ICU mortality lower * Hospital mortality lower Harms: No evidence	* ICU LOS shorter ~ Hospital LOS	? Cost or revenue impact	36,43,44,55,62,71,73,80,81,87,91,94,104,106,107,109,110,123,131,227, 240,257

ICU = intensive care unit; LOS = length of stay
Key: *superior (telehealth benefit), ~ no difference or inferior (telehealth no benefit), ? inconclusive (inconsistent results)

Remote Intensive Care Units: Detailed Results

Figures 5 through 8 and Table 3 includes the results for mortality, LOS, and costs from the included studies of remote ICUs.

All but two studies of remote ICUs were conducted in the United States. The exceptions are a study conducted in India of cardiac intensive care[240] and a study of remote ICU in Australia and New Zealand.[227] Thirteen are before-after designs comparing outcomes from a period before implementation of remote ICUs to the period after this model of care was in operation in the same hospital or hospitals.[36,55,62,81,87,91,94,107,109,110,123,131,227,257] The remaining studies include four retrospective cohorts,[44,71,73,240] two prospective cohorts,[80,106] one cross sectional survey,[43] and one pre-post survey.[104] The studies did not provide detail on the nontelehealth care, though it likely included a mix of care by nonspecialists, less care by specialists based on availability in person, and transfers to other hospitals if specialists were not available to care for the patients.

Remote Intensive Care Units: Effectiveness in Improving Clinical and Economic Outcomes

Most of the remote ICU studies included both ICU and in-hospital mortality as primary outcomes. We generated pooled estimates of 12 of these studies that used similar remote ICU interventions across sites and reported adequate data. Figures 5 and 6 contain forest plots for these analyses. If the study did not contain data that could be included in the pooled analysis the results are included in Table 3.

Examining the studies individually reveals that most reported lower mortality in the remote ICUs with a minority reporting no significant difference. The pooled risk ratios and 95% confidence intervals confirm lower mortality with telehealth. For ICU mortality the risk ratio is 0.69 (95% confidence interval [CI] 0.51 to 0.89), estimating mortality to be 31 percent lower for patients cared for in the remote ICU arms of the 11 included studies in the meta-analysis. In-hospital mortality is also lower: a pooled risk ratio of 0.76 (95% CI 0.60 to 0.95) though the effect is smaller with an estimate of 24 percent lower mortality rates. Hospital mortality rates include patients who die in the ICU and other wards, and the smaller difference may represent patients who survived their ICU stay but died before leaving the hospital.

We conducted sensitivity analyses to assess the stability of the above conclusions. Specifically, we repeated the analyses with and without one study[73] reporting substantially better odds ratios (that is, lower deaths with remote ICU) after adjustments than the other studies . Omitting this study changes risk ratios (e.g., from 0.69 to 0.72 for ICU mortality), but does not change overall conclusions. Similarly, we repeated analyses stratifying by study design, specially combining only the before-after studies and not including the two studies that used concurrent controls. This changed the risk ratio slightly, but did not alter conclusion.

Six studies evaluated and reported the impact of remote ICU on costs. The studies used very different approaches to assess the economic impact of remote ICUs and the findings were not consistent. Three studies reported benefits: one reported that case volume increased and contributed to higher margins;[81] another reported that ICU patients contributed to increased revenue because shorter ICU stays allowed more patients to be treated by increasing capacity;[36] and the third study reported lower ICU total costs (ratio of after to before 0.69, p=0.031) and attributed this to a decrease in complications after remote ICU implementation.[107] Other studies reported higher costs[62,91] or reported very basic estimates.[109] Given that the evidence is inconsistent and imprecise, we were unable to categorize how remote ICUs affect costs.

Remote Intensive Care Unit: Effectiveness in Improving Intermediate Outcomes

Length of stay in the ICU and in the hospital are intermediate outcomes assessed in many studies of remote ICUs. We also pooled results for these outcomes. These analyses combined the mean difference in length of stay (LOS) in days across studies. The data and pooled results based on the 13 studies with usable data are presented in Figures 7 and 8. The results of studies reporting data that could not be pooled are included in Table 3.

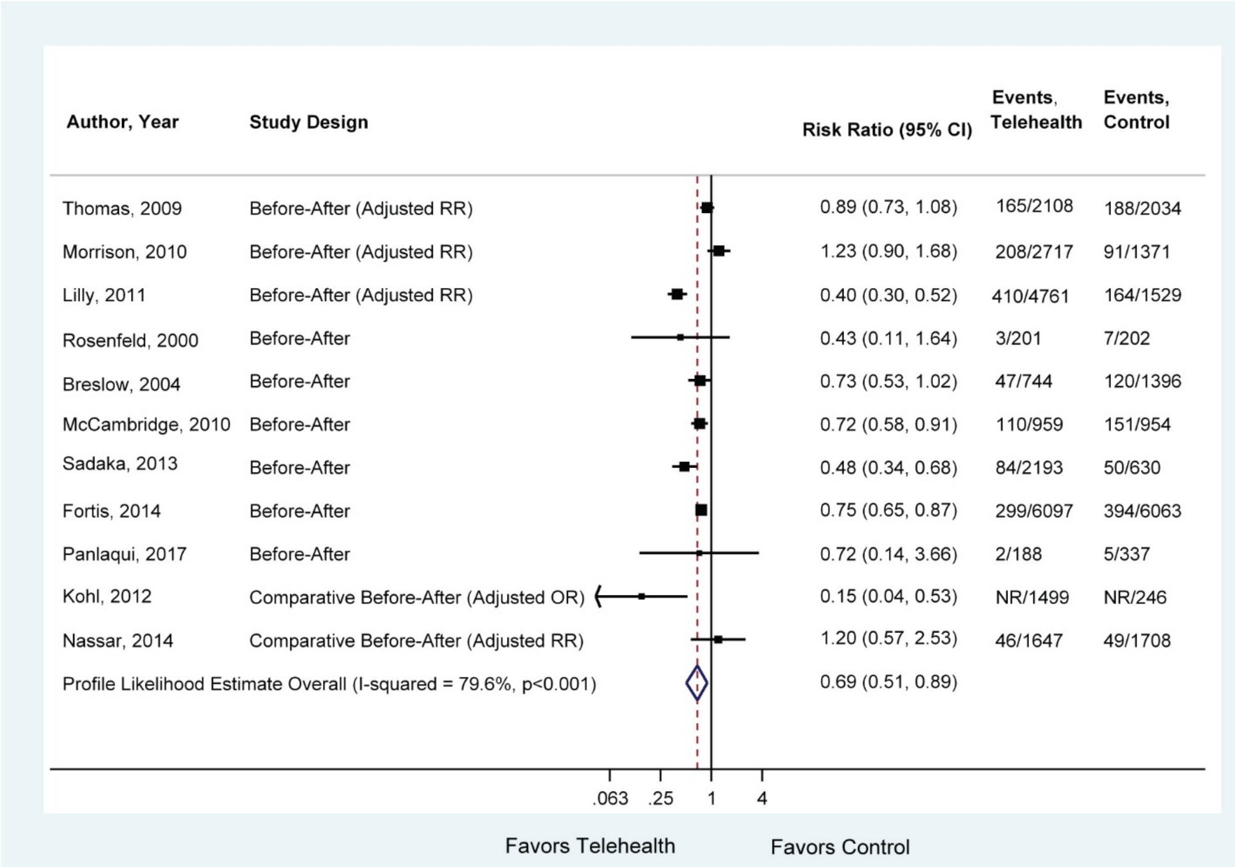
The finding from studies that included ICU LOS were not consistent: some reported shorter LOS and some longer for remote ICU versus usual care. The pooled estimate of the mean difference is -0.39 with a 95% confidence interval of -0.99 to 0.15, indicating that the difference is not statistically significantly different from zero. For total in-hospital LOS the results are similar. The pooled difference is -0.14 (95% CI -0.96 to 0.63), which is lower for remote ICU than usual care, but not significantly different. We tested the stability of the results by repeating the analyses including both raw numbers and adjusted estimates when they were provided, by including only the before-after studies, and by excluding studies with the most extreme results. While the magnitude of the difference changed, none of these variations resulted in a difference that was statistically significant. Authors of these studies suggest that patients are surviving longer as reflected in the decline in mortality, but remain in the hospital longer.

Some of these studies assessed other outcomes including nursing staff satisfaction, staff perceptions of teamwork and safety, readmission to the ICU, adherence to guidelines, and transfers to other hospitals. These results are included in Table 3.

Harms, Adverse Events, or Negative Unintended Consequences of Remote ICUs

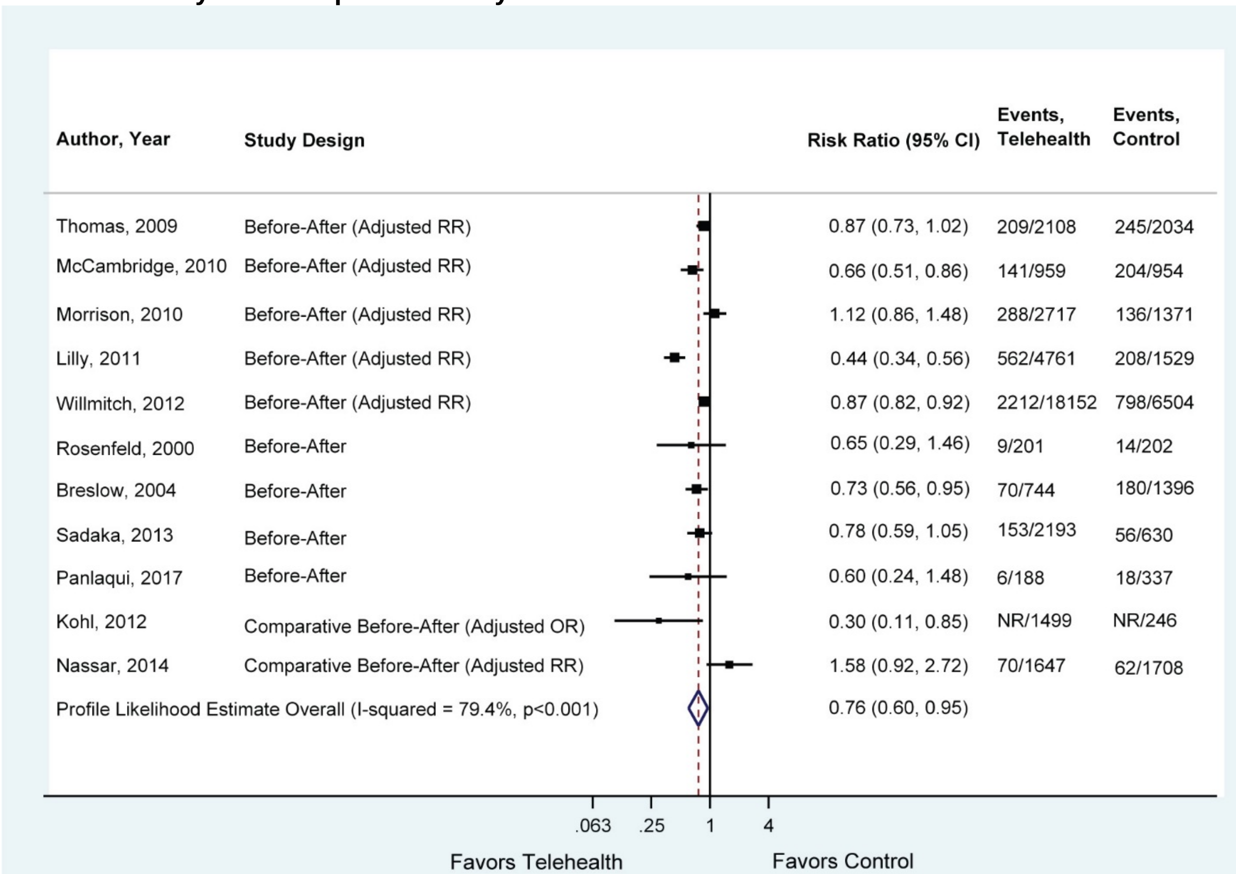
None of the studies expressly reported on harms or adverse events. One reported 90-day mortality increased by 6.1 percent in hospitals that adopted remote ICU, but the researchers did not provide comparable data for the control hospitals, making it difficult to assess if this was a harm.[71] Another study reported that the rate of complications experienced by ICU patients declined with remote ICU.[107]

Figure 5. Meta-analysis of intensive care unit mortality



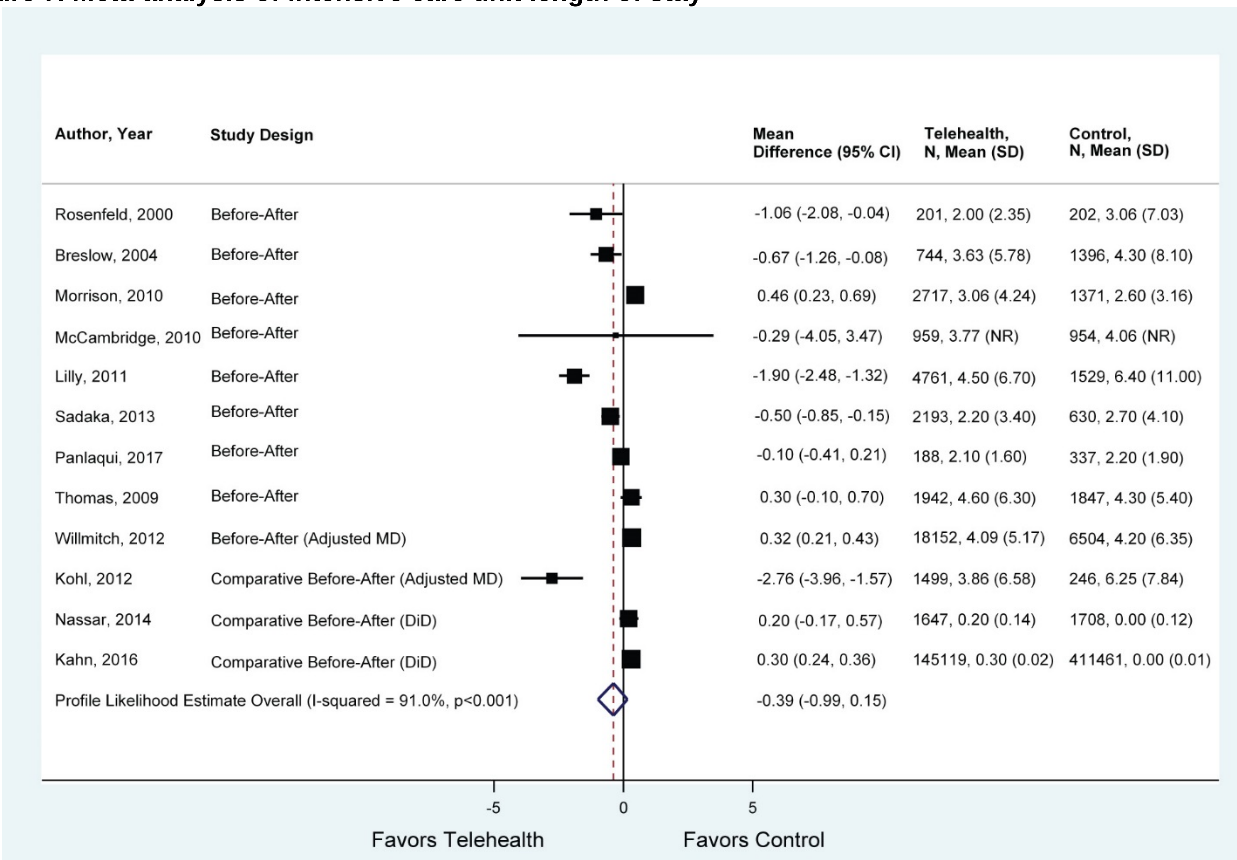
CI = confidence interval; NR = not reported; OR = odds ratio; RR = risk ratio

Figure 6. Meta-analysis of hospital mortality in intensive care unit studies



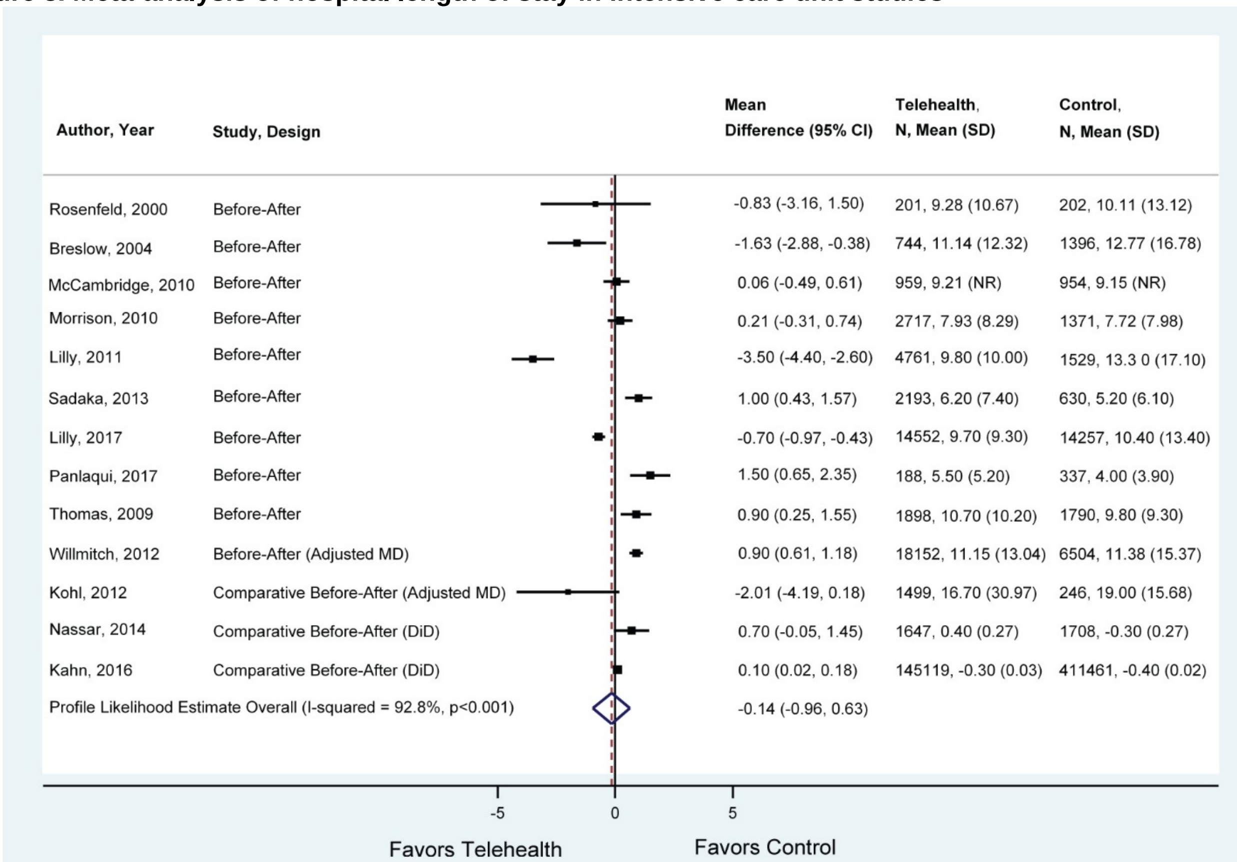
CI = confidence interval; NR = not reported; OR = odds ratio, RR = risk ratio

Figure 7. Meta-analysis of intensive care unit length of stay



CI = Confidence Interval; DiD = difference in difference; MD = mean difference; NR = not reported; SD = standard deviation

Figure 8. Meta-analysis of hospital length of stay in intensive care unit studies



CI = confidence interval; DiD = difference in difference; MD = mean difference; NR = not reported; SD = standard deviation

Table 3. Remote intensive care units: selected outcomes not included in meta-analysis

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Breslow, 2004[36] VA, United States 1 hospital	Before-after Moderate A: Before telehealth, n=1,396 B: After telehealth, n=744	Hospital and ICU mortality in meta-analysis	Hospital and ICU LOS in meta-analysis	Revenue, contribution per month in USD All patients: A: $795,245 B: $1,319,236 (no statistical test reported)
Chu-Weininger, 2010[43] TX, United States 2 community hospitals 1 teaching hospital	Pre-post High A: Pre-Telehealth, n=84 B: Post-Telehealth, n=71	NR	Mean Teamwork Climate score out of 100 ± SD **A: 69.7 ± 25.3** **B: 78.8 ± 17.2,p=0.009** Mean Safety Climate score **A: 66.4 ± 24.6** **B: 73.4 ± 18.5, p=0.045** Overall hospital Safety Climate score A: 69.0 B: 65.4	NR
Collins, 2017[44] PA, United States 1 surgical ICU 1 virtual ICU	Retrospective cohort High A: Surgical ICU, n=6,652 B: Virtual ICU, n=1,037	ICU mortality, n (%) A: 364 (5.5%) B: 3 (0.3%)	NR	NR
Fortis, 2014[55] MN, United States 5 ICUs, including 1 teaching hospital	Retrospective High A: No tele-ICU, n=6,063 B: Tele-ICU, n=6,097	ICU mortality in meta-analysis	Patients readmitted to ICU within 48 hours n (%) **A: 54 (0.89%)** **B: 29 (0.49%), p=0.0064**	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Franzini, 2011[62] Thomas, 2009[123] Gulf Coast, United States 5 hospitals	Economic evaluation, Before-after Moderate A: No telehealth, n=2,034 B: Telehealth, n=2,108	Hospital and ICU mortality in meta-analysis Overall: no difference SAPS II ≤ 50 (less serious): no difference SAPS II > 50 (17% of patients) ICU: 40% reduction Hospital: 37% reduction	Hospital and ICU LOS in meta-analysis ICU complication rate (95% CI) A: 17.9% (16.3% to 19.6%) B: 19.2% (17.5% to 20.9%)	Overall ICU cost per case, in USD A: $13,029 B: $19,324 (48% increase) SAPSII ≤50: ***significant increase in cost ($6415)*** with no significant change in mortality SAPS II >50: no significant increase in cost ($2985) with 11.4% significant decrease in mortality.
Gupta, 2014[240] Dehradun, India 1 ICU	Before-after Moderate A: Before telehealth, n=134 B: After telehealth, n=145	30-Day mortality **A:16.4%** **B: 4.8%** **70% reduction, p=0.001**	Mean door to needle time, in minutes **A: 178.63** **B: 26.23, p<0.001** Mean hospital stay ± SD, in days A: 4.96 ± 1.18 B: 4.69 ± 1.19, p=0.056 Cardiogenic shock, % A: 14.92 B: 10.35, p=0.248 Ventricular fibrillation/ventricular tachycardia, % A: 11.94 B: 8.28, p=0.309 Atrial fibrillation/supra ventricular tachycardia % A: 14.92 B: 15.17, p=0.954	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Kahn, 2016[71] United States 389 hospitals without tele-ICU 132 hospitals with tele-ICU hospitals	Retrospective cohort Low A: No telehealth Before-telehealth, n=419,466 After telehealth, n=411,461 B: Telehealth Before telehealth, n=147,517 After telehealth, n=145,119	90-Day mortality [ratio of odds ratios (95% CI), Group A=Reference] **All hospitals: 0.96 (0.94 to 0.98), p<0.01** Unadjusted Before vs. after telehealth A: 23.5% vs. 23.07%, p<0.01 B: 24.0% vs. 24.3%, p=0.07 Hospitals with telemedicine 12.2% significant decrease 81.1% no significant change 6.1% significant increase	Hospital and ICU LOS in meta-analysis	NR
Kalb, 2014[257] NR, authors US-based 11 hospitals	Before-after High A: Before Tele-ICU implementation, n=NR B_1: After Tele-ICU (2011, Quarter 3), n=NR B_2: After Tele-ICU (2012, Quarter 1), n=NR	ICU mortality ratio[a] **A: 0.34** **B_1: 0.67, p<0.04 vs. A** **B_2: 0.65, p<0.03 vs. A**	Mean % adherence to low tidal volume-based lung protective ventilation **A: 29.5%** **B_1: 44.9%, p<0.002 vs. A** **B_2: 51.8%, p<0.003 vs. A** Mean ventilator duration ratio[b], in days A: 1.08 B_1: 0.92, NS vs. A B_2: 0.96, NS vs. A	NR
Kohl, 2012[73] PA, United States 2 ICUs in the same hospital: one with telehealth, one without	Retrospective cohort Moderate A_1: No telehealth, prior to implementation, n=220 A_2: No telehealth, post telehealth implementation, n=285 B_1: Telehealth, prior to implementation, n=246 B_2: Telehealth, post telehealth implementation, n=1,499	ICU mortality[c] (SEM) **A_1: 0.54 (0.06)** **A_2: 0.42 (0.04)** **B_1: 0.09 (0.02)** **B_2: 0.01 (0.003), p=0.003** Mean hospital mortality[c] (SEM) **A_1: 0.74 (0.05)** **A_2: 0.56 (0.04)** **B_1: 0.13 (0.03)** **B_2: 0.04 (0.01), p=0.023**	Mean ICU LOS[c] (SEM), in days **A_1: 5.27 (0.52)** **A_2: 6.09 (0.43)** **B_1: 6.25 (0.50)** **B_2: 3.86 (0.17), p<0.001** Mean hospital LOS[c] (SEM), in days A_1: 19.0 (1.0) A_2: 12.5 (1.1) B_1: 10.9(0.8) B_2: 16.7 (0.8), NS	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Lilly, 2011[80] MA, United States 7 ICUs	Prospective cohort Low A: No telehealth, n=1,529 B: Telehealth, n=4,761	ICU mortality, n (%) **A: 164 (10.7%)** **B: 410 (8.6%), p=0.003** Hospital mortality **A: 208 (13.6)** **B: 562 (11.8), p=0.005**	Mean ± SD, median (IQR), ICU LOS, in days **A: 6.4 ± 11, 2.5 (0.2 to 6.5)** **B: 4.5 ± 6.7, 2.4 (0.1 to 4.6), p<0.001** Hospital LOS, in days **A: 13.3 ± 17.1, 7.9 (0.2 to 15.0)** **B: 9.8 ± 10, 6.8 (0.2 to 12.0), p<0.001**	NR
Lilly, 2017[81] MA, United States 1 academic medical center ICU	Economic evaluation Moderate A: Before telehealth, n=4,752 B_1: After Telehealth, n=5,735 B_2: After Telehealth with added logistics center, n=6,581	NR	Mean hospital LOS ± SD, in days A vs. B_1 included in Meta-Analysis A: 10.4 ± 13.4 B_1: 9.7 ± 9.3 B_2: 8.8 ± 8.3 **A vs. B_2 p<0.0001** **B_1 vs. B_2 p<0.001**	Total annual costs, in USD A: $142,766,712 B_1: $182,719,738 B_2: $200,934,975 Total annual direct contribution margin A: $7,921,584 B_1: $37,668,512 B_2: $60,586,397
McCambridge, 2010[87] PA, United States 1 hospital	Before-after Moderate A: Before telehealth, n=954 B: After telehealth, n=959	Hospital and ICU mortality in meta-analysis Overall **AOR[d]: 0.605, p=0.002**	Hospital and ICU LOS in meta-analysis Ventilator use **A: 36.1%** **B: 31.5%, p=0.04**	NR
Morrison, 2010[91] IL, United States 2 hospitals	Before-after Moderate A: Before telehealth, n=1371 B_1: After telehealth, 1 year after baseline, n=1287 B_2: After telehealth, 1 year after electronic ICU fully operational, n=1430	Hospital and ICU mortality in meta-analysis Total mortality A: 9.9% B^1: 11.1% B^2: 10.0% A vs. B: NS B vs. B^2: NS	Hospital and ICU LOS in meta-analysis	Mean Cost[e], in USD A: $22.43 B_1: $21.41 B_2: $23.21 A vs. B^1: NS **B^1 vs. B^2: p=0.03**

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Nassar, 2014[94] Midwest, United States 7 VA Hospitals	Before-after Low A_1: Usual care before telehealth period, n=1664 A_2: Usual care after telehealth period, n=1920 B_1: Telehealth, before telehealth period, n=1708 B_2: Telehealth, after telehealth period n=1647	Hospital and ICU mortality in meta-analysis	Hospital and ICU LOS in meta-analysis	NR
Panlaqui, 2017[227] Australia and New Zealand 1 rural facility 1 regional center	Before- after High A: Before telehealth, n=337 B: After telehealth, n=188	Hospital ICU Mortality: in meta-analysis Total mortality, relative risk (95% CI) A: 6.5% B: 4.3% RR 0.98 (0.94 to 1.02), p=0.28	Hospital and ICU LOS: in meta-analysis Hospital transfer relative risk (95% CI) **A: 31.8%.** **B: 22.9%** **RR 0.88 (0.80 to 0.98), p=0.03**	NR
Rincon, 2012[104] PA, United States 1 ICU	Before-after High A: Before telehealth, n=34 nurses B: After telehealth, n=40 nurses	NR	Nurse satisfaction ICU physicians available A: 38% B: 55% NS Adequate physician involvement **A: 44%** **B: 65%, p=0.007** Opportunity to ask questions A: 41% B: 53% NS	NR

Author, Year **Location** **Number of Sites**	**Study Design** **Risk of Bias** **Comparison, n**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Romig, 2012[106] MD, United States 2 ICU in 1 hospital	Prospective cohort and before-after High A: No telehealth, n=612 B: Telehealth, n=793; 403 received telehealth Nurse survey: Pre-telehealth, n=11 Post-telehealth, n= 27	ICU mortality before vs. after telehealth, % (n) A: 4.9% (15/305) vs. 4.6% (14/307) B: 1.5% (6/390) vs. 3.5% (14/403)	ICU LOS before vs. after telehealth, % (n), in days A: 3.9 vs. 3.8 B: 5.1 vs. 4.5 Nurse satisfaction and perceptions of quality after telehealth, mean ± SD survey score out of 5 Remote ICU unit Communications **Pre-telehealth: 2.99 ± 1.13** **Post-telehealth: 3.27 ± 1.27, p<0.01** Working conditions **Pre-telehealth: 3.10 ± 1.10** **Post-telehealth: 3.23 ± 1.11, p=0.02** Education **Pre-telehealth: 3.52 ± 0.84** **Post-telehealth: 3.76 ± 0.78, p<0.03** Control ICU Significant decline in 2 scales Patient care and perceived effectiveness and education	NR

Author, Year **Location** **Number of Sites**	**Study Design** **Risk of Bias** **Comparison, n**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Rosenfeld, 2000[107] MD, United States 1 hospital	Before-after Low A_1: Before telehealth, baseline 1, n=225 A_2: Before telehealth, baseline 2, n=202 B: After tele-ICU, n=201	Hospital and ICU mortality in meta-analysis Complications **A_1: 15.1%** **A_2: 18.8%** **B: 9.5% p<0.05**	Hospital and ICU LOS in meta-analysis	ICU total cost change, in USD **B vs A_1: 75% reduction, p=0.002** **B vs. A_2: 69% reduction, p=0.031** Hospital total cost change, in USD B vs A_1: 88% reduction, NS B vs. A_2: 81% reduction, NS 64% of difference in cost between baselines and intervention were associated with higher incidence of complications during baseline periods.
Ruesch, 2012[109] AK, United States 1 hospital	Before-after High A: Before telehealth, NR B: After telehealth, NR	ICU mortality[c] A: 17 B: 24 Hospital mortality[c] A: 22 B: 36	LOS[c], in days ICU **A: 4.1** **B: 3.66, p ≤0.05** Hospital A: 11.25 B: 9.48, NS	Actual costs not reported. Estimated cost saving based on changes in LOS were: > $2.5 million USD, comparing a calendar quarter before implementation with the last quarter of the evaluation.
Sadaka, 2013[110] MO, United States 1 hospital	Before-after High A: Before telehealth, n=630 B: After telehealth, n=2193	Hospital and ICU mortality: in meta-analysis	Hospital and ICU LOS in meta-analysis	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality	Intermediate Outcomes	Costs/Revenue or Other Resource Use
Willmitch, 2012[131] FL, United States 5 hospitals	Before-after Moderate Comparison: A: Before telehealth, n=6,504 B_1: After telehealth, 1 year, n=6,353 B_2: After telehealth, 2 years, n=6,018 B_3: After telehealth, 3 years, n=5,781	Hospital mortality in meta-analysis	Hospital and ICU LOS in meta-analysis	NR

AOR = adjusted odds ratio; APACHE IV = Acute Physiology and Chronic Health Evaluation IV; CI = confidence interval; ICU = intensive care unit; IQR = interquartile range; LOS = length of stay; NR = not reported; NS = not significant; SAPS II = Simplified Acute Physiology Score II; SD = standard deviation; SEM = standard error of the mean; USD = United States Dollars;VA = Veterans Affairs;

[a] Adjusted for APACHE IV status

[b] Number of days of mechanical ventilation/APACHE IV predicted days of mechanical ventilation

[c] Severity-adjusted

[d] Adjusted for APACHE IV status and DNR status

[e] Adjusted total hospital costs divided by 1000

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Key Characteristics of Remote ICU Studies and Association With Outcomes

In addition to pooling results, we reviewed selected key factors that could help explain differences in outcomes across studies. Table 4 summarizes information on the hospitals in the studies, the coverage and staffing of the remote ICU interventions, and the time periods when outcomes were measured. However, no studies report significant differences between remote ICUs and in-person critical care in terms of these characteristics.

The majority of studies were conducted in larger teaching hospitals or hospitals affiliated with an academic center. The goal of all studies was to provide critical care for 24 hours, but the amount of remote coverage needed to achieve this goal varied. All of the studies included a physician intensivist, though one added this after 9 months of nursing support alone.[109] All but one included nursing[107] and about half included administrative support. Most of the studies collected outcomes data after an implementation period or collected data for multiple periods. The study with the longest followup (3 years) and measurement at multiple periods reported stronger effects in each subsequent year.[131] One study reporting no overall benefit compared outcomes between sicker and less sick patients and found the remote ICU was associated with a decrease in mortality and a nonsignificant increase in costs for sicker patients and no improvement in mortality and higher costs for less sick patients.[62,123] This suggests that the benefit may not be uniform across all critical care patients. The largest study examined several characteristics of the subgroup of hospitals that experienced a reduction in 90-day mortality after implementing remote ICUs and found these were more likely to be high volume and located in urban areas.[71]

Table 4. Remote intensive care units: selected characteristics

Study	Hospital Number Characteristics	Remote ICU Coverage Staffing	"After" Period for Outcomes Measurement	Impact of Remote ICU *Subgroup Assessments*
Breslow, 2004[36]	1 large (650 bed) tertiary teaching	• 19 hours (noon -7AM) • Intensivist, nurse, administrative assistant • Attending controlled level of involvement	Months 4-10 (6 months after a 3-month run in)	Benefit *No subgroups*
Fortis, 2014[55]	5 hospitals in one health system	• 24 hours but different staff and duties day vs. night • Intensivist; nurse • Full authority	1 year immediately following implementation	Benefit *No subgroups*
Franzini, 2011[62] Thomas, 2009[123]	5; 1 large teaching hospital; 2 large urban hospitals; 2 small community hospitals	• 19 hours (noon -7AM) weekdays; 24 hours weekends • 2 Teams of intensivists, 2 nurses, 1 administrative technician • Physicians determined level	60 to 120 days (95 average) post implementation until estimated sample size recruited	No benefit (Overall) *Sicker patients: decrease in mortality; increase in costs*

Study	Hospital Number Characteristics	Remote ICU Coverage Staffing	"After" Period for Outcomes Measurement	Impact of Remote ICU *Subgroup Assessments*
Kalb, 2014[257]	11 moderate-size community hospitals, wide geographic distribution (details not reported); all established teleICU, phase-in for ventilator rounds	• Daily rounds • Intensivist and critical care nurse	1.5 years for first group; 3 months for last (staggered start)	Benefit *No subgroup comparisons*
Kahn, 2016[71]	521 hospitals 132 hospitals adopted telehealth 389 matched hospitals that did not	• Varied, not reported	2 years	Some benefit for 90-day mortality[a] (overall) *Large volume and urban hospitals more likely to have significant reduction in mortality*
Kohl, 2012[73]	2,250 1 hospital 2 ICUs one with and one without telehealth	• 24 hours/days all days • Day time: 2 critical care nurses. Evening 1 intensivist and 1 nurse • Rounds every 1 to 4 hours as needed	8 to 20 months post implementation	Benefit No subgroups, used Apache score to adjust
Lilly, 2011[80]	6,290 2 campuses of an academic medical center 7 ICUs	• 24 hours/day all days • Intensivist • Monitoring alarms, adherence to guidelines, rounds	2 months after first site implementation to 1 year 4 months later (staggered start for sites)	Benefit *Compared day and night admissions, with more impact on night admissions*
Lilly, 2017[81]	1 academic medical center on two campus with 7 adult ICUs	• Off-hours care plan reviews by intensivist • Electronic early detection system; audio-visual link to patients and nurses	8 years of followup data post implementation	Benefit *Also compared telehealth with telehealth augmented by a logistic center*
McCambridge, 2010[87]	1 large (727 bed) academic community hospital	• 12 hours (7 PM -7 AM) • Intensivist and critical care nurse • Did admissions and monitored all patients	10 months after 9-month implementation completed	Benefit *No subgroups*
Morrison, 2010[91]	2 suburban community hospitals; 650 bed teaching 185 bed not teaching	• Not specified • Determined by hospital • Primary provider controlled level of involvement	2 4-month periods: 1 year after baseline and 1 year after implementation	No benefit *Longer followup and level of primary provider involvement did not change results*

Study	Hospital Number Characteristics	Remote ICU Coverage Staffing	"After" Period for Outcomes Measurement	Impact of Remote ICU *Subgroup Assessments*
Nassar, 2014[94]	6,654 7 VA hospitals 8 ICUs 3 academic medical centers 1 small urban 3 rural hospitals	• 21 hours a day, all days • Intensivist and 2 critical care nurses • Alerts, audio and video monitoring and communication	6 months after implementation	Some benefit Small differences, not significant in adjusted analyses *Stratified by risk and ICU size; no difference in results*
Panlaqui, 2017[227]	525 1 regional center 1 rural facility	• Remote facility initiates link daily • Intensivist	1 year after implementation	No benefit *Adjusted for risk and age*
Rosenfeld, 2000[107]	1 community hospital; academic affiliated	• 24 hours • Intensivists only (monitoring from home) • All monitored	16 weeks during the study intervention	Benefit *Benefit attributable to reduction in complications.*
Ruesch, 2012[109]	1 hospital (Anchorage AK)	• 24 hour critical care nurse • 10 hours (9 pm to 7am) intensivist added after 9 months • All monitored	Quarterly for 1.5 years (6 quarters) after implementation	Some benefit *No patient subgroups*
Sadaka, 2013[110]	1 community hospital	• 24/7 • Intensivists, critical care nurses, unit secretaries • Local MD determined level of involvement	15 months starting immediately with implementation	Some benefit *AM admission compared with PM admission (remote only): Same as overall results*
Willmitch, 2012[131]	5 community hospitals, mostly suburban, in one system	• 24/7 • Intensivist, critical care nurses, unit secretary • Local provider determined level of involvement	1, 2, and 3, years after implementation	Benefit *More benefit seen in years 2 and 3. Excluding patients with long stays did not change conclusions.*

ICU = Intensive Care Unit; VA = Veterans Affairs
[a]Other studies studied in-hospital and in-ICU mortality rather than 90-day mortality

Inpatient Specialist Consultations

We identified 32 articles reporting on 31 studies using telehealth to provide specialty consultations for inpatients. Specialty consultations are provided when the input of a specialist is needed for diagnosis, care planning, or treatment and a physician with the specialized knowledge is not available when or where the consultation is needed. Technology for these consultations varies, with some focusing on video interactions that may or may not include the patient, and others consisting of store and forward images, or technology that allows real time collaboration on diagnostic tests or surgery. Generally, specialist consultations are needed to inform decisions, which can be about additional services, such as whether to transfer a patient to a different hospital or whether an in-person followup visit is needed. Consultations may also serve to make or confirm a diagnosis, advise on treatment, or actually provide treatment.

Inpatient Specialist Consultations: Key Points

- Clinical outcomes: Mortality or serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability) improve with telehealth consultations across specialties, but differences are not statistically significant in most studies (low strength of evidence).
- Economic outcomes: Cost savings were realized due to avoided transfers or travel, but telehealth did not save money in all studies (low strength of evidence).
- Intermediate outcomes: The impact of telehealth consultations on intermediate outcomes such as hospital LOS, transfer rate or satisfaction of patients, relatives, or health care providers is also positive, but not convincing with differences that are close to significant and estimates that are less precise (low strength of evidence).
- Adverse effects: Only studies of surgery explicitly examined harms, but study limitations were high based on small sample sizes and high risk of bias (insufficient evidence).

The studies of inpatient specialist consultations cover a wide variety of clinical indications ranging from neonate to geriatric care and from care planning to remote proctoring of surgery. Our ability to draw conclusions is limited to the specialties that have been studied and may or may not be generalizable to other specialties. Table 5 summarizes results across the included studies by clinical specialty and provides an overview of the results. Table 6 provides selected outcomes from each study, and Appendix H includes the strength of evidence assessment by outcome across these specialties.

Table 5. Inpatient specialty consultations: summary of evidence

Clinical Topics	Number of Studies	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
Neonates Cardiology	5	~ Death or cardiac arrest * Fewer very low birthweight deliveries	* LOS, transfers and time to diagnosis	* Net savings	66,102, 103,125, 242
Pediatric Inpatient	4 (5 articles)	~ Hospital mortality	? Mixed LOS and satisfaction * Decrease in transfers/transport	* Cost saving and increased revenue	51,76, 84-86
Pediatric Sexual Abuse Assessment	1	No evidence	* Improved quality of assessment	No evidence	88
Geriatrics	4	* Fewer falls	* Decrease time to consult; increased capacity * High patient satisfaction ~ Hospitalizations	* Cost saving due to avoided travel	63,221, 224,249
Neurology	3	? Mortality	? Health service utilization and transfers	No evidence	165,196, 243
Post stroke care	1	* Lower odds of poor outcome	No evidence	No evidence	138
Psychiatry	2	No evidence	* Fewer transfers * Positive rating and willing to use for next visit	* Lower cost if ≥30 cases per year	164,214

Clinical Topics	Number of Studies	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
Image/Test Review	5	~ Success rate for free flap surgery	* More patients sent to day surgery * Shorter time to assessment or response ~ Transfers, in--person visits and admissions	? Savings	26,115, 209,237, 244
Mentored Surgery	3	* No complications or harms	? Surgery time * Hospital LOS	No evidence	39,116, 149
Critical Care	2	* Mortality	* PCU LOS shorter < Hospital LOS longer * Response time	< Higher cost	29,105
Multiple Specialties	1	~ No difference in mortality	No evidence	No evidence	252

LOS = length of stay; PCU = progressive care unit
Key: ***** superior (telehealth benefit), ~ no difference (no significant difference), < inferior (comparison better than telehealth), **?** inconclusive (inconsistent results or insufficient)

Inpatient Specialist Consultations: Detailed Results

Table 6 includes key results for clinical outcomes (including harms), intermediate outcomes, and costs from the 31 studies about inpatient specialty consultations. Seventeen were conducted in the United States, and the others were conducted in 12 different countries (2 in Australia, 2 in the United Kingdom, and 1 each in Brazil, Finland, Germany, Hong Kong, Israel, Italy, Northern Ireland, Taiwan, Japan, and Spain). Studies of inpatient consultations were predominately cohort studies, including 10 retrospective and 15 prospective cohort designs. There were also three before-after studies and three randomized trials that studied inpatient consultations. Most of the cohort studies included multiple sites with the largest prospective study including 3,060 patients in five intervention and five matched comparison hospitals.[138] The largest study, a retrospective analysis using data from a large healthcare system included over 16,000 patients.[29]

Inpatient Specialist Consultations: Effectiveness in Improving Clinical and Economic Outcomes

Mortality

Twelve studies reported in 13 articles[29,76,84-86,102,125,138,165,196,242,243,252] about inpatient consultations evaluated mortality outcomes.

Ten studies reported mortality to be the same or not statistically significantly lower. For example, declines in mortality were not significant in one study of telehealth cardiology for neonates implemented in nine hospitals,[125] in studies of pediatric inpatient consults,[76,84-86] or in a study of a hospital wide multispecialty consult program.[252] In one pilot study mortality did not differ in a group managed with telehealth compared with a group in which all patients with suspected intracranial bleeds were transferred to a neuro trauma center for in-person neurological care.[243] Two studies about neurology inpatient teleconsultations reported lower mortality with telehealth and one study of specialized post stroke care reported some benefit from telehealth when the outcome was a composite including death, institutional care or disability:

- In a comparison of two hospitals, one that used real-time video to secure early tele-neurological consults and one that did not, the decline in inpatient mortality was statistically significant (from 10.2% to 4.9%, p=0.013), but the 3-month mortality rate was not significantly different (11.7% to 8.6%, p=0.558)[196]
- In a study of over 2,000 patients hospitalized with minor head injuries in hospitals without neurosurgery, the adjusted odds of mortality for patients treated in the centers without telehealth compared with those where telehealth was available was not significant (adjusted odds ratio [AOR] 1.25; 95% CI 0.83 to 1.91), but the odds of death were greater without telehealth when the analysis was limited to patients over 70 years old (AOR 1.14; 95% CI 1.04 to 1.82)[165]
- The odds of death or institutional care were not significantly different when comparing five hospitals participating in the Telemedical Project for Integrative Stroke Care with five matched control hospitals. When the outcome was redefined as death, institutional care or severe disability, the odds of poor outcome at both 12 months and 3 months were significantly lower in hospitals with telestroke.[138]

Inpatient Specialist Consultations: Other Clinical and Economic Outcomes

Six studies[39,116,149,237,242,249] analyzed clinical outcomes other than mortality and reported a significant decline in the rate of very low birthweight deliveries in hospitals without neonatal ICUs after the establishment of telehealth consultations and rounds,[242] no significant difference in the average number of falls per month in one study of geriatric teleconsultations,[249] no difference in surgical flap success rates when comparing telehealth and in-person post-operative monitoring,[237] and no difference in complications in three studies of telehealth mentored surgeries.[39,116,149]

Seven studies reported some assessment of economic outcomes. Studies that found or estimated an economic benefit included an evaluation of remote cardiology assessments for neonates that calculated a net savings of $13,900 per infant;[103] a study of a referral network to a children's hospital that estimated telehealth almost doubled hospital revenue and billing;[50] and a study of pediatric intensive care consultations provided to a rural hospital that estimated annual savings of $300,000 per year for patients and $279,000 in additional revenue for the rural hospital for patients who were treated with telehealth consultations and not transferred to another location.[85] An evaluation of a telegeriatrics program calculated lower annual costs with telehealth consultations (73,078 vs. 98,909 Australian dollars), but that savings were only realized when roundtrip travel for an in-person consultation would have exceeded 125 kilometers.[221] Similarly costs for telehealth consults for inpatient psychiatric care were lower than in-person consultations if a certain number of cases (30 in this study) could be addressed with telehealth per year.[164] Two studies reported no benefit from telehealth, including one that found no evidence of cost saving for the hospital to offset the capital investment required for a teleconsult service for plastic surgery and burns,[209] and a study that reported higher mean direct costs ($12,301without telehealth vs. $13, 180 with telehealth).[29]

Inpatient Specialist Consultations: Effectiveness in Improving Intermediate Outcomes

Most of the outcomes reported in the evaluation of inpatient specialty consultations were intermediate outcomes. Twenty-seven studies reported intermediate outcomes such as LOS, rates of transfers to other hospitals, satisfaction, receipt of specific tests or services, and quality/process indicators.

- Two of the four studies analyzing cardiology consultations and echocardiogram via telehealth reported reductions in LOS,[102,125] while one study was not large enough to determine if the difference was statistically significant.[103] One study reported lower, but not significantly different inappropriate transfer rates[66] while in another study transfers to tertiary care were significantly lower.[125]
- The studies of pediatric inpatient consultations reported no significant difference in LOS, although one study of a single hospital reduced its transfers from 100 to 86 percent ($p=0.04$) after establishing a pediatric telehealth consult system with a tertiary children's hospital.[76] Satisfaction with pediatric telehealth consults was generally good, though the mean rating by parents were lower than those of staff.[84-86] A study evaluating a program designed to increase use of a regional children's hospital increased transfers and LOS.[51] A study comparing five hospitals with remote access to experts for pediatric sexual abuse evaluations with three hospitals that did not have telehealth found the quality of the assessments was higher with telehealth.[88]
- Geriatric telehealth consultation improved patient performance of self-management, reduced wait time, and increased patient satisfaction.[249] A video geriatric rounds program provided consultations that were similar in length to in-person visits[221] while another geriatrics telehealth program decreased the initial consultation time but made no different in overall time spent on the case and did not significantly change triage decisions.[224]
- A hospital with inpatient telehealth neurology consultations had shorter LOS than a comparison hospital but no difference in the number of readmissions or primary care followup visits.[196] A telehealth consult service allowed some patients with suspected intracranial bleeds to be treated at hospitals without neurosurgical services, reducing the number of transfers but LOS was not different.[243]
- When telehealth was used for consultations, transfers to other hospitals were lower[214] and the majority of patients, families, and providers who used video telehealth for psychiatric inpatient care planning preferred to have their next conference via video.[164]
- Consults involving image or test data transmission resulted in faster assessment[26] and response,[237] though one study reported faster handling by the consultant but no difference in the time it took for the requesting physician to receive a response.[115]
- One randomized trial reported remotely mentored surgeries were shorter than unmentored surgeries (mean of 139 minutes compared to 200 minutes) and that patients had shorter LOS.[149] Another study that randomized endoscopic surgery to be proctored in-person or remotely found teleproctored surgeries took approximately 4 minutes longer on average; though statistically significant, this difference is unlikely to be clinically meaningful.[39] A third nonrandomized, prospective study reported no difference in the duration of procedures.[116]

Inpatient Specialist Consultations: Harms, Adverse Events, or Negative Unintended Consequences

The only studies that reported harms were the three of remoted monitored surgery. These studies reported low or no complications, which were not greater when telehealth was compared with in-person supervision. In the study of teleproctored endoscopic sinus surgery, researchers looked for postoperative negative outcomes including cerebral spinal fluid leaks, orbital hematoma, visual disturbance, and need for blood transfusion. These did not occur in any cases in either the teleproctored group or the control group. They also compared the blood loss per case and found no significant difference between the groups.[39] Similarly a study of telementoring for laparoscopic bariatric surgery reported no complications in the telementored group,[149] and a study of telementoring for robotic surgery reported no intraoperative complications in the telementoring group and one case with complications in the in-person group.[116]

Key Characteristics of Inpatient Specialist Consultation Studies and Correlation With Outcomes

The studies of inpatient consultations included several specialties; however, the function of the telehealth consultation is essentially the same – to expand access to needed expertise. This expertise is used to assist in the diagnosis, treatment and management of patients. The details of the diagnosis and management decision ranged from deciding whether to transfer a critically ill child to another hospital to treatment plans for stroke patients, homecare clients, or hospitalized psychiatric patients to remote proctored surgery. While some studies mention whether the patient is involved or present in the consultation, others do not. Studies also do not report details of the consulting interaction well. The roles and qualifications of the providers involved are often mentioned, but none of the studies provided extensive details. For example, they do not describe how many different specialists are involved, the nature of the relationships among the different organizations, or the payment model for the specialist consultations.

Overall, inpatient telehealth consultations are not well described, making it problematic to determine how characteristics of the intervention or environment relate to effectiveness. The evidence does not provide insight into how clinical and financial relationships among the organizations and/or the providers should be organized or what may or may not make these not just effective, but also sustainable and replicable.

Table 6. Inpatient specialty consultations: selected outcomes

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Neonate Cardiology	Huang, 2008[66] CA, United States 1 community hospital, 1 university children's hospital	Before-after Moderate A: Before telehealth, n=280 B: After telehealth, n=385	NR	Echocardiogram upon admission: **A: 27%** **B: 40%, p<0.001** Inappropriate transfers A: 7 B: 2, p=0.06	NR
Neonate Cardiology	Kim, 2013[242] AR, United States 6 hospitals 3 with, 3 without telehealth	Prospective cohort High A: No telehealth, site without NICU, n=77 B: Telehealth, site without NICU, n=181	Very low birthweight **A: 13%** **B: 7%, p<0.001** Mortality A: 13% B: 7% Comparison hospitals: no change; Statewide mortality decreased during study period	NR	NR
Neonate Cardiology	Rendina, 1998[102] NC, United States 2 hospitals	Retrospective cohort Low A: Site without telehealth, n=137 B: Site with telehealth, n=177	NR	Mean LOS in NICU, in days (%) **A vs. B: -12.5 (-17%), p<0.05**	NR
Neonate Cardiology	Rendina, 1997[103] NC, United States 1 university hospital 1 regional medical center	Economic evaluation High A: Usual care, n= 38 B: Telehealth, n=48	Mortality A: 1 B: 1	Hospital LOS, in days A: 41.2 B: 35.2, pooled variance t-test p=0.23 Electrocardiographic interpretation reporting time A: 24 hours B: 20 minutes	Net savings, in USD $13,900 per infant

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Neonate Cardiology	Webb, 2013[125] Multiple locations, United States 9 sites	Prospective cohort Moderate A: Site without telehealth, n=337 B: Site with telehealth, n=337	Mortality AOR: 0.922, NS Cardiac arrest AOR: 0.527, NS	Mean LOS, in days Total **A: 1.6** **B: 0.72, p=0.027** ICU **A: 1.6** **B: 0.65, p=0.027** Mean time to diagnosis, in minutes **A: 147** **B: 100, p<0.001** Transport to tertiary care **A: 10%** **B: 4%, p<0.01**	NR
Pediatric Inpatient	Dharmar, 2013[50] CA, USA 1 tertiary children's hospital 16 remote hospitals	Retrospective cohort High A: No telehealth, n=515 B: Telehealth, n=1514	NR	Mean number of patients transferred per year A: 143 B: 285 Mean LOS of transferred children ± SD, in days **A: 7.7 ± 14.2** **B: 9.2 ± 15.4, p<0.05**	Mean yearly hospital revenue, in USD A: $2.4 million B: $4.0 million Mean yearly professional billing revenue, in USD A: $313,977 B: $688,443

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Pediatric Inpatient	Labarbera, 2013[76] OR, United States 1 community hospital; consult from tertiary children's hospital	Before-after Moderate A: Before telehealth, n=41 B_1: After telehealth, n=56 B_2: After telehealth and hospitalist program at community hospital, n=56	Mortality A: 3% B_1: 1.8% B_2: 3.6%, NS	Mean LOS, in days A: 9.8 B_1: 7.6 B_2: 8.5, NS Transport rate **A: 100%** **B_1: 85.7%** **B_2: 87.5% p=0.04** Transfers to tertiary care **A:19.5%** **B_1: 14.5%** **B_2: 6.1% p=0.0003**	NR
Pediatric Inpatient	Marcin, 2004a;[84] Marcin, 2004b[85] CA, United States 1 hospital	Retrospective cohort, economic evaluation Moderate A_1: No telehealth, n=116 A_2: Patients transferred from other hospitals, no telehealth, n=86 B_1: Patients receiving telehealth, n=47 B_2: All ICU patients during telehealth period, n=180	Mortality A_1: 2.6% A_2: 3.5% B_1: 2.1% B_2: 1.6%	Mean satisfaction with telehealth (5-point scale) Referring nurse: 4.53 Referring MD: 4.56 Parent or guardian: 4.05	Estimated savings, in USD Annual cost: $172,000 Transport: $300,000 For rural hospital Estimated revenue available: $186,000 Estimated revenue available due to no transport: $279,000
Pediatric Inpatient	Marcin, 2004c[86] CA, United States[a] 1 hospital 224	Retrospective cohort Moderate A_1: No telehealth, historical control n=127 A_2: No telehealth, n=80 B: Telehealth, n=17 C: Combination of A_2 and B, n=97	Observed/expected mortality, OR (95% CI) A_1: 0.95 (0.26 to 3.48) A_2: 0.44 (0.07 to 1.96) B: Reference C: 0.73 (0.06 to 1.44), NS	ICU LOS, in days A_1: 3.5 A_2: 3.4 B: 5.9 C: 3.8, NS Mean parent satisfaction with telehealth: 3.8 of 5	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Pediatric Sexual Assault Assessment	Miyamoto, 2014[88] CA, United States 5 rural telemedicine hospitals 3 comparison hospitals	Retrospective cohort Moderate A: Site without telemedicine, n=82 B: Site with telemedicine, n=101	NR	Office of emergency services child abuse examination quality (score range: 0 to 5; 5=good) Overall assessment A: 3.24 B: 3.88, NS Total quality score (sum of 7 domains) **A: 29.21** **B: 31.20, p<0.05**	NR
Geriatrics	Chan, et al., 2001[249] Hong Kong 1 Nursing home	Before-after High A: Before telehealth, n=NR B: After telehealth, n=NR Total n=198	Mean monthly falls: A: 9.8 B: 6.8	Failed inhaler technique A: 93% B: 50% Waiting time for consult, in weeks A: 4 to 13 B: within 2 Patient satisfaction: 96% favorable	11% of patients needed onsite visit at a cost to nursing home
Geriatrics	Grabowski, 2014[63] MA, United States 11 nursing homes	RCT High Nontelehealth nursing homes, n=5 A_1: Pre-intervention A_2: Post-intervention Telehealth nursing homes, n=6 B_1: Pre-intervention B_2: Post-intervention, n=6	NR	Hospitalization per 1,000 nursing home resident days A_1 vs. A_2: 3.8 vs 3.6, 5.3% reduction B_1 vs. B_2: 3.5 vs. 3.2, 9.7% reduction More engaged telehealth facilities: 11.3% reduction Less engaged telehealth facilities: 5.2% reduction	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Geriatrics	Gray, 2009[221] Australia 1 hospital NR	Economic evaluation Moderate A: Without telehealth, n=NR B: With telehealth, n=12	NR	Mean consultation time, in minutes (95% CI) A: 13.7 (11.5 to 15.9) B: 15.3 (13.6 to 16.09) Mean consultation time for new patients (95% CI), in minutes A: 19.0 (15.2 to 22.8) B: 19.7 (17.0 to 22.4)	Costs per year, in AUD A: $90,909 B: $73,078 In the base-case, cost savings became effective when roundtrip travel is ≥125 km between locations.
Geriatrics	Martin-Khan, 2016[224] Australia 3 hospitals Geriatrician location NR	RCT Moderate A: Usual care, n=81 B: Telehealth, n=85	NR	Mean consultation time (range) ± SD, in minutes **A: 25.91 (4 to 77) ±9.38** **B: 9.89 (4 to 35) ± 5.83, p<0.005** Overall time: no difference Triage decisions not significantly different.	NR
Neurology	Craig, 2004[196] North Ireland, UK 2 hospitals	Prospective cohort Moderate A: Without telehealth, n=128 B: With telehealth, n=164 (not used for all patients)	Inpatient mortality **A: 10.2%** **B: 4.9% p=0.013** 3-month mortality A: 11.7% B: 8.6%, NS	Mean LOS, in days **A: 11.6** **B: 8.1, p=0.016** **HR: 1.13, p=0.045** Hospital readmissions A: 16.8% B: 15.0%, NS Mean number of primary care visits at 3-months A: 2.49 B: 2.14, NS	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Neurology	Klein, 2010[243] Israel 3 hospitals	Retrospective cohort Moderate A_1: No telehealth, mandatory transfer, n=152 A_2: No telehealth, algorithm-based guideline, n=73 B: Telehealth consult, n=98	Mortality, n (%) A_1: 0 (0.0%) A_2: 1 (1.4%) B: 1 (1.0%), NS Need neurosurgery, n (%) A_1: 17 (11.2%) A_2: 9 (12.3%) B: 9 (9.2%), NS	Transferred, n (%) A_1: 152 (100.0%) A_2: 54 (74.0%) B: 40 (40.9%) Delayed transfer, n (%) A_1: NA A_2: 1 (1.3%) B: 2 (2.0%), NS Length of stay A_1: 4.19 A_2: 3.92 B: 4.48, NS Need neurological rehabilitation, n (%) **A_1: 4 (2.6%)** **A_2: 15 (20.8%)** **B: 8 (8.2%), p<0.001**	NR
Neurology	Migliaretti, 2013[165] Italy Number of hospitals NR	Prospective cohort High A: No telehealth, n=1895 B: Telehealth, n=462	Mortality risk without telehealth, AOR[b] (95% CI) All patients: 1.25 (0.83 to 1.91) People over 70: **1.14 (1.04 to 1.82)**	NR	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Post Stroke Care	Audebert, 2009[138] Germany 5 intervention hospitals 5 matched comparison hospitals	Prospective cohort Low A: Without telehealth, n=1938 B: With telehealth, n=1122	Death or institutional care 12 months AOR: 0.89, NS 30 months AOR: 0.93, NS Poor outcome (death, institutional care, or severe disability) **12 months** **OR: 0.65, p<0.001** **30 months** **OR: 0.82, p=0.031**	NR	NR
Psychiatry	Buckley, 2012[214] New South Wales, Australia 19 district hospitals 1 regional hospital	Before-after Moderate A: Before telehealth, n=1153 B: After telehealth, n=790	NR	Patients transferred, % (95% CI) **A: 67% (64.0 to 69.5)** **B: 60% (56.1 to 63.1), p=0.001** **AOR[c]: 0.69 (0.49 to 0.97)**	NR
Psychiatry	Mielonen, 2000[164] Finland 2 remote centers 34 patients	Prospective cohort High A: Without telehealth, n=20 B: With telehealth, n=14; Satisfaction survey, n=124	NR	Staff satisfaction Video as good (almost as good) as conventional meeting: 47% (48%) Prefer video for next meeting Healthcare staff: 86% Patients: 84% Patient relatives: 92%	Cost per patient Videoconference: FIM 2510 Conventional conference: FIM 4750 Video is cheaper if ≥30 cases per year. With 50 cases the savings would be FIM 117,000
Test/Image Based Assessment	Alemi, 2017[26] CA, United States 2 hospitals	Prospective cohort High A. No telehealth, n=31 B. Telehealth, n=29	NR	Mean time for assessment (range) ± SD, in minutes **A: 34 (10 to 60) ± 16** **B: 13 (5 to 35), ± 8, p<0.001**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Test/Image Based Assessment	Engel, 2011[237] Taoyuan, Taiwan 1 hospital	Prospective cohort High A: No telehealth, n=57 B: Telehealth, n=46	Surgery success rate A: 95.1% B: 97.8%, p=0.4	Return to operating room, n (%) A: 5 (8.8%) B: 4 (8.7%) **Mean response time ± SD, in minutes** **A: 180 ± 104** **B: 8 ± 3, p=0.01**	NR
Test/Image Based Assessment	Nagayoshi, 2016[244] Kumamoto, Japan 12 rural hospitals 2 centers	Before-after High A: Before telehealth, n=18 B: After telehealth, n=48	NR	Transfers, n (%) **A: 10 (55%)** **B: 10 (21%), p<0.05** Waiting period A: 17.2 days B: 9.2 days, p=0.23	NR
Test/Image Based Assessment	Sharma, 2016[115] PA, United States 2 academic hospitals	Before-after High A: Before telehealth, n=38 B: After telehealth, n=25	NR	Mean handling time, in minutes (95% CI) **A: 43.5 (37.9 to 49.0)** **B: 26.9 (15.4 to 38.4), p=0.004** Mean time to response, in minutes (95% CI) A: 405.7 (301.0 to 510.3) B: 344.7 (291.3 to 398.0), p=0.602 Teledermatology alone sufficient: 10 of 25 consultations	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Test/Image Based Assessment	Wallace, 2008[209] United Kingdom 1 hospital providing consults to >60 sites	Prospective cohort High A: No telehealth, n=607 B: Telehealth, n=389; telehealth used in 243 referrals	NR	Difference in overall management of patients: **p=0.004** Admission (95% CI) A: 28.3% (24.9 to 32) B: 29.6% (25.2 to 34.3) In-person review A: 22.1% (19.0 to 25.5) B: 15.4% (12.2 to 19.3) Day surgery **A: 17% (14.2 to 20.2)** **B: 27.5% (23.3 to 32.1)**	No evidence of cost saving for hospital (details not reported) Substantial investment: £70,000
Mentored Surgery	Burgess, 2002[39] HI, United States 1 hospital	Prospective cohort High A: No telehealth, n=42 B: Telehealth, n=45	No complications or harms	Mean surgery time, in minutes: ***A: 24.67*** ***B: 28.54, p<0.027*** ***16% increase***	NR
Mentored Surgery	Fuertes-Guiró, 2016[149] Barcelona, Spain 2 community hospitals 1 university hospital	RCT High A: No telehealth, n=16 B: Telementoring, n=20	A: 3 (13%) experienced minor complications (n=2 bleeding of surgical wounds; n=1 urological infection)	Mean surgery time ± SD, in minutes **A: 200 ± 46** **B: 139 ± 33, p<0.01** Mean hospital stay ± SD, in days[d] A**: Mean 6.7 ± 0.5** **B: Mean 4.6 ± 0.5, p<0.01**	NR
Mentor Surgery	Shin, 2015[116] CA, United States 1 academic hospital	Prospective cohort High A: No telehealth, n=29 B: Telementoring, n=26	A: 1 intraoperative complication reported resulting in no postoperative sequelae B: 0 intraoperative complications Estimated blood loss m/L, median (range) A: 2.5 (0 to 7) B: 2.5 (0 to 7)	Median estimated duration (range), in minutes A: 15 (5 to 25) B: 15 (5 to 35) Robotic skills assessment p>0.05 **Mentors preferred remote to in-room p=0.05**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Critical Care	Armaignac, 2018[29] FL, United States Large healthcare system Number of sites NR	Retrospective cohort Clinical outcomes: low Cost outcomes: high A: Usual care, n=8,000 B: Telehealth, n=8,091	PCU mortality **A: 83 (1.0%)** **B: 60 (0.7%), p=0.048** Hospital mortality **A: 410 (5.2%)** **B: 342 (4.4%), p=0.013** Unadjusted HR: **0.79 (0.68 to 0.91)** Adjusted HR[e]: **0.56 (0.41 to 0.76)**	Mean LOS (95% CI), in days PCU **A: 3.2 (3.1 to 3.3)** **B: 2.6 (2.5 to 2.7)** **p <0.0001** Hospital ***A: 6.8 (6.6 to 6.9)*** ***B: 7.3 (7.2 to 7.5)*** ***p <0.0001***	Overall mean direct cost, in USD ***A: $12,301*** ***B:$13,180 p<0.0001***
Critical Care	Robison, 2016[105] DE, United States 1 children's hospital 3 units with telehealth; 3 without telehealth	Prospective cohort High A: Usual care, n=43 B: Telehealth, n=48	NR	Time to establish contact, in minutes **A: 3.7** **B: 2.6** **p=0.012** Admitted to PICU A: 73% B: 58%, p=0.13 Mean number of Interventions A: 1.9 B: 1.4 NS	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Multiple Specialists	Steinman, 2015[252] Sao Paulo, Brazil 1 spoke hospital 1 hospital providing teleconsultations	Before-after and prospective cohort High A: 1 year before telehealth B: 1 year after telehealth n=unclear Once telehealth established C: Nontelehealth consultations D: Telehealth consultations n=unclear	AMI mortality A vs. B: 17% vs. 14% C vs. D: 14% vs. 8% Septic shock mortality A vs. B: 66% vs. 68% C vs. D: 71% vs 40% Ischemic stroke mortality A vs. B: 50% vs. 44% C vs. D: 76% vs. 32% Hemorrhagic stroke mortality A vs. B: 23% vs. 28% C vs. D: 37% vs. 16% A vs. B comparisons: all NS C vs. D comparisons: p=NR, trending significant	NR	NR

AMI = acute myocardial infarction; AOR = adjusted odds ratio; AUD= Australian Dollars; CI = confidence interval; FIM = Finnish markka; HR = hazard ratio; ICU = intensive care unit; LOS = length of stay; MD = medical doctor; NA = not applicable; NICU = neonatal intensive care unit; NR = not reported; NS = not significant; OR = odds ratio; PCU = progressive care unit; PICU = pediatric intensive care unit; RCT = randomized control trial; SD = standard deviation; UK = United Kingdom; USD = United States Dollars

[a] Time periods overlap with other Marcin articles

[b] Adjusted for sex, age, seriousness of the patient's injury at diagnosis, referral center

[c] Adjusted for age, sex, clustering in hospitals and repeat visits

[d] Different values reported in the abstract and text of article

[e] Scores matched on age, sex, and race, severity of illness, and risk of mortality

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant

Emergency Care Results

We identified 73 articles reporting results from 70 studies on the use of telehealth for consultations in emergency care. These are divided below into three functional categories, and are presented and cited in three subsections. The first section summarizes the literature on the use of telehealth for urgent stroke diagnosis and treatment decision. Referred to as *telestroke*, this has been the most frequently studied application of telehealth for provider-to-provider consultation in emergency care. The second section reports on consultations by various specialists provided as part of care in an emergency room or department. The third section reviews studies of telehealth consultations used by EMS providing out of hospital care or by clinicians providing urgent care for all other topics except stroke.

Table 7 includes the number of articles that addressed each of these subtopics, a summary assessment of key outcomes across the studies, and the citations. Figure 9 and Tables 8, 9, and 10 each provide more detail, focusing on the key results for each study, and the accompanying text discusses selected characteristics of the subset of studies, highlighting any trends or anomalies. Detailed information abstracted from each article is provided in Appendix F. The criteria and overall rating for risk of bias assessment of each study are in Appendix G. The strength of evidence assessment is in Appendix H and summarizes the evidence by outcome in each of the three categories.

Emergency Care Key Points

Telestroke:

- Clinical outcomes: The evidence suggests that telestroke does not result in differences in either in-hospital or 3-month mortality (moderate strength of evidence)
- Intermediate outcomes: Changes in thrombolytic therapy (tissue plasminogen activator [tPA]) use and time to treatment with telestroke were not significantly different (low strength of evidence).

Adverse events: No increased harms, specifically hemorrhage (moderate strength of evidence).

Specialty consultations in emergency departments:

- Clinical outcomes: The impact on clinical outcomes including mortality and functional status is generally positive, though the results are not always statistically significant (low strength of evidence).
- Economic outcomes: Analyses of costs were available only in a few studies, and the results favored savings (low strength of evidence).
- Intermediate outcomes: Teleconsultations have a positive effect on intermediate outcomes such as appropriate triage and transfers and shorter time in the emergency department (moderate strength of evidence).
- Adverse events: No information was available about harms (insufficient evidence).

EMS and urgent care:

- Clinical outcomes: Telehealth reduces morality for heart attack patients (moderate strength of evidence).
- Economic outcomes: Reductions in air transfers and referrals contributed to estimates of lower costs (low strength of evidence).

- Intermediate outcomes: Telehealth led to more timely provision of care and a reduction in air transfers and referrals to higher-level care following urgent care (moderate strength of evidence), and these
- Adverse effects: Information on harms was very limited (insufficient evidence).

Table 7 provides an overview of the evidence available about the use of telehealth consultations in emergency care.

Table 7. Emergency care: summary of evidence

Topic	Number of Studies	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
Telestroke	29	~ Mortality ~ Harms ~ Function	* Increase in tPA use ? No clear effect on time to treatment	No information	27,41,48,64,67,68,96,101,120,121, 135,137,139,150,155,156,159,161, 163,174,176,178,183,193,216,226, 236,238,255
EMS and Urgent Care	22 (reported in 23 articles)	* Reduced mortality Harms: Insufficient evidence	* Timeliness of care and appropriateness of transfers	* Lower costs related to fewer transfers and lower staff costs	34,35,77,78,100,113,124,141-143, 162,171-173,179,189,197,204, 218,225,242,246,254
ED Specialty Consultations	19 (reported in 21 articles)	* Lower mortality, better outcomes Harms: insufficient information	* Better transport triage, shorter ED time, better quality of care	~ 4 studies report savings, but not always significant; 1 increased costs	47,49,51,53,83,89,90,93,95,97,111, 117,133,136,191,235,239,241,245, 247,253

ED = emergency department; EMS = emergency medical services; ICU = intensive care unit; LOS = length of stay; tPA = tissue plasminogen activator
Key: * superior (telehealth benefit), ~ no difference, < inferior (comparison better than telehealth), ? inconclusive (inconsistent results)

Detailed Results

Acute Stroke or Telestroke

Twenty-nine of the included studies investigated telestroke programs or initiatives. These involve the use of telemedicine to convey information about a patient to a vascular neurologist/stroke specialist for assessment and diagnosis with a focus on determining whether tPA is appropriate. tPA is an effective treatment that can reduce death and disability from acute ischemic stroke when administered within 4.5 hours of the patient developing symptoms. Appropriate use of tPA requires confirming the diagnosis and beginning treatment as soon as possible. Although tPA has been approved for almost two decades and is the standard for initial care, some patients who may benefit from this treatment are not receiving it due to limited access to stroke expertise. Telestroke attempts to solve this access issue by using technology to provide timely consultations for patients at remote locations or at times when vascular neurologists are not physically available. Telestroke programs may involve video and/or audio communications, and the transfer of data from an ambulance or ED to the specialist who can then advise on transport or treatment. Usual care is to provide tPA after the in-person assessment if appropriate.

Table 8 and Figure 9 provide selected information and the results from the identified studies of telestroke. Given that there were numerous studies with a similar intervention reporting mortality as the outcome for similar populations, we pooled these results in a meta-analysis represented in Figure 9. Other outcomes from these studies and from studies not providing data on mortality that could be combined in the meta-analysis are provided in Table 8.

Telestroke Effectiveness in Improving Clinical and Economic Outcomes

Mortality was the most frequently reported clinical outcome in telestroke studies. Given that several studies had small samples sizes and most found no significant difference in mortality, pooled estimates were generated and included 16 studies (Figure 9) to assess whether combining samples would change the overall conclusion. The resulting pooled risk ratios also found no statistically significant benefit and produced the following risk ratios and 95% confidence intervals: 0.92 (0.62 to 1.34) for in-hospital mortality based on nine studies; 0.94 (0.82 to 1.08) for 3-month mortality based on seven studies; and 0.64 (0.35 to 1.16) for the two studies that reported overall mortality.

In Figure 9 the pooled estimates are grouped by in-hospital, 3-month and overall (not defined) mortality to make comparisons across equivalent outcomes. The figure contains the study design, specifies whether the population was all evaluated patients or only those who received tPA, the number of deaths in each arm (with and without telestroke), and the risk ratio for mortality for each study. Two studies calculated adjusted risk ratios and provided raw data.[64,67] We repeated the meta-analysis with the adjusted values for these studies and confirmed that it would not change the overall conclusion. Another consideration is that within this analysis there are two pairs of studies that may have overlapping populations. Two studies analyzed data from the Telemedical Pilot Project for Integrative Stroke Care (TEMPiS) and report 3-month mortality from different but overlapping timeperiods.[137,178] Two other studies were both conducted at the University of Pittsburgh Medical Center during overlapping periods and reported inpatient mortality, but they had different authors, funding, and comparisons.[27,64] Again, we examined the impact of including both or excluding one study in each pair and found that it did not change the conclusion.

Fifteen studies included discharge disposition or a functional measure as a clinical outcome. As several different measures were used, these could not be pooled. Of the 15, only two reported statistically significantly better outcomes with telestroke.[137,216] The majority (13 studies) reported small differences that did not rise to the level of statistical significance.[27,67,101,135,150,159,161,176,178,193,238,255]

The identified studies of telestroke did not evaluate the costs of telestroke consultations.

Telestroke Effectiveness in Improving Intermediate Outcomes

The primary intermediate outcomes in these studies are indicators or improved access (rate of providing tPA) and quality of care (timeliness of treatment). These are process measures, not patient results, but increasing both the number of people treated and the timely delivery of treatment is one of the primary goals of most telestroke programs

Thirteen studies reported rates of tPA use with and without telestroke. Of these, four studies reported statistically significant increases. In three studies, the initial rate of tPA use ranged from 0 to 2.8 percent; all three studies increased tPA use with telestroke with rates ranging from 4.3 to 6.8 percent.[27,41,137] The fourth study reported an initial mean of 34.4 monthly tPA administrations across 21 hospitals and increased to a mean of 61.8 administrations with telestroke.[96] In the rest of the studies the differences were either not significant or statistical tests were not reported.

Timeliness of treatment was included in 23 of 29 studies. Measures included time to treatment (referred to as time to "needle") from either symptom onset or arrival at the hospital (sometimes referred to as "door time"). The results in terms of this outcome are inconsistent. Six studies found telehealth improved timeliness of care by at least one measure,[68,96,121,156,161,174] three studies found time to treatment was significantly longer with telehealth,[135,193,238] and the majority of studies reported there was not a statistically significant difference in time to treatment with and without telehealth.

Harms, Adverse Events, or Negative Unintended Consequences

The primary concern related to harms of telehealth for stroke is that a patient will receive a contraindicated treatment that will lead to negative outcomes or complications. Specifically, tPA given incorrectly can result in intracranial hemorrhage. Eleven studies reported on hemorrhage and all reported either no events or no statistically significant difference in rates comparing telestroke to usual care.[27,41,48,67,96,135,159,161,176,193,226]

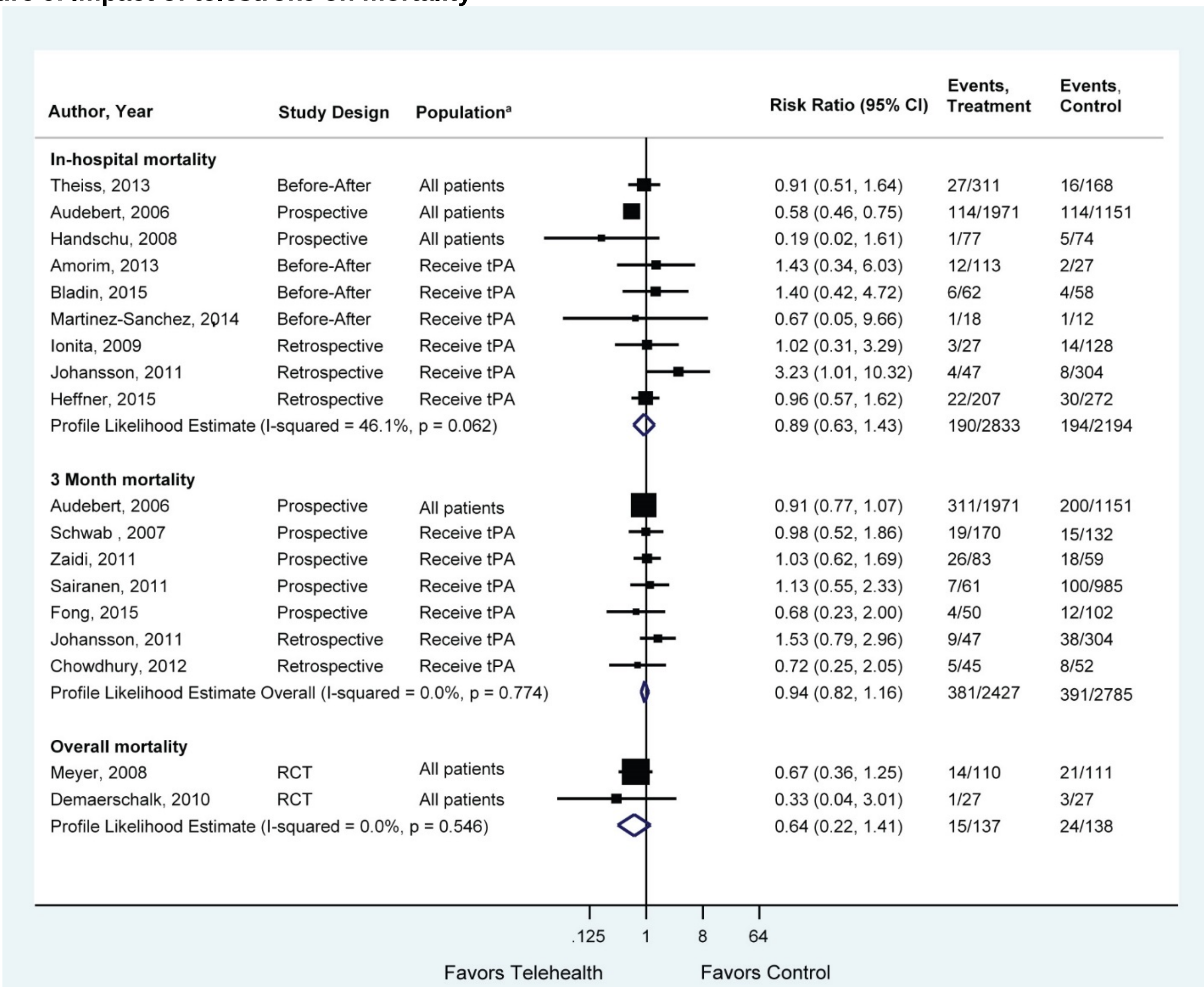
Key Characteristics of Telestroke and Association With Outcomes

The number of sites/hospitals included in each study is listed in Table 8. In all but one study the services are provided by one organization to another; that is, one or two hospitals with stroke expertise (often, referred to as the hub) provide consultations to hospitals that do not have that expertise (the spokes). The one study not following this model[238] established a telehealth system to allow off site neurologists to provide after-hours coverage within a single organization.

The number of hospitals in these arrangements varies, with some involving only two hospitals (1 hub and 1 spoke) and others involving one or two consulting or hub hospitals and 2 to 25 spoke hospitals. It is possible that in addition to the number of participating hospitals, other aspects of the structure of these relationships, such as how services are paid for or if there are incentives to treat patients in particular locations, could impact the effectiveness of telestroke programs. Unfortunately, there is not enough information available in the published studies to evaluate this.

Information on the number of hospitals involved is one of the only characteristics of the programs other than basic descriptions of the technology (e.g., whether video was one or two way, what test results or images could be transmitted) provided in some but not all of these articles. The studies do not report characteristics of the providers or the environments and information that would allow assessment of whether the patients changed before and after telehealth or were different at the intervention and comparison hospital was not provided. Given that research on emergency care often faces time constraints and challenging environments, less data may be collected, producing less information about the context, and restricting synthesis to the major outcomes and limiting subgroup analysis.

Figure 9. Impact of telestroke on mortality



CI = confidence interval; RCT = randomized controlled trial; tPA = tissue plasminogen activator

[a] Indicates whether original study analyzed all patients or only those who received tPA.

Table 8. Telestroke: outcomes in addition to mortality

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Amorim, 2013[27] PA, United States 12 community hospitals 1 academic hospital	Before-after Moderate A: Before telestroke, n=919 B: After telestroke, n=1669	Mortality: in meta-analysis Discharge outcomes Home: A: 33.3% B: 26.5%, NS Rehabilitation: A: 33.3% B: 32%, NS Symptomatic Intracerebral hemorrhage A: 3.7% B: 0.9%, NS	Overall IV tPA use **A: 2.8%** **B: 6.8%, p<0.001** Protocol violations A: 0.2% B: 0.3%, NS Onset-to-treatment, in minutes A: 129.8 B: 124.4, NS Door-to-treatment, in minutes A: 74.2 B: 74.0, NS
Audebert, 2006[137] Germany Bavaria 2 academic hospitals 5 community intervention hospitals 5 comparison hospitals	Prospective cohort Low A: Not telestroke, n=1151 B: Telestroke, n=1971	Mortality: in meta-analysis Hospital discharge destination: **Home:** **A: 38%** **B: 39%** **Dead:** **A:10%** **B: 8%** **Rehab unit:** **A: 34%** **B: 38%** **Nursing home:** **A: 5%** **B: 3%** **Other hospital:** **A:13%** **B: 13%** **p=0.001** Total % poor outcomes at 3 months: **A: 54** **B: 44, p<0.001**	Thrombolytic treatment **A: 0%** **B: 5%, p<0.0001** Mean LOS, in days **A: 11.9** **B: 10.7, p<0.0001**
Bergrath, 2012[139] Germany, Aachen 4 ambulances- one with telehealth Hospital numbers NR	Prospective cohort Moderate A: Usual care, n=46 B: Telehealth, n=18	NR	Median EMS alarm to physician arrival time (IQR), in minutes **A: 7 (4)** **B: 5 (2), p=0.0182** Median door to brain imaging time (IQR), in minutes A: n=42; 57.5 (80) B: n=16; 59.5 (67.5), p=0.6447

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Bladin, 2015[216] Australia 1 regional hospital,1 metropolitan hospital	Before-after Low A: Before telestroke, n=144 B: After telestroke, n=138	Mortality: in meta-analysis Discharged home or to rehabilitation **A: 33%** **B: 80%, p=0.02**	tPA use, n (%) All strokes <4.5 hours A: 10 (17%) B: 16 (26%), NS Ischemic stroke <4.5 hours A: 10 (19%) B: 16 (28%), NS Median minutes (IQR) Door to needle time A: 101 (75 to 153) B: 85 (72 to 117), NS Stroke onset to needle time A: 218 (180 to 258) B: 173: (148 to 234), NS Median LOS, in days (IQR) A: 3 (1 to 6) B: 4 (2 to 6), NS
Choi, 2006[41] TX, United States 2 community hospitals one university hospital	Before-after High A: Before telestroke, n=327 B: After telestroke, n=328	Median pretreatment NIHSS score[a] A: NR B: 10 Improved by 4 points on NIHSS scale A: NR B: 7 Worsened on NIHSS scale A: NR B: 3 Intracerebral hemorrhages A: NR B: 0	tPA use, n (%) **A: 2 (0.8%)** **B: 14 (4.3%), p<0.001** Median door to needle time (range), in minutes A: NR B: 85 (27 to 165)
Chowdhury, 2012[193] London, United Kingdom 1 hospital	Retrospective cohort High A: Usual care, n=52 B: Telehealth, n=45	Mortality: in meta-analysis Favorable outcome A: 36.5% B: 42%, p=0.9 Symptomatic intracranial hemorrhage A: 7.7% B:4.4%, p=0.7	Onset to treatment, median minutes (IQR) ***A: 100 (78 to 120)*** ***B: 125 (55 to 105) p=0.001*** Admission to treatment, median minutes (IQR) ***A: 33 (23 to 47)*** ***B: 61 (43 to 106), p<0.001***
Demaerschalk, 2010[48] United States 2 spoke hospitals 1 central hub hospital	RCT Moderate A: Telephone only, n=27 B: Telehealth, n=27	Mortality: in meta-analysis Intracerebral hemorrhage A: 0% B: 4%, p>0.99	Onset to decision time ± SD, mean minutes A: 164 ± 28.6 B: 188.2 ± 138.2, p=0.07

Author, Year **Location** **Number of Sites**	**Study Design** **Risk of Bias** **Comparison, n**	**Mortality** **Short-Term Outcomes** **Long-Term Outcomes**	**tPA Administration** **Time to Treatment** **Other Intermediate Outcomes**
Dharmasaroja, 2010[236] Thailand, Thammasat 1 hub hospital 25 spoke hospitals	Before-after High A: Before telehealth, n=170 B: After telehealth, n=406	NR	tPA use A: 8% B: 27%
Fong, et al., 2015[238] Hong Kong 1 hospital with offsite neurologists	Prospective cohort Moderate A: No telestroke, n=102 B: Telestroke, n=50	Mortality: in meta-analysis Excellent outcome[b] at 3 months A: 43% B: 52%, NS In multivariate analyses, the absence of onsite neurologists was not associated with negative outcomes.	All received tPA Median minutes (IQR) Door to needle time ***A: 71 (60 to 89)*** ***B: 97 (85 to 119), p<0.001*** Onset to needle time ***A: 133 (109 to 154)*** ***B: 148 (134 to 170), p=0.012***
Handschu, 2008[150] Bavaria, Germany 2 stroke centers 2 local hospitals	Prospective cohort Moderate A: Telephone consultation, n=74 B: Telestroke with video, n=77	Mortality: in meta-analysis Institutional care 10 days post-stroke A: 5.4% B: 2.6%, NS Admission to stroke ward A: 45.9% B: 59.7%, NS Transfer to stroke center **A: 14.9%** **B: 9.1%, p<0.05** Diagnosis corrected at discharge **A: 17.6%** **B: 7.1%, p<0.05**	Total time for consultation, in minutes ***A: 27.1*** ***B: 49.8, p<0.01*** LOS, in days A: 12.3 B: 11.4, NS
Heffner, 2015[64] PA, United States 1 hub hospital 5 spoke hospitals	Retrospective cohort Moderate Comparison A_1: Not telestroke, treated at hub hospital, n=272 A_2: Not telestroke, treated at spoke then transferred to hub hospital, n=73 B: Telestroke, treated at spoke hospital, n=134	Mortality: in meta-analysis	All received tPA Door to needle time, in minutes A_1: 71.98 A_2: 74.89 B: 76.57 A_1 vs. B, NS; B vs. A_2, NS Onset to needle time, in minutes A_1: 155.6 A_2: 133.8 B: 147.57 A_1 vs. B, NS; B vs. A_2, NS LOS, in days >6 days, OR (95% CI) **B vs. A_1: 4.696 (2.428 to 9.083)** **B vs. $A_1 + A_2$: 4.280 (2.356 to 7.774)** Longer stay in telehealth group

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Hubert, 2016[155] Helsinki, Finland 1 central hospital with telehealth 15 spoke hospitals 2 hub hospitals with telehealth	Retrospective cohort Moderate A: Usual care, n=912 B: Telehealth, n=1779	NR	Median (IQR); mean ± SD, in minutes Onset-to-door time **A: 88 (60 to 135); 105.3 ± 55.9** **B: 65 (48 to 101); 80.1 ± 45.3, p<0.001** Door-to-needle time *A: 18 (13 to 30); 25.1 ± 20.0* *B: 39 (26 to 56); 44.7 ± 26.7, p<0.001* Onset-to-treatment time A: 117 (81 to 168); 130.4 ± 59.1 B: 115 (87 to 155); 124.8 ± 49.4 p=0.452
Ickenstein, 2005[156] Germany 12 community hospitals 2 specialized stroke centers	Before-after High A: Before telehealth, n=155 B: After telehealth, n=164	NR	Patients presenting with 3 hours and receiving tPA A: 10 (6%) B: 45 (27%)
Ionita, 2009[67] NY, United States 1 hub hospital 10 community hospitals	Retrospective cohort Moderate A: Not telestroke, n=128 B: Telestroke, n=27	Mortality: in meta-analysis Poor mRS score[c] at discharge A: 61 (48%) B: 13 (48%), NS Post thrombolytic intracranial hemorrhage A: 26 (20%) B: 9 (33%), NS	Mean time from onset to needle in minutes A: 143.9 B: 130.7, NS
Itrat, 2016[68] United States 1 Mobile stroke units w/ telehealth 9 hospitals with telehealth	Prospective cohort Moderate A: Usual care, n=56 B:Telehealth, n=100	NR	Median minutes (IQR) Door to computed tomography read A: 25 (19 to 35) B: 25 (20 to 29), p=0.59 Door to IV-tPA **A: 58 (53 to 68)** **B: 32 (24 to 47), p<0.001**
Johansson, 2011[159] Austria, Salzburg 5 regional hospitals 1 specialized stroke center	Retrospective cohort Moderate A: Usual care, n=304 B: Telehealth, n=47	Mortality: in meta-analysis Good functional outcome[d] at 3 months A: 43% B: 47%, p=0.694 In-hospital complications A: 22% B: 23%, p=0.85 Hemorrhagic bleeding A: 7.6% B: 6.4%	Onset to needle time, mean minutes A: 122 (n=277) B: 113 (n=42), p=0.263

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Martinez-Sanchez, 2014[161] Madrid, Spain 1 community hospital 1 stroke center	Before-after Moderate A: Before telestroke, n=259 B: After telestroke, n=225	Mortality: in meta-analysis Patients treated with tPA, Favorable outcome, n (%) A: 4 (33.3%) B: 10 (55.6%), p=0.145 Stroke recurrence, n (%) A: 0 B: 1 (5.6%) Intracranial hemorrhage, n (%) A: 2 (16.7) B: 0, p=0.152	Received IV rt-PA A: 4.7% B: 8%, p=0.125 Door to needle time, median minutes (IQR) A: 143.5 (48) B: 66 (54), p<0.0001
Mazighi, 2017[163] Paris, France 10 community hospital EDs 1 stroke center	RCT High A: Usual care, n=22 B: Telethrombolysis, n=25	NR	Received IV rt-PA A: 4 B: 21 Delay time from symptom onset to administration of IV rt-PA, median minutes (range) A: 184 (178 to 258) B: 145 (110 to 200)
Meyer, 2008[255] CA, United States 1 hub hospital 4 spoke hospitals 222 (Included in Demaershalk, 2012)	RCT Low A: Telephone only, n=111 B: Telestroke, n=111	Mortality: in meta-analysis Barthel Index score of 95 to 100 at 90 days, n (%) A: 56 (54) B: 45 (43) OR: 0.6, NS mRS score of 0-1 at 90 days, n (%) A: 48 (47) B: 36 (34) OR: 0.6, NS	tPA use A: 23% B: 28%, NS Correct decision **A: 82%** **B: 98%** **OR 10.9, p=0.0009** Onset to needle time, in minutes A:143 B:157.2, NS
Nagao, 2012[226] Melbourne, Victoria, Australia 1 spoke hospital 1 hub hospital	Before-after High A: Before telestroke, n=30 B: After telestroke, n=24 (for treatment in place)	Discharge n (%) Dead: A: 3 (13) B: 3 (10) Home: A: 14 (47) B: 12 (50) Other Hospital: A: 13 (43) B: 8 (33) p=0.6 Complications, n (%) Further stroke: A: 0 B: 2 (8.3) Intracerebral hemorrhage: A: 0 B: 0	Received thrombolysis, n (%) A: 0 B: 8 (33%)

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Nguyen-Huynh, 2018[96] Northern California, United States 21 hospitals 1 stroke center	Before-after Moderate A: Before telehealth, n=310 B: After telehealth, n=557	Symptomatic intracranial hemorrhage rates A: 2.2% B: 3.8%, p=0.29	Alteplase administration per month, mean ± SD **A: 34.4 ± 12.4** **B: 61.8 ± 12.4, p<0.001** Door to needle time, mean minutes ± SD **A: 63.2 ± 31.2** **B: 41.8 ± 30.6, p<0.001**
Pedragosa, 2009[174] Spain 1 hub hospital 1 community hospital	Before-after High A: Before telestroke, n=201 B: After telestroke, n=198	Urgent ambulance transfer: **A: 17%** **B: 10%, p=0.04** Unnecessary transfers to the stroke center: **A: 51%** **B: 20%, p=0.02** Stroke unit admissions: A: 11% B: 8%, NS	tPA use A: 4.5% B: 9.6%, NS Onset to needle time, in minutes **A: 210** **B: 162, p=0.05** tPA in 0 to 3 hour window **A: 30%** **B: 68%, p=0.04** Specialized neurologist evaluation **A: 17%** **B: 38%, p<0.001**
Pervez, 2010[101] Boston, MA, United States 33 hospitals 12 with telehealth 21 without 1 regional stroke center	Retrospective cohort High A: Telephone, n=181 B: Telehealth (for treatment in place), n=115	In-hospital mortality A: 17.4% B: 14.9%, p=0.57 Discharge outcomes Home: A: 30.5% B: 28.6%, p=0.74 Inpatient rehabilitation A: 55.3% B: 53.3%, p=0.67 Ambulatory at discharge A: 77.7% B: 73.8%, p=0.5	Median onset to tPA time (IQR), in minutes A: 130 (102.5 to162.8) B: 140 (117.3 to165.3), p=0.06 Mean LOS ± SD, in days **A: 7.6 ± 6.5** **B: 5.9 ± 3.7, p<0.001**
Sairanen, 2011[176] Helsinki, Finland 5 community hospitals 1 university hospital	Prospective cohort Moderate A: Usual care, n=985 B: Telehealth, n=106 61 received thrombolysis	Mortality: in Meta-analysis Intracerebral bleeding A: 9.4% B: 6.7%, p=0.427 3 month mRS 0-2 A: 58.1% B: 49.1%, p=0.214 3 month mRS 0-1 A: 36.8% B: 29.4%, p=0.289	NR
Schwab, 2007[178] Germany, Regensburg and Munich 12 community hospitals 2 specialized stroke	Prospective cohort Low A: Usual care, n=132 B: Telehealth, n=170	Mortality: in meta-analysis Good functional outcome at 6 months A: 30.9% B: 39.5%, p=0.10	Onset to treatment time, mean minutes A: 143.6 B: 140.6, p=0.45

Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Mortality Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Switzer, 2009[120] GA, United States, 6 rural hospitals 1 hub	Prospective cohort Moderate A: ED, n=26 B: Telehealth, n=49	NR	Onset to treatment time, mean minutes ± SD (95% CI) A: 145.88 ± 46.99 (126.9 to 164.87) B: 127.57 ± 36.33 (117.14 to 138.01), NS
Taqui, 2017[121] Cleveland, OH, United States 1 mobile stroke unit 3 comprehensive stroke centers 11 primary stroke centers	Prospective cohort High A: Traditional ambulance, n=53 B: Mobile stroke unit, n=100	NR	Median minutes (IQR) Alarm-to-thrombolysis time **A: 94 (78 to 105)** **B: 55.5 (46 to 65), p<0.0001** Door-to-thrombolysis time **A: 58 (52 to 66)** **B: 31.5 (24 to 47), p=0.0012** Symptom-onset-to-thrombolysis time **A: 122.5 (110 to 176)** **B: 97 (61 to 144), p=0.0485**
Theiss, 2013[183] Erfurt, Germany 5 comprehensive stroke centers 5 Neuro Net hospitals 5 matched control hospitals	Before-after Moderate A: Control hospitals without telehealth, n=168 B: Comprehensive stroke centers, n=845 C: Neuro Net hospitals with stroke telemedicine, n=311	Mortality: in meta-analysis	Likelihood of receiving tPA C vs. A, before: OR 5.7, p=0.07 **C vs. A, after: OR 4.5, p<0 .0001** **B vs C, before: OR 3.7, p<0.0001** B vs. C, after: OR 1.3, p=0.06
Zaidi, 2011[135] Pittsburgh, PA, United States, 12 spoke hospitals 1 stroke center	Prospective cohort Moderate A: Stroke center, n=59 B: Telestroke (for treatment in place), n=83	90-day mortality A: 30.4% B: 31.6%, p=0.6 Favorable outcome A: 37.5% B: 42.1%, p=0.7 Asymptomatic intracranial hemorrhage A: 18.6% B: 16.2%, p=0.7 Symptomatic intracranial hemorrhage A: 5.1% B: 1.2%, p=0.1 mRS ≤ 1 at 90 days A: 22.0% B: 34.9% mRS ≤ 2 at 90 days A: 37.5% B: 42.1%, p=0.7	Mean minutes (SD) Onset-to-treatment time A:156.7 (31.6) B: 145.5 (42.8), p=0.09 Arrival-to-treatment time ***A: 67.8 (26.1)*** ***B: 89.9 (36.3), p=0.01***

CI = confidence interval; ED = emergency department; EMS = emergency medical services; IQR = interquartile range; IV tPA = intravenous tissue plasminogen activator; IV rtPA =intravenous recombinant tissue plasminogen activator; LOS = length of stay; mRS = modified Rankin Sale; NIHSS = National Institutes of Health Stroke Scale; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized controlled trial; SD = standard deviation; tPA = tissue plasminogen activator

[a] A moderate or severe ischemic stroke; range 5-23

[b] An excellent mRS outcome is 0-1

[c] A poor mRS score is 4-6

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant

Emergency Care Telehealth Specialist Consultations

Twenty-one articles reported on 19 studies of specialist consultations with ED providers. Given the variety of injuries, illnesses and conditions treated in EDs, it is not practical for many EDs to have all potential specialty needs addressed in person, creating the opportunity for telehealth consultants to increase access overall and timeliness. The studies we identified reflected this and included a range of specialties such as trauma, pediatrics, neurology, psychiatry, cardiology, burns, orthopedics and plastic surgery. In ED consultations, like specialty consultations for inpatient care, interactions between providers about specific patients are limited to a single consultation in a short time period. In the case of emergency care, consultations are often executed under time pressure or chaotic conditions.

Table 9 provides general information and the results from these studies. The majority of these studies (13) were conducted in the United States[47,49,51,53,83,89,90,93,95,97,111,117,133] while two (in three articles) were conducted in Hong Kong[239,245,247] and one each in Japan,[241] Italy,[191] South Korea,[235] Brazil,[253] and Turkey.[136] Several of the studies are small, including less than 100 patients[97,111,117,191,235,239,241] while at the other extreme, two studies evaluated several thousand patients from multistate[95] and single state[93] hospital networks. All of the studies used either video so the specialist could see the patients or transmitted images such as scans or x-rays.

Emergency Care Telehealth Specialist Consultations: Effectiveness in Improving Clinical and Economic Outcomes

The 13 studies reporting clinical outcomes all reported improvements. Most of these reported lower mortality that was not statistically significantly different. For example, the mortality rate for trauma patients at seven rural EDs declined from 7.8 to 4.8 percent when telehealth consultations provided via video were available but this was not statistically significant.[53] The exception is a study comparing telephone, teleradiology and video consults for head injuries, which reported that mortality was significantly lower for video consults compared with telephone-only consultations.[247] While four studies included other clinical outcomes, including function,[239,247] complications,[41,239] or diagnosis,[136] the only significant finding was a lower rate of adverse events during transfer in a small (n=63) study of consultations for brain injury.[239]

Five studies evaluated economic outcomes. Four reported some savings with telehealth, though not always significantly different, while one study reported higher costs. One studies reported a dollar estimate for potential savings per case when transfers were avoided, but did not test this difference.[95] An evaluation of a statewide network providing psychiatric consultations reported savings in both inpatient charges (significant) and total healthcare charges (not significant) in the 30 days after the ED visit. Having both inpatient and total charges suggests that costs are not just being shifted from one site of care to another, though details about what specific costs were included was not provided.[93] One study of trauma consultations for seven rural EDs reported a large reduction in hospital costs (from $7.6 million to $1.1 million) but did not provide information or details that explain these savings.[53] A study of consultations for sepsis in an ED reported that total hospital costs were lower, but the difference was not significant.[83] The study reporting higher costs evaluated neurological consults in Hong Kong and found the average cost per patient increased with video consults by approximately 2000 Hong Kong dollars; researchers attributed this to the increased time before a decision was made and the 30 percent failure rate of the video technology used.[247]

Emergency Care Telehealth Specialist Consultations: Effectiveness in Improving Intermediate Outcomes

All of the studies reported at least one intermediate outcome. The most frequently included were rate of transfer and time to treatment or decision. The impact of telehealth consultations appears greater on these intermediate outcomes, and the effect is generally positive. For example, pediatric video consultations compared with phone only or no consultation increased quality of care in one study[49] and reduced medication error in pediatric emergency care in another;[51] burn consultations reduced emergency air transports from 100 to 44.3 percent;[111] psychiatric consults reduced hospital time in the ED,[117] as well as admissions and increased odds of 30 and 90 day outpatient followup;[93] and cardiology consultations resulted in faster[136] and more aggressive[253] treatment. The study using video for neurology consultations reported time from referral to decision was longer with both telephone and video consultation when compared with no consultation, but it is unclear if this is a problem or a reflection of more complete assessments.[245,247]

Emergency Care Telehealth Specialist Consultations: Harms, Adverse Events, or Negative Unintended Consequences

None of the included studies reported on harms or negative unintended consequences of telehealth specialty consultations as part of emergency care.

Key Characteristics of Emergency Care Telehealth Specialist Consultations with Emergency Departments and Overview of Outcomes

All of the ED telehealth consultations involved visual data. Most were centered on video that allows visual assessment of patients, observation of ED procedures, and audio communication. Only one study included only the transmission of images.[191] The studies in the United States focused on providing expertise to rural EDs as a means to get specialty assessments to patients in a shorter time than it would take to transfer them to a trauma center where the patient could be assessed by the specialist in person. The non-United States studies appear to have similar goals though increasing access to care in rural areas was not explicitly stated as one of the goals of these studies.

The combination of the similarity in objectives and technology, the wide range of types of specialties and patients, and the lack of detailed information on the environment or specifics of telehealth implementation make identifying subgroups of patients or programs with different outcomes problematic.

Table 9. Emergency care telehealth specialty consultations: selected outcomes

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: General	Natafgi, 2017[95] 7 states, US 85 rural hospitals 1 central hub	Economic evaluation Moderate A: Tele-ED not activated, n=164,291 B: Tele-ED activated, n=9,048	Mortality, n (%) A: 791 (0.5%) B: 358 (4.0%)	Transferred, n (%) A: 1059 (0.7%) B: 4224 (47.6%)	Estimated savings per avoided transfer, in USD: $3,823
ED: Trauma	Duchesne, 2008[53] MS, United States 7 rural EDs	Before-after High A: Before telehealth, n=351 B: After telehealth, n=463 (51 sent to trauma center)	Mortality, n (%) A: 17 (4.8%) B: 4 (7.8%), NS	Discharge outcomes Home: A: 0% B: 61.3% Admitted to community hospital: A: 0% B: 13.6% Transfer to trauma center: A: 100% B: 11% LOS at community hospital, in hours, transfers only **A: 47** **B: 1.5, p<0.001** Mode of transfer A: 74.9% ground B: 70.5% ground	Trauma center costs, in USD for transfers **A: $7,632,624** **B: $1,126,683, p<0.001**
ED: Trauma	Mohr 2018[90] and 2017[89] ND, USA 36 Critical access hospitals	Retrospective cohort Low A: Usual care, n=2,371 B: Telehealth, n=291	Mortality Adjusted OR (95% CI) Telemedicine Use 0.9 (0.5 to 1.4) NS Telehealth availability 1.2 (0.9 to 1.7) NS	Interhospital transfers Adjusted OR (95% CI) Telemedicine Use 1.28 (0.94 to 1.75), NS **Telemedicine Availability** **1.2 (1.1 to 1.4), p<0.0.05**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Pediatrics	Dayal, 2016[47] CA, USA 1 Children's Hospital PICU 75 EDs	Retrospective cohort Low A: No telehealth, n=524 B: Telehealth, n=582	Mortality n (%) A: 23 (4.4) B: 14 (2.4), p=0.07 Pediatric Risk Mortality III score **A: 4.0** **B: 3.2, p<0.05**	Mean PICU LOS, days ± SD A: 3.8 ± 9.4 B: 3.1 ± 5.5, p=0.11	NR
ED: Pediatrics	Dharmar, 2013[49] CA, United States 5 EDs	Retrospective cohort Low Comparison A_1: No telehealth, no consult, n=199 A_2: No telehealth, phone consult, n=63 B: Telehealth, n=58	NR	Mean overall quality of care score[a] A_1: 5.26 A_2: 5.38 B: 5.76 **B vs. A_1: p<0.01** A_2 vs. A_1. NS Changes in diagnosis **B: 47.8%** **A_2: 13.3%, p<0.01** Changes in treatment **B: 55.2%.** **A_2: 7.1%, p<0.01**	NR
ED: Pediatrics	Dharmar, 2013[51] CA, United States 8 EDs 1 academic children's hospital	Retrospective cohort Low A_1: No telehealth, no consult, n=85 A_2: No telehealth, phone consult, n=76 B: Telehealth, n=73	Mortality, n (%) A_1: 2 (2.6) A_2: 1 (1.2) B: 3 (4.1)	Physician-related ED medication errors (%) A_1: 16 (12.5) A_2: 18 (10.8) B: 5 (3.4) **B vs. A_2: p<0.05** **B vs. A_1: p<0.05**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Pediatrics	Yang, 2015[133] CA, United States 8 rural EDs 1 university hospital	Retrospective cohort Moderate A: Telephone, n=64 B: Telehealth, n=74	NR	Hospital admissions A: 87.5% B: 59.5%, p<0.05 Observed to expected admission ratio (95% CI) Pediatric Risk of Admission II, Overall A: 2.58 (2.00 to 3.32) B: 2.36 (1.80 to 3.10) Revised Pediatric Emergency Assessment Tool, Overall A: 2.57 (1.99 to 3.31) B: 2.34 (1.78 to 3.07)	NR
ED: Neurology	Goh, et al., 1997[239] Hong Kong 2 referring hospitals 1 consulting medical center	Prospective cohort High A: No telehealth, n=28 B: Telehealth, n=35	GOS at 6 months Death A: 14.3% B: 14.3% Vegetative A: 7.1% B: 8.6% Severe disability A: 10.7% B: 2.9% Moderate disability A: 14.3% B: 14.3% Good A: 53.6% B: 60%, NS Adverse events during transfer **A: 32.1%** **B: 6.4%, p=0.017**	Therapeutic interventions before transfer A: 10.7% B: 32.1%, NS Mean transfer time, in minutes A: 80 B: 72, NS	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Neurology	Wong, 2006[247] Poon, 2001[245] (pilot for Wong) Hong Kong 249 spoke hospitals 1 hub hospital	RCT Wong: Moderate Poon: High A: No telehealth, n=235 B_1: Telehealth, tele-radiology, n=239 B_2: Telehealth, video consult, n=236	Mortality 6 months after admission, n (%) A: 81 (35%) B_1: 59 (25%) B_2: 79 (34%) **B_1 vs. A: p=0.025** B_2 vs. A: p=0.923 **B_2 vs. B^1: p=0.043** Favorable outcome after 6 months, n (%) A: 130 (56%) B_1: 146 (47%) B_2: 124 (74%) B_1 vs. A, NS B_2 vs. A, NS	Time from referral to decision, in hours A: 0.70 B_1: 1.01 B_2: 1.30 B_1 vs. A, NS **B_2 vs. A: p=0.003** B_2 vs. B_1, NS Video failure: 30%	Average cost per patient in Hong Kong dollars (USD) A: 14,075 (17,237) B: 14,455 (22,906) C: 16,370 (22,587)
ED: Psych	Narasimhan, 2015[93] SC, United States 18 hospitals	Prospective cohort Moderate A: Site without telehealth, n=7,261 B: Site with telehealth, n=7,261	NR	Inpatient admission **OR[b]: 0.41 p=0.022** LOS in days **OR[b]: -0.43, p=0.002** 30-day outpatient followup **OR[b]: 5.44, p<0.001** 90-day outpatient followup **OR: 5.65, p<0.001**	Change in charges 30 days after ED visit, in USD Inpatient charges: **-2,338, p=0.041** Total charges: -649, NS

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Psych	Southard, 2014[117] IN, United States 1 rural ED	Before-after Moderate A: Before telehealth, n=24 B: After telehealth, n=38	NR	Mean LOS in ED, in hours **A: 31.7** **B: 17.0, p<0.001** Mean order to consult time, in hours **A: 16.2** **B: 5.4,p<0.001** Door-to-consult time, in hours **A: 22.7** **B: 10.5, p<0.001** Disposition Inpatient observation A: 100% B: 39% Home with followup A: 0% B: 29% Tertiary care center A: 0% B: 8% Behavioral facility A: 0 B: 24%	NR
Emergency physician-Airway management	Cho, 2011[235] Seoul, Korea 2 EDs	RCT High A: Usual care, n=13 B: Telehealth, n=12	Complication rate: p=0.36 Success rate: p>0.05	Mean intubation time ± SD, in seconds A: 56 ± 2 B: 62 ± 12 p=0.30	NR
ED: Cardiology	Astarcioglu, 2015[136] Turkey 1 rural hospital	Prospective cohort High A: Not telehealth, n=55 B: Telehealth, n=53	False STEMI: A: 8.3%. B: 0%, NS	Mean time in minutes Door to balloon time, **A: 130** **B: 109, p<0.001** Door to door time **A: 109** **B: 91, p<0.001** Catheterization lab to balloon A: 18 B: 16, NS	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Cardiology	Macedo, 2016[253] Sao Paulo, Brazil 22 EDs 1 reference hospital	Before-after Moderate A: Before telehealth, n=113 B: After telehealth, n=263	In-hospital mortality A: 8% B: 3% p=0.06	Use of pharmacoinvasive strategy **A: 38%** **B: 55.8%** **p=0.002**	NR
ED: Burns	Saffle, 2009[111] United States 3 hospitals and 1 burn center	Before-after Moderate A: Before telehealth, n=28 B: After telehealth, n=70	Mortality, n (%) A: 1 (3.6) B: 0	**Air emergency transport** **A: 100%** **B: 44.3%, p<0.05** Median LOS (IQR), in days A: 8 (24) B: 13 (23), NS Satisfied with telemedicine visit Burn center physicians: 76.9% Referring physicians: 86.4% Patients transferred: 75.9% Patients not transferred: 69.2% All respondents: 78.2%	NR
ED: Cancer	Hashimoto, 2001[241] Japan One district hospital	Before-after High A: Before telehealth, n=17 B: After telehealth, n=12	1-year survival A: NR B: 72% 2 year survival A: NR B: 42% Mean hospitalization time A: NR B: 2.3 months Successful ambulation for patients who were nonambulant A: 25% B: 83%, p<0.05	Treatment within 24 hours A: 17.6% B: 92% Mean onset to radiotherapy time, in days **A: 7.1** **B: 0.8, p<0.05**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Pediatric Fractures	Zennaro, 2014[191] Italy One hospital	Pre-post High A: Pre-telehealth, n=42 B: Post-telehealth, n=42	NR	In-hospital consultation required **A: 76.1%** **B: 38%, p<0.001** Immediate activation of other services **A: 0** **B: 33.3%, p<0.001** Mean time for decision making, in minutes **A: 56.2** **B: 23.4, p<0.001**	NR
ED: Plastic Surgery	Paik, 2017[97] NJ, United States 1 university hospital	Retrospective cohort High A: Usual care, n=42 B: Telehealth, n=42	NR	Response time, in minutes **A: 48.3** **B: 8.9, p<0.001** Overall agreement rate 90.5%, n=38	NR
ED: Sepsis	Machado, 2018[83] Columbus, OH, USA 1 ED	Retrospective cohort Clinical: Moderate Cost: High A: Usual care, n=219 B: Telehealth, n=95	Mortality, n (%) A: 49 (22.4%) B: 25 (26.3%), p = 0.471	Mean time in minutes To antibiotics ± SD **A: 163.4 ± 204.4** **B: 122.3 ± 83.3, p=0.043** Antibiotics administered within 3 hours A: 71.2% B: 82.1%, p=0.097 Mean ED LOS ± SD, in days A**: 0.16 ± 0.37** **B: 0.08 ± 0.28, p=0.036** Mean hospital LOS ± SD, in days A: 10 ± 8.5 B: 8.6 ± 5.7, p=0.088 Readmission in 30 days, n (%) A: 25 (11.4%) B: 16 (16.8%), p=0.204	Total hospital costs, in USD A: $24,364 ± 25,068 B: $19,713 ± 16,550, p=0.274

CI = confidence interval; ED = emergency department; GOS = Glasgow Outcome Scale; IQR = interquartile range; LOS = length of stay; NA = not applicable; NR = not reported; NS = not significant; OR = odds ratio; PICU = pediatric intensive care unit; RCT = randomized control trial; SD = standard deviation; STEMI = ST-elevation myocardial infarction; USD = United States Dollars

[a] Adjusted for age, PRISA II score, and year of consultation

[b] Adjusted for weekend versus weekday visit, sex, age, and race

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Emergency Medical Services/Urgent Care

Table 10 contains details and results from 21 studies reported in 23 articles in which telehealth was used to advise EMS personnel or urgent care providers caring for patients outside of the hospital. In these studies, telehealth was used to allow an emergency medicine physician or specialist to contribute to patient assessments and decisions about prehospital treatment and transport. Transport decisions include where the patient should be taken (e.g., the closest hospital, a trauma center, a cardiac center) and what mode of transport should be used (e.g., air, ambulance, personal vehicle).

More than half of these studies (11 of 21) involved transmitting information, frequently including electrocardiograms, about patients experiencing heart attack symptoms. EMS then received assistance with determining if the patient had ST-elevation myocardial infarction (STEMI), directions for preliminary treatment, and advise on whether to transport the patient directly to a location equipped to provide primary percutaneous coronary intervention (PCI). This is important because outcomes are better if patients are treated quickly after symptom onset and diagnosis. For this reason, similar to telestroke, a frequently reported outcome is time to treatment, in this case often referred to as time to balloon, referring to the use of a balloon to open blockages in cases of myocardial infarction (MI).

Among the other nine studies, six studies (reported in 7 articles) addressed the use of telehealth to inform triage and ultimately transport and treatment decisions for a broad range of patients served by EMS, and three (reported in 4 articles) assessed the utility of telehealth in urgent care.

Most studies (7 of 11) of prehospital decisions for STEMI patients were conducted in Europe: five in Italy,[143,162,171,172,189] one in Germany,[141] and two in Denmark.[173,179] Additionally, one each were conducted in Canada,[218] Brazil,[254] and the United States.[113] Similarly, the studies of triage and urgent care are international with most set in the United States,[34,35,77,78,100,124] and others in South Korea,[242] Austria,[225] Taiwan,[246] Ireland,[197] and Germany.[142]

Emergency Medical Service/Urgent Care Telehealth: Effectiveness in Improving Clinical and Economic Outcomes

Ten studies reported clinical outcomes. Nine of these were studies of prehospital cardiac care and compared mortality (some in hospital, some 30-day, one 1-year) for MI patients assessed and treated with and without prehospital telehealth, and in seven of these,[162,171-173,189,218,254] the mortality rates were significantly lower with telehealth. The studies of more general triage and urgent care did not report clinical outcomes with the exception of one study of pain medications administered by EMS, which reported that complications and nausea and vomiting did not differ.[142]

Five studies included comparisons of costs of staff and equipment or estimates of savings. One study of prehospital cardiac care in Brazil reported the mean cost of admissions was higher for patients treated with telehealth.[254] Two studies (reported in three articles) of triage and urgent care reported savings due to lower transportation costs.[77,78,246] One study reported that the telehealth costs were lower than the staff costs of providing the service without telehealth[197] while another study that examined costs for patients and families as well as the health system reported no significant difference in patient costs and healthy system costs were slightly higher or no different depending on the model used to adjust the costs.[204] In general, economic outcomes were not reported and the analyses were simple.

Emergency Medical Service/Urgent Care Telehealth: Effectiveness in Improving Intermediate Outcomes

All of the included studies reported at least one intermediate outcome. In the studies of prehospital cardiac assessment, nine[113,143,162,171-173,179,189,218] included a measure of time to treatment (e.g., time to treatment, percent treated within recommended time, total ischemic time), and all of these reported time to treatment was statistically significantly shorter with telehealth. Other outcomes included no difference in guideline adherence[141] and a statistically significant increase in admissions to tertiary hospitals in a study conducted in Brazil.[254]

The available studies of general triage and treatment conclude that telehealth reduced the number of referrals or transfers. Two of the EMS studies evaluated teleconsultations on decisions about whether to air transport a patient from island locations (Penghu Islands, Taiwan or Palm Island Australia) to a distant hospital and found reductions in air transfers with patients either being treated in place or transferred another way.[225,246] A study in the United States used telehealth to recommend whether a patient needed to be transported by ambulance or could take personal transportation to a primary care office or ED and found transport by ambulance and time for ambulances to return to service decreased while patient satisfaction did not change.[77,78]

Two urgent care studies included evaluations of minor injury centers where nurse practitioners or nurses provided treatments with telehealth input from physicians in Ireland and the United States.[34,35,197] These found no significant differences in care needs or patient or clinician assessments.

Emergency Medical Service/Urgent Care Telehealth: Harms, Adverse Events, or Negative Unintended Consequences

Only one study of pain medications administered by EMS reported clinical outcomes that could also be considered harms or adverse events. A study of pain medication administration by EMS found that complications and nausea and vomiting did not differ.[142]

Key Characteristics of EMS/Urgent Care Telemedicine and Impact of These on Outcomes

Very little detail was provided in the studies of telehealth for support beyond the type of patients served and brief descriptions of what information was shared. Additionally, different uses of telehealth in this category are evaluated using very different outcomes (e.g., mortality and type of transport). This makes it difficult to identify any subgroups or characteristics that could be used to differentiate successful telehealth interventions within the categories provided (i.e., cardiac care, general triage, and urgent care). Additionally, the categories are fundamentally different, making comparisons across categories inappropriate.

Table 10. Emergency medical services and urgent care telehealth: selected outcomes

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Cardiac	Brokmann, 2016[141] Aachen, Germany 5 ambulances 1 telehealth center	Before-after Moderate A. Before telehealth, n=39 B. After telehealth, n=39	NR No harms detected	Guideline adherence number of patients 12-lead ECG A: 39 B: 38, p>0.99 Acetylsalicylic acid A: 33. B: 31, p=0.73 Heparin A: 33 B: 34, p>0.99 Morphine A: 27 B: 29, p=0.50 Oxygen **A: 18.** **B: 29, p=0.007**	NR
EMS – Cardiac	Brunetti, 2014[143] Apulia, Italy Meta-analysis: number of sites NR	Prospective cohort Moderate A: Usual care, n=174 B: Telehealth, n=123	NR	Mean time to balloon ± SD, in minutes **A: 94 ± 61** **B: 41 ± 17, p<0.001**	NR
EMS – Cardiac	Chan, 2012[218] Canada Unclear	Retrospective cohort Low A: Usual care, n=427 B: Telehealth, n=167	30-day mortality **A: 13.3%** **B: 5.4%, p=0.006** 1-year mortality A: 17.5% B: 6.6%, p=0.019	90-minute door to balloon time **A: 8.7%.** **B: 80.4%, p<0.001** Post-procedural TIMI flow grade 3 **A: 91.4%.** **B: 97.6%, p = 0.02**	NR
EMS – Cardiac	Marcolino, 2013[254] Belo Horizonte, Brazil 18 basic support units 6 advanced support units	Before-after Moderate A: Before telehealth, n=1242 B: After telehealth, n=1358	AMI in-hospital mortality **A: 12.3%** **B: 7.1%** **p<0.001**	AMI hospitalizations, including ICU stay **A: 32.4%** **B: 66.1%, p<0.001** Proportion of AMI admitted to tertiary hospitals **A: 47.0%** **B: 69.6%, p<0.001**	Mean cost of admission ± SD, in Brazilian reals ***A: 2,480.00 ± 4054*** ***B: 3,501.00 ± 3202*** ***p<0.001***

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Cardiac	Martinoni, 2011[162] Italy Unclear	Retrospective cohort Moderate A: Usual care, no ECG, n=2298 B: Telehealth, n=1603	30-day mortality of patients admitted by EMS **A: 7.9%** **B: 5.3%, p=0.06**	First medical contact to balloon, median minutes (IQR) **A: 75 (49 to 112)** **B: 50 (30 to78.5), p<0.001**	NR
EMS – Cardiac	Ortolani, 2007[171] Italy 1 intervention lab	Retrospective cohort Low A: Usual care, n=79 B: Telehealth, n=42	In-hospital cardiac mortality: **A: 44%** **B: 21%** **OR: 0.34, p=0.02** In-hospital all-cause mortality: **A: 46%.** **B: 21%** **OR 0.32, p=0.01** 1-year survival rate: **A: 52%.** **B: 74%** **OR: NR, p=0.019**	Median total ischemic time (IQR), in minutes A: 212 (150 to 366) B: 142 (106 to 187) Total Ischemic time <120 mm **A: 40(51%).** **B: 32(76%), p=.01**	NR
EMS – Cardiac	Ortolani, 2006[172] Bologna, Italy Unclear	Retrospective cohort Low A_1: Usual care, ED, n=316 A_2: Usual care, local hospital, n=176 B: Telehealth, 166	Overall Mortality, n (%) A1: 23 (7.3) A2: 13 (7.4) A3: 8 (4.8) NS In-hospital mortality among cardiogenic shock subgroup (n=80) **A: 48.1% (13/27).** **B: 37.5% (9/24)** **C: 13.8% (4/29)** **p=0.019**	Median treatment delay (IQR), in minutes **A_1: 191 (135 to 318.7)** **A_2: 236 (163.7 to 363.2)** **B: 146 (108.2 to 214.5), p=0.001**	NR
EMS – Cardiac	Pedersen, 2009[173] Denmark Ambulance number NR 1 high volume center	Prospective cohort Low A: Usual care, n=821 B: Telehealth, n=616	All-cause mortality or nonfatal MI hazard ratio (95% CI) **0.67; (0.46 to 0.97), p=0.035**	Median door to balloon time (IQR), in minutes **A: 103 (80 to 135)** **B: 83 (67 to 100)** **p <0.001**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Cardiac	Sanchez-Ross, 2011[113] NJ, United States 1 university hospital	Prospective cohort Moderate A: Not telehealth, n=50 B: Telehealth, n=92	Mortality A: 6% B: 1.1%, NS	Median door to balloon time (IQR), in minutes **A: 119 (96 to 178)** **B: 63 (42 to 87), p<0.0004** Median LOS (IQR), in days **A: 5.5 (3.5 to 10.5)** **B: 3 (2 to 4), p<0.001**	NR
EMS – Cardiac	Sejersten, 2008[179] Denmark 4 local hospitals 2 coronary centers	Prospective cohort Moderate A: Usual care, n=89 B: Telehealth, n=168	Mortality A: 6.9% B: 6.0% p=0.67 Arrhythmia A: 7% B: 10%, p=0.37	911 call PCI, median minutes (IQR) **A: 127 (103 to 151)** **B: 74 (64 to 94), p<0.001** Door to PCI, median minutes (IQR) **A: 97 (80 to 124)** **B: 34 (19 to 46), p<0.001**	NR
EMS – Cardiac	Zanini, 2008[189] Mantova, Italy 6 local hospitals 1 acute care	Retrospective cohort Moderate A: Usual care, n=263 B: Telehealth, n=136	In-hospital Mortality Total **A: 8.7%.** **B: 3%, p =0.039** PCI A:7.2% B: 3.3%, p=0.14	Onset to balloon time ± SD, in minutes **A: 262 ± 112** **B: 148 ± 81, p<0.001**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Triage and Transport	Kim, 2011[72] Wonju, South Korea 6 ambulances; 1 hospital	Retrospective cohort High A: Not telehealth, n=750 B: Telehealth, n=188	NR	Mean time in minutes Arrival to scene A: 6.6 B: 6.6, NS Treatment time at the scene **A: 6.3** **B: 4.4, p<0.001** Mean transport time ***A: 15.8*** ***B: 19.4, p<0.001*** % receiving medical direction for treatment **A: 0.3%** **B: 8.0%, p<0.001** % receiving medical direction for ambulance diversion **A: 0.1%** **B: 14.4%, p<0.001**	NR
EMS – Triage and Transport	Langabeer, 2016;[78] Langabeer, 2017[77] TX, United States 1 Fire department	Retrospective cohort Moderate Economic evaluation High A: Usual care, n=5570 B: Teleconsult, n=5570	Mortality A: 0% B: 0%	Disposition to ED by ambulance A**: 74%** **B: 18% , p<0.001** Patient satisfaction A: 87%. B: 88%, p=0.250 Total back in service time, median minutes (IQR) **A: 83 (20 to 140)** **B: 39 (27 to 90), p<0.001**	Average unit cost per patient ± SD, in USD **A: 270 ± 77.7** **B: 167 ± 42.7** **p<0.0001**

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Triage and Transport	Mathews, 2008[225] Australia 1 community	Before-after High A: Before telehealth, n=78 B: After telehealth, n=113	NR	Aeromedical retrievals **A: 92%.** **B: 78%, p=0.009** Not transferred **A: 5%** **B: 16%, p=0.022** Helicopter flights **A: 73%.** **B: 52%, p=0.004** Median LOS (IQR), in days A: 3.0 (0.1 to 98.8) B: 2.0 (0.1 to 144.8), NS	NR
EMS – Triage and Transport	Traub, 2013[124] United States 1 ED	Retrospective cohort High A: Usual care, n=196 B: Telehealth, n=106 (36 used telehealth)	NR	Mean ± SD Admitted A: 64 ± 32.7 B: 12 ± 33.3, p=0.936 LOS ± SD (95% CI), minutes A: 258 ± 172 (234 to 282) B: 274 ± 125 (231 to 316), p=0.525 Time to physician evaluation ± SD (95% CI), minutes Full Sample: NS Subgroup: n=36 **A: 42 ± 31 (38 to 46)** **B: 16 ± 15 (11 to 21), p<0.001**	NR
EMS – Triage and Transport	Tsai, 2007[246] Pengu Island, Taiwan 4 rural EDs 1 rescue command center	Prospective cohort Low A: No telehealth, n=685 B: Telehealth, n=137	NR	Average flights per month A: 19.6 B: 12.5	Annual savings on emergency air medical transports, USD: $ 448,986

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS – Triage and Transport	Patel, 2015[100] DE, United States 1 pediatric transport team 1 command hospital	RCT Moderate A: Cell phone, n=25 B: Telehealth, n=25	NR	Average call duration, seconds A: 186 B: 139, p=0.055 Medical Command Officer Survey, n=12: 100% found video intuitive 92% disposition based on phone report was difficult 80% video provided better understanding of patient condition 70% video assisted disposition 80% believed video should be used for transport	NR
EMS – Analgesia	Brokmann, 2016[142] Aachen, Germany 5 ambulances 1 telehealth center	Before-after Moderate A: Before telehealth, n=80 B: After telehealth, n=80	Complications A: 0 B: 0 Nausea and vomiting A: 11% B: 11%	Reached adequate prehospital pain reduction[a], A: 31/32 patients B: 61/65 patients, NS Mean pain reduction during mission in NRS points ± SD **A: 4.38 ± 2.2 points** **B: 3.78 ± 2.0 points** **p = 0.0159**	NR

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Urgent Care	Brennan, 1998;[35] Brennan, 1999[34] NJ, United States 2 hospitals 1 central site	RCT High A: Usual care, n=50 B: Telehealth, n=50	NR	Mean throughput time, minutes A: 117 B: 106 72 hour return visit A: 0%. B: 0% NS Need for additional care A: 2.4%. B: 2.3% NS Positive patient-physician interaction A: 100% B: 98% Positive patient-nurse interaction A: 98% B: 98% Overall patient satisfaction A: 95%. B: 98% NS	NR
Urgent Care	Darkins,1996[197] Ireland 1 minor treatment center	Before-after High A: Before telehealth, n=6729 B: After telehealth, n=9972	NR	Referred to ED: A: 2.3% B: 1.5% Referred to primary care: A: 11.9% B: 3.8%	Direct costs per year A: £50,000 for onsite staff B: £7,250 for equipment

Clinical Topic	Author, Year Location Number of Sites	Study Design Risk of Bias Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Urgent Care	Noble, 2005[204] United Kingdom Single hospital ED	Economic evaluation Low A: Not telehealth, n=191 B: Telehealth, n=62	NR	Returned to normal activity in 7 days (95% CI) A: 47.6% (34.9% to 60.6%) B: 47.0% (41.0% to 53.2%)	Mean 7-day cost difference per patient (95% CI) [95% bias corrected CI] NHS Cost: £39.5 (-1.3 to 80.2) [28.3 to 73.7] Patient/family cost: £14.3 (-26.6 to 55.2) [-11.2 to 25.9] Total cost: £53.75 (-6.97 to 114.46) [24.10 to 101.81]

AMI = acute myocardial infarction; CI = confidence interval; ECG = electrocardiogram; ED = emergency department; EMS = emergency medical services; GBP = British Pound; ICU = intensive care unit; IQR = interquartile range; LOS = length of stay; NHS = National Health Services; NR = not reported; NS = not significant; NRS = Numerical Rating Scale; OR = odds ratio; PCI = percutaneous coronary intervention; RCT = randomized controlled trial; SD = standard deviation; TIMI = thrombolysis in myocardial infarction; USD = United States dollars

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

[a] A reduction of the Numerical Rating Scale of ≥2 points or NRS <5 at end of mission

Outpatient Consultation Results

Collaboration with a specialist as part of outpatient care is what is mostly commonly thought of as a healthcare consultation. We identified 106 articles that evaluated telehealth consultations used to inform diagnosis, treatment, or management of patients receiving care in the outpatient setting. These studies span several specialties and use several different technologies to facilitate consultations. They also vary in the outcomes used to assess effectiveness. To capture and organize this diverse group of studies, we presented the results in three ways. First, we provided an overview of the results summarized by clinical topic in Table 11. Second, the key results are described in text accompanying selected results for each study provided in tables by clinical topic. Third, we looked across clinical topics and summarize how the results for outpatient consultations address the Key Questions for this review.

Organization of Evidence

The 106 included articles evaluating telehealth consultations in the outpatient setting are summarized in Table 11 below. They are grouped in 11 clinical topics, eight of which are separate specialties wherein we identified three or more articles (i.e., dermatology, wound care, ophthalmology, orthopedics, dentistry, cancer, psychiatry, and infectious diseases). The remaining articles are organized in three additional categories. The last category in the overview table and this section consists of studies of programs designed to facilitate consultations with multiple specialists. These programs connect primary care providers to a hospital or group of specialists rather than one specific specialty. We split the remaining specialties containing one or two included articles into two categories. The first consists of consultations using diagnostic technology as part of the consultation, including echocardiograms, ultrasounds, endoscopies, and Dopplers. In these studies consultations were conducted using real time transmission of images and data, and in some, specialists guided the technician on their use. The other group includes articles about specific specialty consultations that do not use diagnostic technology. Most of these studies evaluate telehealth consultations in the management of chronic conditions including hypertension, diabetes, arthritis and chronic pain.

Given the volume of evidence and range of topics, the key points are followed by the findings across the clinical topics. Then for each of the 11 clinical topics there is a short narrative description of the evidence followed by a table with details from each study.

Outpatient Key Points

- Clinical outcomes: Clinical outcomes were reported in just over one-quarter of the studies of telehealth consultations and in 7 of 11 clinical topics. In three topics, there is moderate strength of evidence of the benefits of telehealth (better healing in wound care, higher response to treatment in psychiatry, and improvement in chronic condition outcomes), and in dermatology the findings show no difference in clinical outcomes (low strength of evidence). In three topics (cancer, infectious disease, and multiple specialties) studies were identified, but the results were inconsistent (insufficient evidence).
- Intermediate outcomes
  - Access: Telehealth consultations improved access by reducing wait times and time to treatment and by increasing the number of patients receiving indicated diagnostic tests or treatment (moderate strength of evidence).
  - Management and utilization: Telehealth consultations reduced utilization (the number of in-person specialist and hospital visits; number of hospitalizations, and shorter

lengths of stay) in most studies. Findings were inconsistent about agreement on diagnosis and management (low strength of evidence).
    - Satisfaction: Patients were generally more satisfied with telehealth consultations, particularly when telehealth saved time or expense compared with the alternative. Clinicians tended to be less satisfied with telehealth than in-person consultations, though differences were rarely statistically significant (low strength of evidence).
- Costs: Studies report lower costs and in most cases savings are attributable to reductions in transfers or less transportation. However, the rigor of the measurement, imprecision of estimates and inconsistency in the magnitude of the effects limits confidence in these findings (low strength of evidence).
- Harms: Only two of studies explicitly examined harms, reporting lower rates of complications with telehealth (insufficient evidence).

Table 11. Outpatient care consultations: summary of evidence

Clinical Topics	Number of Studies	Clinical Outcomes and Harms	Intermediate Outcomes	Costs	Citations
Dermatology	22 (reported in 28 articles)	~ Clinical course	* Improved access	? Mixed: lower costs in some but not all; savings due to avoided travel and lost productivity	33,40,45,65,75,98, 99,126-130, 146-148,160,166, 169,175,192,195, 199,201,202,213, 222,223,233
Wound Care	6	* Better healing; fewer amputations	* Fewer hospitalizations	* Lower costs	118,180,190,228, 251,256
Ophthalmology	6	No evidence	* Increased screening and treatment; fewer surgeon visits; high satisfaction	~ Difference only due to patient travel and avoided transport	122,132,185,188, 215,219
Orthopedics	4 (reported in six articles)	* Fewer missed fractures (1 study)	* Improved quality, similar management	* Lower costs	79,151,153,158, 170,187
Dentistry	4	No evidence	* Reduced time to treatment	< Outreach clinics less expensive than telehealth	154,167,177,205
Cancer	9 in 10 articles	* Fewer side effects	* Some decrease in time to treatment; increased adherence to guidelines * Satisfaction better or no different	* Lower costs if number of consults is sufficient	32,52,70,112,181, 182,198,200,230, 234
Psychiatry	3 studies (in 5 articles)	* Higher response to treatment; decreased symptoms	* Higher satisfaction	No evidence	46,56-59
Infectious Disease	4	~ No difference in hepatitis C studies * Significant improvement in HIV study	* Reduced time to completed consult * Increase in care and completion of therapy	No evidence	30,108,119,134

Clinical Topics	Number of Studies	Clinical Outcomes and Harms	Intermediate Outcomes	Costs	Citations
Single Specialties with Diagnostic Technology	10	No evidence	* Timely, increased access; better management of care	* Lower costs due to patient costs	37,54,82,114,140, 203,206,211,231, 258
Single Specialties	17	* Improvements in chronic condition outcomes	? Effects on satisfaction and management are unclear	~ Some limited impact on costs	31,42,61,69,74,92, 144,145,168,186, 194,210,217,220, 232,248,250
Multiple Specialties[a]	8 (reported in 10 articles)	No evidence	* Improved management; higher satisfaction ? Unclear impact on emergency department and hospitalizations	? Mixed: lower costs in two studies; higher in one large trial	28,38,60,152,157, 184,207,208,212, 229

Key: * superior (telehealth benefit), ~ no difference, < inferior (comparison better than telehealth), ? inconclusive (inconsistent results)

[a] These studies evaluated programs that made consultations available covering different numbers of specialties (i.e., ranging from 4 to 28) or any specialty available (disciplines not specified)

Detailed Results

Results Across Clinical Topics

Outpatient Telehealth Consultations: Effectiveness in Improving Clinical and Economic Outcomes

Approximately one-quarter of studies (28) reported clinical outcomes. These were concentrated – though not exclusively limited – to studies in which the consulting relationship was ongoing and involved treating and managing a condition over time as opposed to a single consultation. Most of these (22 of 28) reported a benefit from telehealth. For example, three studies about psychiatric consultations, four about wound care, and three about infectious disease all reported positive outcomes such as reduced symptoms, faster healing, or reduced viral load. Most, but not all of these studies, involved real time, video consultations, and patients were often present. In other studies, specialists reviewed updated records, including images or test results and contacted the treating physician with recommended changes in treatment or requested more information. The four studies of wound care used store and forward approaches to provide images and information, which the specialist reviewed when available and used them to develop a treatment plan that was communicated to the patient and referring clinician at separate time. Three dermatology studies in which the consultation was limited to a single interaction for diagnosis and initial management recommendations reported improvement in patients' conditions or that the clinical course did not differ between telehealth and in-person consultations.

Just under one-third of the studies (32) about outpatient consultations included some assessment of cost or economic impact. These varied from basic estimates of travel costs to detailed assessments of the different sources of fixed and variable costs. However, most are comparatively simple, and while about half (14) of the studies reported some cost savings for teleconsultations, these were mostly limited to avoided travel costs and loss of productivity for patients. In a small number of studies (4), telehealth consultations were not less expensive: for example a study of dental consultations to underserved communities concluded that telehealth consultations were more expensive than outreach visits by dentists,[194] and a study of a network linking primary care to multiple specialists via video found telehealth consultations to be more expensive due to treatment costs and the extra time required to have both the specialist and primary care physician available for real time video consultations.[207]

Outpatient Telehealth Effectiveness in Improving Intermediate Outcomes

Most studies of outpatient telehealth consultations used intermediate outcomes to assess efficacy. These outcomes included impacts on access to services, health services utilization and the management of patients' conditions, and patient and provider satisfaction. Overall, the results support the use of telehealth consultations, though the amount of evidence varies across the different intermediate outcomes.

Thirty-five studies evaluated whether telehealth consultations improved access to services. We interpreted increased access to include both timelier access to services as well as increased rates of use. These were concentrated in dermatology (6 studies), studies of multiple specialties (6 studies), specialty consultations that included diagnostic technology (3 studies), and ophthalmology (3 studies). The impact on access is related to the type of care. For example, in the dermatology studies, telehealth consultations reduced wait time and time to treatment, and studies of consults with diagnostic technology reported increased numbers of patients receiving indicated tests and in less time with telehealth.

Thirty-one studies reported outcomes related to utilization and management. In some clinical categories, only one study addressed these outcomes, while in other clinical categories, as many as 10 articles studied utilization and management. Not unexpectedly, telehealth consultations reduced the number of in-person specialist and hospital visits; they also were associated with fewer hospitalizations, shorter lengths of stay, and care that is more likely to follow establish guidelines. The one aspect of management for which the findings were less consistent was agreement on diagnosis and management, with some studies reporting a significant difference between telehealth and in-person conclusions or that telehealth was unable to facilitate a diagnosis, though the reasons were not clear (i.e., whether the cause was due to issues with or limitations of the technology or the comfort of the provider in making a diagnosis without a hands-on physical exam).

Twenty-two studies assessed satisfaction with telehealth consultations and generally reported that patients and providers were as satisfied with telehealth consultation as in-person visits. In some cases, patients and families were more satisfied, particularly when the telehealth consultation saved travel and associated time and expense, while providers tended to be slightly less satisfied with telehealth consultations though this difference was not statistically significant.

Outpatient Telehealth Consultations: Harms, Adverse Events, or Negative Unintended Consequences

Two outpatient studies explicitly addressed harms or unintended consequences in reporting lower rates of complications.[30,234] One studied complications in cancer treatments,[30] and the other reported serious adverse events related to hepatitis C treatment.[234] In part, the overall lack of reporting on harms reflects the relatively short-term followup in most outpatient studies and the focus on intermediate outcomes. Although there are some other findings that are not positive (e.g., a portion, but not the majority of patients reporting they are uncomfortable being videotaped or less than ideal agreement on management), these do not rise to the level of harms.

Outpatient Telehealth Consultations: Key Characteristics of Studies and Association With Outcomes

As is evident from the detailed results, the outpatient studies of telehealth consultation include multiple disciplines. For most clinical topics, the studies were conducted in a variety of geographic locations and countries with about 40 percent being conducted in the United States. There are some exceptions, for example, all included studies of telehealth psychiatric consultations were conducted in the United State while all the included dental studies were conducted in European countries. The body of literature also includes studies with different designs and with sample sizes ranging from as small as 11 to several thousand. This variety is interesting; however, there are no patterns evident that associate these general descriptive characteristics with whether telehealth consultations produce a benefit. Additionally, similar to the inpatient and emergency care studies, outpatient studies did not report many details about the environment or context. Notably, they provided very little information on the organizations themselves, any staffing and/or training needed to facilitate telehealth consultations, or payment models for consultations or other care related to the consultation.

There were two characteristics of telehealth consultations that we included in the in-text tables in this section that were not included in the inpatient and emergency care results sections. These are whether consultations occurred in real time or were asynchronous (e.g., store and forward) and when the consultation was a single event or if there were ongoing, continuous interactions between the consultant and referring physician. Table 12 presents percentages of studies with each of these characteristics. More studies were of real time consultations (about two-thirds) rather than asynchronous (about one-third). The distribution between consultations that were one-time and continuing was closer to an even split (56% and 43%, respectively). We also looked at the percentage of studies with each of these characteristics to determine if they were more or less likely to report that telehealth produced a benefit relative to the comparison group. Fewer studies with real time consultations reported a benefit (44%) than studies with asynchronous consultations (76%). This may be because the asynchronous studies more often measured access and time to treatment, and these are consistently better with telehealth. The difference is similar when comparing the percentage of one-time (43%) and continuing (70%) consultations that reported results favoring telehealth. The studies of ongoing consultations tended to report clinical outcomes or intermediate outcomes involving the management of chronic conditions (e.g., wound healing, reductions in blood pressures); results that likely required time and repeated input from specialists.

These characteristics are confounded with the clinical topic thereby making it difficult to draw conclusions from this information or generalize further. For example, most of the dermatology studies are asynchronous while all of the studies involving diagnostic technology are real time by definition. It is also likely that other factors that have not been measured may be more strongly associated with benefits. Nevertheless, looking at characteristics across studies and outcomes is an important initial step to increase our understanding of when and how telehealth consultations are most likely to be effective.

Table 12. Characteristics of outpatient consultations and outcomes, percent (counts)

Characteristic	Real Time	Asynchronous	One Time	Continuing
Percent of all outpatient studies[a]	63% (59+ of 94)	36% (34 of 94)	56% (53 of 94)	43% (40 of 94)
Percent of studies with the characteristic reporting a benefit[b]	44% (26 of 59)	76% (26 of 34)	43% (23 of 53)	70% (28 of 40)

[a] Timing and frequency were both unclear in one study each, + includes studies that used both real time and asynchronous

[b] In any outcome where telehealth was better than the comparator: clinical, intermediate, or cost

Results for Each Clinical Topic

In this section, results for each study are presented in tables according to the 11 specialty groups. The accompanying text provides a brief description or highlights key findings.

Dermatology

Dermatology as a field was an early adopter and has continued to adapt and study telehealth applications. While many studies in the field focus on diagnostic concordance or accuracy, this was not one of our Key Questions for this review, and we included studies researching patient clinical outcomes and intermediate outcomes such as measures of access or health services use. We identified 22 dermatology studies reported in 28 articles, resulting in more studies of telehealth consultations than any other outpatient specialty. In the majority of studies, the consultations were asynchronous: specifically, images and medical history were made available to a dermatologist who reviewed them at a different time, made a diagnosis, and sometimes provided treatment recommendations (16 studies). This process is often referred to as store and forward. A smaller number of studies (5 studies) used video to facilitate real time evaluations and discussion among the dermatologist, referring physician, and patient, while one study employed both store and forward and real time consultations.[202] In 16 of the 22 studies, the consultation was a one-time interaction about the patient, though physicians may have collaborated on many patients over time. In six studies, the dermatologist was involved in some ongoing care and followup. Store and forward was usually used for consultations involving a single interaction for a given patient, but there were some cases where store and forward consultations were used to initiate a longer relationship. Real time consultations were used for both ongoing and one-time consultations.

Only three dermatology studies evaluated clinical outcomes. In one, more patients recovered (20%) in the telehealth group than in the group without telehealth (4.1%) in the month between their initial visit and the in-person dermatology assessment.[146] In the telehealth group a consult was used to provide management advice faster, and treatment was started during the time patients waited for an in-person appointment. The other two studies evaluating clinical outcomes compared the clinical course of patients who were evaluated using store and forward dermatology and in face-to-face visits and found no difference in the numbers of patients who improved, had no change, or were worse.[98,130]

Most of the studies evaluated teledermatology in terms of one or more intermediate outcomes (e.g., assessment, satisfaction, and care management) or in terms of costs compared to usual care. Overall, teledermatology improved access by dramatically reducing wait times for visits and time to treatment (e.g., mean wait times for new patients were 9.75 days for teledermatology and 32.9 days for in-person visits,[33] and time from consultation to operation was 60.6 days for in-person and 26.1 days with telehealth consultations).[148] The findings for satisfaction and cost were mixed with most studies reporting a benefit (similar satisfaction and lower costs) while the findings related to the impact on management also varied (e.g., reductions in referrals and unnecessary visits: an advantage; but issues with disagreement on diagnosis or inability to make a diagnosis: a disadvantage). The results from each study are presented below in Table 13.

Table 13. Dermatology telehealth consultations: selected outcomes

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical and Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Bezalel, 2015[33] FL, United States 1 VA Hospital	Before-after High Asynchronous Continuing A: Before telehealth, n=1557 new patients B: After telehealth, n=1508 new patients n for established patients NR	New patient wait time, in days: **A: 32.9** **B: 9.75, p<0.001** Established patient wait time, in days: A: 4.14 B: 1.49, NS	NR
Byamba, 2015[233] Mongolia 20 rural health clinics 1 National Dermatology Center	RCT Moderate Asynchronous One time A: Not telehealth, n=229 B: Telehealth, n=221	Hospital referrals, n (%) **A: 28 (12.2%)** **B: 7 (3.1%), p<0.01** Time to receive care, in hours A: 322 B: 53	Patients travel expense, in USD: A: $3,174 B: $320 Total reduction in costs: $76.36 per patient
Carter, 2017[40] TX, United States 1 outpatient clinic 1 hospital	Retrospective cohort High Asynchronous One time A. In-person, n=173 B. Telehealth, n=79	Median time to evaluation, in days A: 70.0 B: 0.5 Median time to treatment, in days A: 73.5 B: 3.0	NR
Collins,2004[195]; Bowns, 2006[192] UK 8 General Practices 1 hospital	RCT Moderate Asynchronous Continuing A: Not telehealth, n=97 B: Telehealth, n=111	Satisfaction with care received A: 90% B: 81%, NS Satisfaction with management of skin problem: A: 87% B: 84%, NS	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Datta, 2015[45] NC, United States 3 primary care sites 2 VA Medical Centers	Economic evaluation Moderate Asynchronous Continuing A: Usual care, n=196 B: Telehealth, n=195	Dermatology clinic visits A: 303 B: 214	Total mean cost, USD Societal Perspective A: $106,194 B: $89,523 VA Perspective A: $66,145 B: $59,917 Mean per participant cost ± SD Societal Perspective **A: 541 ± 403** **B: 460 ± 428** **Difference (95% CI): -82 (-152 to -12)** VA Perspective A: 338 ± 291 B: 308 ± 298 Difference (95% CI): -30 (-79 to 20),NS
Eminovic, 2009[146]; 2010[147] Netherlands 35 general practices 2 hospitals	RCT; Economic evaluation Moderate Asynchronous One time A: Not telehealth, n=304 B: Telehealth, n=301	RECOVERED AT 1 MONTH A: 4.1% B: 20% Preventable consultation **A: 18.3%.** **B: 39.0%** **Difference: 20.7% (95% CI 8.5% to 32.9%)** General satisfaction A: 3.8 B: 3.8	Mean total costs (95% CI) A: €354.0 (228.0 to 484.0) B: €387 (281.0 to 502.5) Mean out-of-pocket cost, (95% CI) A: €16.3 (8.1 to 24.5) B: €12.4 (5.4 to 19.6) Mean travel costs A: €15.2 B: €11.5 Mean employer costs, (95% CI) A: €47.3 (18 to 83.1) B: €46.2 (18.4 to 86.1) Savings when distance is >75 km or when consultation volume can be increased >37%
Ferrandiz, 2007[148] Seville, Spain 6 primary care 1 University hospital	Prospective cohort and pre-post Moderate Asynchronous One time A: Not telehealth, n=NR B: Telehealth, n=NR	Mean consultation to operation wait time (95% CI), in days **A: 60.6 (56.2 to 64.9)** **B: 26.1 (24.5 to 27.7), p<0.001** Accuracy of telediagnoses **k=0.86 (95% CI 0.83 to 0.89)** Agreement rate between the surgical technique planned through teleconsultation and technique performed: k=0.75 (95% CI 0.04 to 0.79)	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical and Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Gilmour,1998[199] UK 3 health centers 3 hospitals	Prospective cohort High Real time One time A: Not telehealth, n=NR B: Telehealth, n=NR	Investigations requested after consultations: no difference Followup arrangements: no difference ***Definitive diagnosis made:*** ***A: 97%*** ***B: 60%, p=0.002*** 81% management plan correct	NR
Hsiao, 2008[65] CA, United States 1 VA Medical Center 3 remote primary care clinics	Retrospective cohort Moderate Asynchronous One time A: Not telehealth, n=77 B: Telehealth, n=92	Mean days to initial evaluation **A: 48** **B: 4, p<0.0001** Mean days to biopsy **A: 57** **B: 38, p=0.034** Mean days to surgery **A: 125** **B: 104, p=0.006**	NR
Krupinski, 2004[75] AZ, United States 1 medical center 1 hospital	Retrospective cohort High Asynchronous One time A: Not telehealth, n=50 B: Telehealth, n=50	Recorded notes of action **A: 12%** **B: 43% z=3.14, p<0.01** Patients seen again by referring clinician after referral for same problem A:10% B: 8%, z=0.40, NS	NR
Lamminen, 2001[160] Finland 1 health center 1 University hospital	Economic evaluation High Real time One time A_1: Ophthalmology, n=85 A_2: Dermatology, n=64 B_1: Tele-Ophthalmology, n=24 B_2: Tele-Dermatology, n=18	NR	Consultation cost per patient: A_1: €126 A_2: €143 B_1 and B_2: €9,760 + 37.6 per patient Number of teleconsultations to break even: 110 in ophthalmology and 92 in dermatology
Lim, 2012[222] Waikato, New Zealand 1 community clinic 1 hospital clinic	Prospective cohort High Asynchronous One time A: Face to face, n=100 B: Telehealth, n=200	Mean waiting time, in days A: 114 days B: 39 days Patient satisfaction survey: 1 to 5 (5=excellent) Overall experience A: 3.8 B: 4.5	Financial cost/patient NZ$ A: $306 B: $264

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical and Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Loane, 2000[202] Northern Ireland, UK[a] 4 health centers 2 hospitals	RCT High Real-time and asynchronous One time A: Usual care, n=102 B_1: Telehealth video, n=102 B_2: Telehealth store and forward, n=96 (from original 102 telehealth video group)	Required at least one subsequent hospital appointment A: 45% B_1: 46% B_2: 69%	NR
Loane, 2001[223] New Zealand[a] 2 rural health centers 1 hospital	Economic evaluation Moderate Real time Continuing A: Not telehealth, n=94 B: Telehealth, n=109	Average consultation time, in minutes A: 21.6 B: 20.0	Total cost of dermatologist's time spent in performing consultations, in NZ $ A: $5,724 B: $6,163 Cost of patient time to attend consultations, in NZ $ A: $7,838 B: $1,846 Total travel costs for patients to attend consultations, in NZ $ A: $16,519 B: $877 Total societal costs of consultations, in NZ $ A: $30,081 B: $34,346
Loane,1999[201] Northern Ireland, UK 4 health centers 2 hospitals	RCT High Real time One time A: Not telehealth, n=103 B: Telehealth, n=61	Mean time, in minutes Total time, including waiting and travel A: 84.4 B: 59.3 Wait time A: 20 B: 5.4 Consultation time A: 16.8 B: 22.0 Total travel time A: 48.0 B: 31.6 Mean travel distance, in km A: 25.4 B: 10.4	NR

Author, Year **Location** **Number of Sites**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison, n**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Mahendran, 2005[213] England, UK	Pre/post High Asynchronous One time A: Pre-telehealth, n=163 B: Post-Telehealth, n=163; same as group A	Agreement on management plan 55% Managed appropriately 13% required reassurance only 9% recommended further review 33% minor operation Not adequately managed by telehealth 15% poor image quality 20% complex and required in-person exam and consent 10% recommended unnecessary or wrong surgery	NR
Moreno-Ramirez, 2009[166] Spain 12 Primary Care Centers 1 hospital	Economic evaluation Low Asynchronous One time A: Not telehealth, n=2,009 B: Telehealth, n=2,009	NR	Unit cost per patient **A: €129.37** **B: €79.78, p=0.005** Cost ratios A to B Overall: 1.62 For benign lesions: 3.29
Nordal, 2001[169] Norway 1 municipality 1 hospital	Retrospective cohort Moderate Real time One time A: Not telehealth, n=NR B: Telehealth, n=NR	Dermatologist satisfaction 22% favored face-to-face 14% favored telehealth Patient reports 61% no disadvantage to video 18% reduced contact with specialist 7% discomfort being recorded 86% favored having GP present for teledermatology	NR
Pak, 2007[98]; Pak, 2009[99] TX, United States	RCT and economic evaluation Moderate Asynchronous One time A: Not telehealth, n=236 B: Telehealth, n=272	CHANGES IN CLINICAL COURSE Improved A: 65% B: 64% No change A: 32% B: 33% Worse A: 3% B: 4%, NS	Total costs, in USD A: $129,133 B: $119,402 Direct costs, in USD A: $98,365 B: $103,043 Lost productivity, in USD A: $30,768 B: $16,359 Telehealth is less expensive when including lost productivity

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical and Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Piette, 2017[175] Paris, France 39 GPs	RCT Low Asynchronous Continuing A: Usual care, n=50 B: Telehealth, n=53	Median delay for specialist response/treatment initiation **A: 40 days** **B: 4 days** **Adjusted HR: 2.55, p<0.011** Patient global satisfaction, n (%) Very satisfied or satisfied A: 47 (94%) B: 45 (84.9%) Unsatisfied or very unsatisfied A: 3 (6%) B: 8 (15.1%) p=0.99 Patient satisfaction, time to treatment Very satisfied or satisfied A: 13 (26%) B: 38 (71.7%) Unsatisfied or very unsatisfied A: 37 (74%) B: 15 (28.3%) p=0.20	NR
Whited, 2002, 2003, 2004[126-128] NC, United States 2 VA hospitals 3 outpatient clinics	RCT; Economic evaluation Moderate (2003 and 2002) /High (2004) Asynchronous One time A: Not telehealth, n=140 B: Telehealth, n=135	Mean days ± SD (Median) Time to initial definitive intervention intention to treat analysis: **A: 114.3 ± 72.3 (127)** **B: 73.8 ± 71.6 (41), p=0.0001** Actual clinic visit analysis[b], mean days ± SD **A: 135.6 ± 94.3** **B: 93.4 ± 96.1, p=0.0027** Referring clinician overall satisfaction with consult Agree: A: 23% B: 92% Neutral: A: 42% B: 5% Disagree: A: 35% B: 3% Patient overall satisfaction with TH consultation outcome: 82% Preferred TH: 42% Preferred usual care: 37% Neutral, no preference: 22%	Total annual cost[c], in USD A: $116,416 B: $198,016 Per patient[c] A: $21.40 B: $36.40 Incremental cost per patient of teledermatology[c] +$15.00

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical and Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Whited, 2013[129]; Whited, 2013[130] United States 2 community based outpatient clinics 1 hospital 2 medical centers	RCT Moderate Asynchronous One time A: Not telehealth, n=136 B: Telehealth, n=125	BASELINE TO 9 MONTHS Resolved or improved A: 72% B: 72% Unchanged - not clinically relevant: A: 11% B: 10% Unchanged - clinically relevant: A: 13% B: 10% Worse A: 4% B: 8% NS	NR
Whited, 2013[129]; Whited, 2013[130] (continued) United States 2 community based outpatient clinics 1 hospital 2 medical centers	RCT Moderate Asynchronous One time A: Not telehealth, n=136 B: Telehealth, n=125	Mean change in quality of life Skindex-16 score[d] ± SD: Composite Baseline to 3 months A: -5.8 ± 19.1 B: -7.8 ± 21.9, p=0.39 Baseline to 9 months A: -13.2 ± 21.6 B: -12.0 ± 24.5, p=0.66	NR

CI = confidence interval; EU = euro; GP = general practitioner; HR = hazard ratio; k = kappa; NR = not reported; NS = not significant; NZ = New Zealand dollar; RCT = randomized controlled trial; SD = standard deviation; TH = telehealth; USD = United States dollars; VA = Veterans Affairs

[a] Potentially overlapping populations

[b] Date to clinic visit is used if telehealth patient went to clinic despite no recommended visit

[c] Extrapolated cost data from 275 patients to the total population of patients serviced by dermatology clinic in 2001, n=5,440

[d] Negative indicates improvement

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Wound Care

Six studies reported on different approaches to telehealth for wound care (Table 14). The studies consisted of small numbers (all <200) of home care, wound clinic, long-term care, and primary care patients. The five studies reporting clinical outcomes used different approaches to telehealth (one real time video[256] and four image and/or record review[180,190,228,251]) but all reported clinical benefit, in terms of better healing or fewer amputations with telehealth expert consultations than with usual care. In all of these studies, consultations continued over the course of the patients' treatment for the wound or ulcer. Costs of telehealth consultations were lower than the cost of in-person consultations, and overall healthcare costs were also lower.

Table 14. Wound care telehealth consultations: selected outcomes

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Cost/Revenue Outcomes
Kobza, 2000[256] United States Hospital based home care agencies number NR	Before-after High Real time Continuing A: Before telehealth, n=120 B: After telehealth, n=76	Rate of healing Stage II pressure ulcer A: 34% B: 83% Stage IV pressure ulcer A: 10% B: 38% Healing rate for all wounds improved with telehealth except stage III pressure ulcers Healing time decreased in all categories with telehealth Discharge with healed wounds: A: 37% B: 58%	Mean home visits per wound patient A: 60 B: 33 Hospitalizations A: 18% B: 6%	NR
Santamaria, 2004[228] Kimberly, Australia 4 clinics	RCT High Asynchronous Continuing A: Not telehealth, n=43 B: Telehealth, n=50	Healing rate, per week **A: -4.9%** **B: 6.8%, p=0.012** Amputation A: 6 B: 1 Mortality A: NR B: 2	NR	Total Cost[a], in AUD A: $862,161 B: $670,226
Smith-Strom, 2018[180] Norway 3 clinics	RCT Low Asynchronous Continuing A:Usual care, n=88 B:Telehealth, n=94	Mortality A: 5.7% B: 5.3% Mean difference (95% CI) -0.4% (–6.5 to 5.7) Amputations A: 14.8% B: 6.4% Mean difference (95% CI) **-8.3% (–16.3 to –0.5)**	Ulcers healed A: 76.1% B: 79.8% Mean time to healing, in months ± SD A: 3.8 ± 3.4 B: 3.4 ± 3.2 Mean difference (95% CI): -0.43 (–1.50 to 0.65)	

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes Harms	Intermediate Outcomes	Cost/Revenue Outcomes
Specht, 2001[118] IA, United States 1 long term care facility	Economic evaluation Moderate Asynchronous Continuing A: Not telehealth, n=NR B: Telehealth, n=NR	NR	Mean time spent on appointment A: 8.5 hours B: 20 minutes	Mean cost consultation, in USD A: $246.28 B: $136.16
Stern, 2014[251] Ontario, Canada 12 long term care facilities	Before-after (stepped wedge) Moderate Asynchronous Continuing Total wounds analyzed: 259 among 137 long-term care residents A: Not telehealth, n=unclear B: Telehealth, n=unclear	Mean rate of healing 1.0058 times slower in intervention period (95% CI 0.985 to 1.027), p=0.6 Time to healing Intervention HR: 1.48 (95% CI 0.79 to 2.78), p=0.22	Visual analogue scale wound-specific pain scores Estimated mean 0.39 units higher during intervention period (95% CI -0.55 to 1.34), NS Hospitalizations Estimated mean rate 1.2 times higher during intervention (95% CI 0.62 to 2.36), NS ED visits Estimated mean rate 1.3 times larger during intervention (95% CI 0.58 to 2.90), NS	Telehealth reduced direct care costs by CAD $649 per resident[b]
Zarchi, 2015[190] Denmark 4 home-care organizations	Prospective cohort Moderate Asynchronous Continuing A: Not telehealth, n=40 B: Telehealth, n=50	Adjusted telehealth hazard ratio (95% CI), p-value **1-Year wound healing** **2.19 (1.15 to 4.17), p=0.017** Complete wound healing at 1-year followup A: 45% B: 70%	NR	NR

AUD = Australian dollars; CAD = Canadian dollars; CI = confidence interval; ED = emergency department; NR = not reported; NS = not significant; RCT = randomized controlled trial; SD = standard deviation; USD = United States dollars
[a] 43 subjects per group were used in the costing analysis to eliminate the effect of the larger group of intervention patients
[b] 42 participants crossed study phases
Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Ophthalmology

None of the six ophthalmology studies reported clinical outcomes (Table 15). Two studies reported minimal information on telehealth and nontelehealth costs in ophthalmology with one reporting no difference in the per visit cost and estimating the only savings were from patients avoiding travel,[185] and the second reported savings due to avoided transfers to a distant hospital for evaluation.[215] Telehealth did reduce the number of visits to a surgeon in a study of cataract management,[188] and two other studies reported increases in screening completion rates.[122,219]

Table 15. Ophthalmologic telehealth consultations: selected outcomes

Author, Year Geographic Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Intermediate Outcomes	Cost/Revenue Outcomes
Blackwell, 1997[215] Queensland, Australia 1 remote hospital 1 specialist hospital	Before-after High Real time One-time A: Before telehealth, n=315 B: After telehealth, n=264; 24 received telehealth	Patients transferred for urgent care A: 17 B: 4	Amount hospital saved due to transfers avoided, NZ $ $6,500
Crossland, 2016[219] Rural, regional, urban Australia Telehealth 5 without ophthalmologic location NR	Prospective cohort High Unclear Continuing A: Usual care, n=577 B: Telehealth, n=447	Screening rates A: 22% to 53% B: 100% Diagnosed with mild-moderate diabetic retinopathy A: 5% B: 9% Appropriate followup A: 29% B: 95%	NR
Taylor, 2007[122] TN, United States 1 community clinic 1 ophthalmic clinic	Before-after High Asynchronous One-time A: Before telehealth, n=294 B: After telehealth, n=201	Screen completion A: 31% B: 100%	NR

Author, Year Geographic Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Intermediate Outcomes	Cost/Revenue Outcomes
Tuulonen,1999[185] Oulu, Finland 1 rural healthcare center 1 University clinic	Before-After Moderate Real time One-time A: Before telehealth, n=41 B: After telehealth, n=29	Mean time including travel, in hours **A: 8.5** **B: 2.0, p=0.0001** Mean time absent from work, A: 6.6 B: 3.3, test NR Very satisfied with overall care A: 69% B: 86%, NS Selecting TH for next visit A: 81% B: 96%, NS Want TH for next visit due to reduced travel A: 97% B: 86%, NS	Overall cost of visits, in USD A: $111 B: $110, no difference Reduced travel saved $55 per visit for patients, not included in overall cost.
Wilson, 2005[132] AZ, United States 2 primary care medical clinics	Before-after Moderate Asynchronous One-time A: Before telehealth, n=2,910 B: After telehealth, n=4,068	Retinal exam rate (95% CI) for diabetic patients **A: 50% (44% to 56%)** **B: 75% (70% to 80%), p<0.0001** Rate of laser therapy for diabetic retinopathy A: 19.6 per 1,000 patients with diabetes B: 29.5 per 1,000 patients with diabetes 51% increase in laser treatment rate.	NR
Zahlmann, 2002[188] Germany 5 ophthalmologists	Prospective and retrospective cohort High Both (asynchronous followed by real time) One time A: Not telehealth, n=20 B: Telehealth, n=42	Mean number of visits To referring ophthalmologists A: 1.85 B: 2.02, NS To surgical ophthalmologists **A: 2.05** **B: 1.07, p=0.0001** Mean travel time ± SD, in hours A: 2.53 B: 2.17, NS Total ophthalmologist ± SD, in hours **A: 3.03 ± 0.73** **B: 2.08 ± 0.61, p=0.0001** Mean satisfaction with overall treatment (10 point scale; 0=very positive) **A: 0.95** **B: 0.14, p=0.019**	NR

CI = confidence interval; NR = not reported; NS = not significant; NZ = New Zealand dollars; SD = standard deviation; TH = telehealth; USD = United States dollars

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Orthopedics

Six articles reported the results of four studies about telehealth in orthopedic consultations (Table 16). One study used consultations and image transmission to assess fractures,[158] one used telehealth consultations to screen electronic records and recommend treatments for osteoporosis,[79] and two studies evaluated a range of orthopedic conditions encountered in primary care that would be referred to orthopedic surgeons.[151,153] None of these studies reported clinical outcomes; they all reported either intermediate or economic outcomes. One of these found that using telehealth to transmit records and x-rays resulted in fewer missed fractures and fewer unnecessary hospital trips.[158] Availability of orthopedic video consultations with primary care practices resulted in lower costs, successful exams, and management plans that were not significantly different.[151,187] A US VA project had specialists review records of patients with recent fractures and write recommendations about medications and bone density testing for primary care clinicians. These consults conducted via the electronic record significantly increased adherence to guidelines for recommended treatments.[79]

Table 16. Orthopedic telehealth consultations: selected outcomes

Author, Year **Location** **Number of Sites** **Number of Patients**	**Study Design** **Risk of Bias** **Timing** **Consultation** **Frequency** **Comparison, n**	**Intermediate Outcomes**	**Cost/Revenue**
Harno, 2001[151] Finland 2 hospitals	Economic evaluation High Real time One time A: Not telehealth, n=168 B: Telehealth, n=57	Mean time of visit, in minutes: A: 12 B: 13 Diagnosis revised A: 16% B: 12% Decision to perform surgery A: 38% B: 53%	Total cost per patient A: €154 B: €41 Outpatient is 45% higher Marginal cost decreased 48 Euros for each visit
Haukipuro, 2000[153] Ohinmaa, 2002[170] Vuolio 2003[187] (1-year followup) Finland 1 outpatient clinic	RCT, Economic evaluation High Real time One time A: Not telehealth, n=69 B: Telehealth, n=76	Mean time of visit including travel, in hours A: 8 B: 1.5 Mean distance travelled, in km A: 170 B: 8 Success of exam, rated at least good by practitioner A: 99% of cases B: 80% of cases Management plan for first admission patients Operation: A: 54% B: 64% Followup or further examinations: A: 18% B: 18% Problem solved at 1st visit: A: 28% B: 18%, NS	Total cost per patient, including travel and indirect costs based on 100 patients A: €114 Euros B: €88 Euros Difference dependent on patient travel: Breakeven point: 80 cases at160 km 200 case at 80 km

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Intermediate Outcomes	Cost/Revenue
Jacobs, 2015[158] Ameland, Netherlands 2 general practices	Before-after High Asynchronous One time A: Before telehealth, n=312 B: After telehealth, n=482	Referral to hospital A: 26.6% B: 8.1% Unnecessary trips to the hospital A: 13.1% B: 0.4% Missed fractures A: 13.6% B: 1.7%	NR
Lee, 2014[79] United States 3 VA Medical Centers	Prospective cohort High Asynchronous One time A: Not telehealth, n=NR B: Telehealth, n=NR	Difference before and after introduction of telehealth Change in treatment rates for bisphosphonates **A: 1.8% decrease** **B: 2.5% increase, p=0.02** Change in treatment rates for calcium and/or vitamin D **A: 1.2% decrease** **B: 13.9% increase, p<0.01**	NR

NR = not reported; NS = not significant; RCT = randomized controlled trial; VA = Veterans Affairs
Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Dental

Four studies, all conducted in Europe, evaluated the use of telehealth for dental consultations (Table 17). Three focused on specific issues (dental implants,[167] temporomandibular joint [TMJ] disorders,[177] and impacted molars[154]), and the fourth used video to replace in-person visits for restorative dentistry.[205] The results were not robust, and no clinical outcomes were reported. The strongest result reported is that telehealth consultations resulted in a significantly shorter time to treatment for TMJ (76.8 days versus 2.3).[177] The single cost analysis determined that telehealth visits cost less than hospital visits but more than outreach visits (i.e., when dentists go to communities in need of services).[205]

Table 17. Dentistry telehealth consultations: selected outcomes

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Intermediate Outcomes	Cost/Revenue Outcomes
Herce, 2011[154] Seville, Spain 4 primary care 1 university hospital	Prospective cohort High One-time Store and forward A: Usual care n=2,550 B: Telehealth n=97	Time to care outcome measured differently in A and B Mean days to intervention (95% CI) **A: 28 (24.51 to 29.6)** Mean days to be added to surgical wait list **B: 3.33 (2 to 4.65), p<0.001** Cancellation rate on day of surgery, (95% CI) A: 8.85% (5.62 to 11.81%) B: 7.8% (3.8% to 10.5%), p=0.76	NR
Nickenig,2008[167] Germany 1 dental clinic 2 external experts	Prospective cohort Moderate Real time One time A: No telehealth, n=772 B: Telehealth, n=85	Changes in diagnosis A: 4% B: 0% Change in prosthodontic protocol A: 7% B: 3% Change in number and position of implants A: 19% B: 15%	NR
Salazar-Fernandez, 2012[177] Seville, Spain 1 hospital 10 Primary Cares	Prospective cohort Clinical outcomes: Moderate Economic outcomes: High Asynchronous Continuing A: No telehealth, n=710 B: Telehealth, n=342	Patients referred to maxillofacial surgery A: 11.6% B: 10.2%, NS Resolved consultation A: 74.5% B: 88%, NS Second consultations A: 4.6% B: 0.8%, NS Mean lost working hours **A: 32.24** **B: 16.80, p=0.01** Mean time to treatment, in days **A: 78.6** **B: 2.3, p<0.001** Complaints A: 0.8% B: 0.3%, NS	NR
Scuffham,2002[205] UK 2 general dental practices 1 hospital	Economic evaluation Moderate Real time One time A_1: No telehealth, outreach visits, n=NR A_2: No telehealth, hospital visits, n=NR B: Telehealth, n=NR	NR	Total variable costs per patient, in GBP A_1: £233.86 A_2: £1,181.52 B: £404.10 Total societal costs, in GBP A_1: £403.11 A_2: £1,181.51 B: £582.69

CI = confidence interval; GBP = British pound; NR = not reported; NS = not significant
Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Cancer

We identified ten articles reporting on nine studies about using telehealth for consultations in cancer care (Table 18). In these studies, telehealth was either used to convene virtual tumor boards and interdisciplinary meetings or to allow oncologists to confer with patients and a local physician to plan for cancer care provision in a remote or rural area. All of these studies used video to communicate, and records and images were shared electronically.

Outcomes in included cancer studies varied. A study of remote oncology guidance for chemotherapy was the only one to measure patient outcomes and reported the rate of serious side effects per patient was lower in the telehealth group.[234] In the other studies, the effectiveness of cancer teleconsultations was evaluated in terms of care processes, satisfaction, and cost. In one study, using a referral institution and nine other hospitals in the US VA, telehealth provided more comprehensive care and avoided travel, but the time from referral to treatment was not significantly different.[112] In a cluster RCT of breast cancer planning meetings in Scotland, telemedicine was less expensive, and the ratings of participants were not different except that face-to-face meeting participants felt a consensus was reached more frequently than did telehealth participants.[200] Likewise, a study conducted in Sweden reported similar ratings of communication by telehealth participants as in face-to-face and in-person tumor boards, similar presentation time, less time traveling and waiting, and overall similar costs because equipment costs balanced out the reduction in travel costs.[181,182] Another study in Australia reported net savings as the travel avoided exceeded the cost of telehealth equipment.[230] In two studies the impact of telemedicine on time to treatment is less clear; one reported shorter mean time to initial evaluation (18 vs. 21 days) but longer time from evaluation to surgery (28 vs. 48 days)[32] while the second found no significant difference in the time from visit to surgery.[198]

Table 18. Cancer telehealth consultations: selected outcomes

Author, Year **Location** **Number of Sites** **Number of Patients**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison, n**	**Clinical Outcomes** **Intermediate Outcomes** (Clinical outcomes are <u>UNDERLINED AND CAPITALIZED</u>)	**Cost/Revenue Outcomes**
Beswick, 2016[32] CA, United States 1 Medical Center 2 remote sites	Prospective cohort High Real-time Continuing A: Not telehealth, n=26 B: Telehealth, n=15	Mean time from initial referral to evaluation (range), in days A: 21 (6 to 61) B: 18 (6 to 53) Mean time from evaluation to surgery (range), in days A: 28 (0 to 55) B: 48 (11 to 101) Mean time from referral to surgery (range), in days A: 49 (22 to 83) B: 54 (17 to 108)	NR
Chan, 2015[234] Queensland, Australia	Retrospective cohort Moderate Real time and asynchronous Continuing A: Usual care, n=117 B: Teleoncology, n=89	<u>SERIOUS SIDE EFFECTS</u> Rate per patient A: 9.5% B: 4.4% Inpatient hospital admissions A: 35.3% B: 28%	NR

Author, Year **Location** **Number of Sites** **Number of Patients**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison, n**	**Clinical Outcomes** **Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Davison, 2004[198] London, UK 2 hospitals	Before-after High Real-time One time A: Before telehealth, n=50 B: After telehealth, n=62	Mean time from initial clinic visit to surgery ± SD, in days A: 69 ± 38 B: 54 ± 26, p>0.05 Thoracotomy resections, per year A: 14.7 B: 19, 30% increase	NR
Doolittle, 1997[52] MO, United States 3 Oncology clinics	Economic evaluation High Real-time Unclear A_1: No telehealth, outreach clinic, n=81 A_2: No telehealth, traditional clinic, n=NR B: Telehealth, n=103	NR	Average cost per visit, USD A_1: $897 A_2: $812 B: $149
Jue, 2017[70] FL, United States 1 VA Medical Center Several regional centers	Retrospective cohort Moderate Real time Continuing A: Without telehealth, same patients B: Telehealth, n=296	Reduction in travel distance: 80.7%	Total cost savings[a] in USD: $155,627.20
Kunkler, 2007[200] Edinburgh, Scotland 2 general hospitals 1 cancer center	RCT High Real time One time A: Not telehealth, n=195 B: Telehealth, n=278	Mean response of multidisciplinary team members on 5 point scale (5=strongly agree) Consensus reached by all parties involved **A: 4.20** **B: 4.06, p=0.048** Confident decision was in the best interest of the patient A: 4.16 B: 4.07, NS Discussion of patient appropriately shared by participants A: 4.17 B: 4.04, NS Compliance of decisions with guidelines on best practice at meeting A:100% of discussions B: 99% of discussions	Telemedicine meetings became cheaper than standard meetings if there were approximately 40 meetings per year.

Author, Year **Location** **Number of Sites** **Number of Patients**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison, n**	**Clinical Outcomes** **Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Salami, 2015[112] United States 1 VA referral institution 9 VA Medical Centers	Retrospective cohort Moderate Real time One time A: Not telehealth, n=68 B: Telehealth, n=48	Comprehensive clinical evaluation prior to initiation of treatment **A: 64.7%** **B: 91.7%, p=0.001** Guideline driven clinical evaluation prior to initiation of treatment **A: 75%** **B: 100%, p<0.001** Assessment of tumor stage **A: 73.5%** **B: 91.7%, p=0.002** Assessment of transplant eligibility **A: 85.3%** **B: 95.8%, p=0.006** Median time from referral to evaluation, in days **A: 39** **B: 23, p<0.001** Median time from referral to treatment initiation, in days A: 63 B: 55, p=0.152 Median distance travelled by patient to receive evaluation, in miles **A: 683** **B: 0, p<0.001**	NR
Stalfors, 2003[182] Sweden 3 district hospitals 1 Regional Hospital	Prospective cohort High Real time One time A: Not telehealth, n=46 B: Telehealth, n=58	Mean time spent including travel and waiting time ± 95% CI, in hours A: 8.9 ±0.8 B: 3.4 ± 0.5 Mean presentation time ± 95% CI, in minutes A: 14.2 ± 1.4 B: 13.3 ± 2.03 Felt meeting went too fast A: 23% B: 42% Patient rating of information received: Very good ***A: 69%*** ***B: 44%, p<0.05*** Good **A: 26%** **B: 44%, p<0.05** Insufficient: A: 0% B: 4%, NS Bad: A: 0% B: 0%	NR

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes Intermediate Outcomes (Clinical outcomes are UNDERLINED AND CAPITALIZED)	Cost/Revenue Outcomes
Stalfors, 2005[181] Sweden 1 regional hospital 2 district general hospitals	Economic evaluation Moderate Real time One time A: Not telehealth, n=50 B: Telehealth, n=68	NR	Combined cost, in SEK A: 2,267 B: 2,036, NS Direct medical, in SEK A: 576 B: 1,550[b] Direct nonmedical, in SEK A: 886 B: 176 Indirect nonmedical, in SEK A: 805 B: 310
Thaker, 2013 [230] Queensland, Australia 1 cancer center 6 rural centers	Economic evaluation Moderate Real time Continuing A: Not telehealth, n=NR B: Telehealth, n=147	NR	In AUD Net savings: $320,118 Total cost of teleconsults: $442,276 Estimated travel expense avoided: $762,394 Travel costs for patients and escorts: $658,760 Aeromedical retrievals : $52,400 Travel for specialists: $47,634 Accommodation costs for a proportion of patients: $3,600 Telehealth costs would need to increase 72% to negate savings.

Abbreviation: AUD = Australian dollars; CI = confidence interval; NR = not reported; NS = not significant; RCT = randomized controlled trial; SD = standard deviation; SEK = Swedish Krona; VA = Veterans Affairs; UK = United Kingdom; USD = United States dollars

[a] Combination of commuting and hotel fees averted

[b] SEK 1,288 is equipment cost + hypothetical avoided costs reported in article not included

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant

Psychiatry

Five articles reported the results of two studies of telehealth programs used to provide consultations for the treatment of depression[46,57-59] and one study of consultations for treatment of posttraumatic stress disorder (PTSD)[56] in adults (Table 19). Telehealth was used in all of the programs to facilitate a multifaceted comprehensive treatment program. The telehealth versions of these evidence-based treatment programs were designed to expand access to mental healthcare in rural areas or to practices with no mental health services. The studies randomized either practices or patients to the telehealth program or usual care. All three programs reported improvement in clinical outcomes such as decreases in symptoms or higher remission rates of systems after 6 months or a year. Intermediate outcomes, such as medication adherence and satisfaction, were also higher. The one analysis of costs found an expected increase in primary care costs for depression treatment, along with an increase in specialty physical care costs, which were attributed to case management referrals for pain management and management of other comorbid chronic conditions.[57] The same study also found that minority patients responded to treatment at higher rates using telehealth, suggesting that telehealth as part of collaborative care could help ameliorate racial disparities in care.[46]

Table 19. Psychiatry telehealth consultations: selected outcomes

Author, Year **Location** **Number of Sites** **Number of Patients**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical Outcomes**	**Intermediate Outcomes**
Fortney, 2007[58]; 2011[57]; Davis, 2011[46] South-central United States 7 Veterans Administration primary care centers	RCT: Moderate Economic evaluation[57]: High Real time and asynchronous Continuing A: Not telehealth, n=218 B: Telehealth, n=177	Depression treatment response in telehealth **At 6 months: OR=1.94, p=0.02** At 12 months: OR=1.42, p=0.18 Minority vs. Caucasian A: 18% vs. 8%, NS **B: 42% vs. 19%, p=0.004** **Minority response, Caucasian reference** **AOR=6.0, p=0.01** Remission of depression At 6 months: OR=1.79, p=0.14 **At 12 months: OR=2.39, p=0.02** Health status indicators Change in PCS, group difference At 6 months: 0.31, NS At 12 months: 1.09, NS Change in MCS, group difference At 6 months: 2.46, NS **At 12 months: 3.90, p<0.01** Change in QWB,: group difference **At 6 months: 0.037, p<0.01** At 12 months: 0.005, NS	Medication adherence at specified month, OR **6 months: 2.11, p=0.04** **12 months: 2.72, p<0.01** Treatment satisfaction at specified month, OR **6 months: 1.83, p=0.01** **12 months: 1.71, p=0.03** Economic outcomes Expected increase in primary care: **Encounters: Marginal effect 0.34, p=0.004** **Costs: Marginal effect $61.4, p=0.013** Unexpected increase in specialty physical healthcare: ***Encounters: Marginal effect 0.42, p=0.001*** ***Costs: Marginal effect $490.60 p=0.003***
Fortney,2013[59] AR, United States 5 Federally Qualified Health Centers	RCT Moderate Real time Continuing A: Not telehealth, n=185 B: Telehealth, n=179	Response to treatment **AOR: 7.74, p<0.0001** Remission **AOR: 12.69, p<0.0001** Adherence AOR: 1.22, NS Any specialty mental health visits AOR: 0.56, NS Primary care visits AIRR: 1.16, NS Depression-related primary care visits AIRR: 0.99, NS	Satisfaction, AOR At baseline: 1.08, NS **At 6 months: 2.76, p=0.0012** **At 12 months: 1.99, p=0.0313** At 18 months: 1.67, NS Adjusted group difference in depression severity Baseline: -0.04, NS **At 6 months: -0.50, p<0.0001** **At 12 months: -0.49, p<0.0001** **At 18 months: -0.33, p<0.0001**

Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical Outcomes	Intermediate Outcomes
Fortney, 2015[56] United States 11 Veterans Administration outpatient clinics	RCT Moderate Real time Continuing A: Not telehealth, n=132 B: Telehealth, n=133	Mean decrease in PTSD symptom severity[a] **6 month: beta= -3.81, p=0.002** **12 month: beta= -2.49, p=0.04** Mean reduction in depression severity[a] **6 months: beta= -0.25, p=0.01** **12 months: beta= -0.23, p=0.01** Physical concerns[a] **6 months: beta=2.67, p=0.020** 12 months: beta=0.97, NS	Adherence to medication, OR 6 months: 0.86, NS 12 months: 0.91, NS Any PTSD medication prescriptions, OR 6 months: 2.98, NS Prescribed Prazosin prescription, OR 6 months: 2.43, NS Percent attending ≥8 psychotherapy sessions: A: 5.3% B: 27.1% Percent receiving cognitive processing therapy: A: 12.1% B: 54.9% Mean number of cognitive processing therapy sessions attended: **A: 0.8** **B: 4.2** **RR 9.51, p<0.001**

AIRR = adjusted incidence rate ratio; AOR = adjusted odds ratio; MCS = Mental Component Summary; NS = not significant; OR = odds ratio; PCS = Physical Component Summary; PTSD = post-traumatic stress disorder; QWB = quality of well-being score; RCT = randomized controlled trial; RR = risk ratio

[a] PTSD severity measured by Posttraumatic Diagnostic Scale, depression severity measured by Hopkins Symptom Checklist, and physical concerns measured by Physical Component Summary

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant

Infectious Disease

Four studies addressed the use of telehealth in infectious diseases (Table 20). Two of these studies assessed using telehealth to advise on treatment for patients with hepatitis C,[30,108] one studied providing subspecialty consultations about patients with HIV in prison,[134] and one evaluated a system of e-consults for a range of infectious diseases.[119] Three of the studies used video for real time communication[30,108,134] while one incorporated the consult into the electronic health record and allowed the specialists to review and respond when they were available.[119] All four studies were conducted in the United States.

Clinical outcomes focused on viral load or suppression and were not significantly different in the two studies of hepatitis C.[30,108] The HIV study reported significantly better outcomes after six visits.[134] An e-consult system or various infectious diseases reduced time to completion of the consultations from a mean of 16.5 days to about one half day (0.6 days).[119] None of these studies reported economic outcomes.

Table 20. Infectious disease telehealth consultations: selected outcomes

Condition or Specialty	Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes
Hepatitis C	Rossaro, 2013[108] CA, United States 1 physician 5 telemedicine clinics 1 university clinic	Retrospective cohort Moderate Real time Continuing A: No telehealth, n=40 B: Telehealth, n=40	Sustained virologic response A: 43% B: 55%, NS	Completion of therapy, n (%) **A: 21 (53%)** **B: 31 (78%), p=0.03** Mean number of weeks of therapy A: 30.2 B: 36.7, NS Mean number of visits **A: 2.2** **B:19.6, p<0.0001** Mean number of visits per week **A: 0.07** **B: 0.61, p<0.001** Stopped therapy due to depression A: 2.5% B: 10.0% Anti-depressant medication A: 17.5% B: 35.0% Reasons for early termination of therapy: A: Severe anemia, skin rash, and weight loss B: Severe depression, NS
Hepatitis C	Arora, 2011[30] NM, United States 1 university clinic 21 rural clinics	Prospective cohort Low Real time Continuing A: No telehealth, n=146 B: Telehealth, n=261	Sustained virologic response All genotypes A: 57.5% B: 58.2% Difference in response, percentage points (95% CI) All genotypes: 0.7 (-9.2 to 10.7), NS Genotype 1: 3.9 (-9.5 to 17.0), NS Genotype 2 or 3: -1.5 (-15.2 to 13.3), NS Sustained virologic response in univariate models OR: 1.03, NS In multivariate models AOR 1.10, NS Serious adverse events **A: 13.7%** **B: 6.9%, p=0.02**	NR

Condition or Specialty	Author, Year Location Number of Sites Number of Patients	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes
HIV	Young, 2014[134] IL, United States 1 Correctional Facility 1 University Telemedicine Clinic	Before-after Moderate Real time Continuing A: Before telehealth, n=514 B: After telehealth, n=687	Complete virologic suppression attained during first 6 visits **A: 59.3%** **B: 91.1%** **OR: 7.0 (95% CI 5.1 to 9.8), p<0.001**	NR
Several	Strymish, 2017[119] MA, United States 5 community-based outpatient clinics 3 main campuses	Before-after High Asynchronous One time A: Before telehealth, n=195 B: After telehealth, n=285	NR	Time to completion for e-consults, mean ± SD **A: 16.5 days ± 12.4** **B: 0.6 days ± 3.6, p<0.05**

AOR = adjusted odds ratio; CI = confidence interval; HCV = hepatitis C virus; NS = not significant; OR = odds ratio; SD = standard deviation

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Consultations for Single Conditions Using Diagnostic Technology

Telehealth was used for consultations for a specific specialty in 10 studies. The consultations involved guiding the use of diagnostic technology and assessing the transmitted information (Table 21). These studies used fetal echocardiograms,[114,140,203,211,258] ultrasound,[37,82] endoscopy,[206,231] and Doppler.[54] Across these studies, telehealth consultations increased timely access to tests and improved management. Costs were lower, but only due to savings for patients. None of these studies reported patient clinical outcomes or harms.

Table 21. Single specialties using diagnostic technology: selected outcomes

First Author, Year Location Specialty and Technology Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Utilization Outcomes	Other Intermediate Outcomes	Economic Outcomes
Bagayoko,2014[258] Mali Obstetrics and fetal echocardiogram 8 clinics	Prospective cohort for patient costs Before-after for health center costs High Real time (presumed, not stated) One time A: No telehealth, n=NR B: Telehealth, n=NR	Attendance rate increase A: 44.9% B: 79.8%	NR	Mean patient savings with telehealth equivalent to USD $25
Boman,2014[140] Sweden Robot assisted echocardiogram and cardiology 1 primary healthcare center, 1 hospital	RCT Moderate Real time echocardiogram; separate followup One time A: No telehealth, n=19 B: Telehealth, n=19	NR	Median process time (IQR), in days **A: 114 (75 to 140)** **B: 27 (12 to 60), p<0.001** Median time from randomization to echocardiography (IQR), in days **A: 86 (66 to 117)** **B: 12 (7 to 29), p<0.001** Median days, (IQR) from clinical exam to GP signing off results A: 6 (4 to 25) B: 5 (0 to 19), NS	NR
Britt, 2006[37] AR, United States Obstetric ultrasound NR >90 health unit sites >54 hospitals 25 clinical sites	Before-after High Real time One time A: Before telehealth, NR B: After telehealth, NR	Mean number of maternal transports A: 278 B: 237 Mean LOS per maternal transport, in days **A: 8.02** **B: 6.06, p=0.003**	Mean number of remote consultations **A: 108** **B: 269, p=0.01** Mean number of phone consultations **A: 55** **B:107, p=0.03** Mean number of phone consults between doctors **A: 55** **B: 107, p=0.03** Mean number of doctors involved in weekly case discussions A: 4.33 B: 8.58	NR

First Author, Year Location Specialty and Technology Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Utilization Outcomes	Other Intermediate Outcomes	Economic Outcomes
Dowie, 2007[211] London, England Fetal and pediatric echocardiography 5 hospitals	Economic evaluation Moderate Real time and store and forward One time A: Conventional referrals n=387 B: Telehealth n=117		EuroQOL EQ-5D (n=37) Mean ± SD A: 0.72 ± 0.22 B: 0.86 ± 0.14	Mean cost of initial consult A: £277 B: £411 After 6-month followup A: £2,172 B: £3,350, NS
Endean,2001[54] KY, United States Vascular surgery with Doppler probe 1 University hospital; 3 clinics	Pre-post Moderate Real time One time A: Pre-telehealth, n=32 B: Post-telehealth, n=32	NR	Mean evaluation time, in minutes A: 19.0 B: 20.6 Overall concordance n, (%) 29 of 32 (91%) Mean physician satisfaction score with TH consult (7-point scale, 7= highest) 5.71 Mean patient satisfaction score comparing TH to conventional from -1 to 1 (1=better) 0.27	NR
Long, 2014[82] AR, United States Obstetric ultrasound NR >90 health unit sites >54 hospitals 25 clinical sites	Retrospective Moderate Real time One time A: No telehealth, n=NR B: Telehealth, n=NR	Pregnancies receiving comprehensive ultrasound[a] **A: 9.6%** **B: 11.3%, p<0.0001** High-risk pregnancies receiving comprehensive ultrasound[a]: **A: 16.9%** **B: 19.9%, p<0.001**	High-risk pregnancies with prenatal care starting each trimester[a] First trimester A: 74.3% B: 75.0% Second trimester: A: 21.5% B: 21.1% Third trimester: A: 4.2% B: 4.0%	NR
McCrossan,2012[203] Northern Ireland, UK Fetal telecardiology 2 hospitals	Prospective cohort Moderate Real time One time A: No telehealth, n=NR B: Telehealth, n=NR	NR	Aggregate mean patient satisfaction, out of 25 points A: 23.2 B: 23.2, NS	Mean difference in days taken off work **0.61 days, p<0.01**

First Author, Year **Location** **Specialty and Technology** **Number of Sites**	**Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison, n**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
Sharma,2003[114] NY, United States Fetal telecardiology 2 hospitals; 1 with expertise, 1 without	Retrospective cohort High Real time One time A: No telehealth, n=195 B: Telehealth, n=34	Mean number of inadequately identified cardiovascular items, out of 31 A: 2.3 items B: 2.1 items, NS	Patient satisfaction (5-point scale, 5=very satisfied) Comfort during exam A: 4.6 B: 4.3, NS Amount of information received during exam **A: 4.6** **B: 4.3, p=0.05** Doctor's willingness to answer questions A: 4.6 B: 4.5, NS Explanation of exam results A: 4.6 B: 4.4, NS Overall quality of care and services A: 4.6 B: 4.5, NS	NR
van der Pol,2010[206] Scotland, Shetland Islands, and Aberdeen, UK Cancer Endoscopy for airway 2 rural clinics 1 mainland clinic	Economic evaluation Moderate Real time One time A: No telehealth, n=NR B: Telehealth, n=NR	NR	NR	Total per patient A: £381 B: £353 Per clinic mean cost Staff A: £351 B: £361 Equipment A: £247 B: £1390 Disposables A: £32 B: £16 Mean cost per patient Staff A: £18 B: £72 Equipment A: £12 B: £278 Disposables: A: £2 B: £3 Travel A: £349 B: £0

First Author, Year Location Specialty and Technology Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Utilization Outcomes	Other Intermediate Outcomes	Economic Outcomes
Xu,2008[231] Queensland, Australia Pediatric ENT with endoscopy 1 hospital; several clinics	Economic evaluation Moderate Real time Continuing A: No telehealth, n=177 B: Telehealth, n=88	NR	Average number of consultations per person A: 1.5 B: 1.3	Total cost per consultation, in AUD A: $155 B: $161 Variable cost per consultation, in AUD A: $155 B: $108 Total annual variable cost, in AUD A: $27,364 B: $14,160 Difference for 265 consultations A vs. B cost-savings AUD $7,621

AUD = Australian dollar; ENT = ear nose and throat; GP = general practitioner; IQR = interquartile range; LOS = length of stay; NR = not reported; NS = not significant; RCT = randomized control trial; SD = standard deviation; TH = telehealth; UAMS = University of Arkansas for Medical Sciences; UK = United Kingdom; USD = United States dollars
[a] Mean percentages: A: 2001-2003; B: 2004-2007
Bold=statistically significant; telehealth superior

Single Specialty Consultations

An additional 17 studies evaluated the use of teleconsultations to obtain assessments and advice on care from specialists for different conditions (Table 22). Most of these involved consultations designed to assist in managing chronic conditions such as diabetes,[69,144,168,210] hypertension management,[145] pain,[61] and arthritis,[250] and they did not use diagnostic technology during the consultation. This section also includes specialty consultations in areas such as genetic counseling[220,232] and urology,[42] the subject of one or two included studies.

The majority of these consultations were conducted in real time using video to allow the clinicians to interact. The exception is four studies that facilitated asynchronous, ongoing exchanges of information—three between primary care physicians and specialists to facilitate management of hypertension,[145] diabetes,[144] and kidney failure[186] and one in which specialists reviewed sleep studies.[31]

Regardless of the format of telehealth, these studies reported positive effects of telehealth consultations on clinical outcomes (e.g., similar rates of response to treatment or lower mortality rates) and more limited effects on intermediate outcomes (e.g., no difference in satisfaction) and cost savings, which were primarily dependent on patient costs.

Table 22. Single specialty by type: selected outcomes

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Arthritis	Jong, 2004[250] Canada 3 hospitals 6 physicians	Prospective cohort High Real time Continuing A_1: No telehealth, in-person, n=2 A_2: No telehealth, email, n=4 B: Telehealth, n=6	NR	Physician satisfaction Higher for video than in-person or in-person with email, values not provided	Average cost, in CAD A_1: $975 travel cost A_2: NR B: $87.50 per half hour of videoconference, the mean length of a session
Blood Pressure Control	De Luca 2005[145] Naples, Italy 1 university clinic 23 hospital based clinics 60 general practitioners	Prospective cohort Moderate Asynchronous Continuing A: No Telehealth, n=1,985 B: Telehealth, n=1,949	Mean reduction in SBP/DBP blood pressure mmHg **A: 4.1/3.1** **B: 7.3/5.4, p<0.001** Patients with BP <140/90 mmHg **A: 47%** **B: 51% , p<0.001** Major cardiovascular events **A: 4.3%** **B: 2.9%, p<0.02** **AOR: 0.838, p<0.05**	NR	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Childhood Obesity	Mulgrew, 2011[92] United States, CA 1 weight management clinic Remote clinics NR	Prospective cohort High Real time Continuing A: Face to face, n=15 B: Telemedicine, n=10	NR	Overall patient satisfaction defined as a score of 40 to 48, mean ± SD A: 44.5 ± 3.85 B: 43.8 ± 4.83, p=0.42 Satisfaction with consulting healthcare provider on a 10 point scale with 10 being the best, mean ± SD A: 9.3 ± 0.91 B: 9.4 ± 1.01	NR
Diabetes	Basudev, 2016[210] London, England 1 virtual clinic 6 general practices	RCT Moderate Real time Continuing A: Usual care, n=88 B: Virtual clinic, n=79	Reduction of HbA1c (difference ± SD) A: 10 mmol/mol (-0.8 ± 1.9%) B: 8 mmol/mol (-0.6 ± 1.7%), p=0.4 Change in SBP ± SD **A: Increase: 2 ± 18 mmHg** **B: Decrease: 6 ± 16 mmHg, p=0.008** Cholesterol, weight, renal function, NS	NR	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Diabetes	Carallo,2015[144] Calabria, Italy 33 general practitioners	Prospective cohort High Asynchronous Continuing A: No telehealth, n=208 B: Telehealth, n=104	Change in HbA1c mmol/mol from baseline to followup A: no change **B: -4, p=0.01** Change in LDL cholesterol mg/dL from baseline to followup: **A: -9.2, p=0.01** **B: -1.4, p=0.001** Change in body mass index kg/m^2 from baseline to followup: **A: No change** **B: -0.03, p=0.03** No difference between groups in blood pressures, triglycerides, or waist size	Mean number of visits **A: 1.3** **B: 0.6, p<0.0001** Mean duration of visit, in minutes A: 24 B: 7	NR
Diabetes	Izquierdo, 2009[69] NY, United States 25 schools Kindergarden-8th grade	RCT High Real time Continuing A: No telehealth, n=18 B: Telehealth, n=23	HbA1c value at 6 months Values not specified A: Increase, NS **B: Decrease, p<0.02** Hospitalizations for diabetic ketoacidosis A: 22.2% B: 4.3%	Pediatric Quality of Life Diabetes module: No difference between groups Improved emotional function between months 6 and 12 ***A: Improved, p<0.04*** ***B: No change*** Treatment needed at 6 vs. 12 months A: 48 vs. 35 B: 20 vs. 9, p=NR Urgent visits **A: No change** **B: Significant decrease, p-value NR**	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Diabetes	Nikkanen,2008[168] Oulu Arc Sub region, Finland 3 health centers	Pre-post Moderate Real time Continuing A: Pre-telehealth, n=101 B: Post-telehealth, n=101	Mean HbA1c **A: 8.0%** **B: 7.6%** **Difference: (-0.4), p=0.007** Mean LDL cholesterol, mmol/L **A: 3.3** **B: 2.7** **Difference: (-0.6), p=0.001** Systolic blood pressure, mm Hg A: 146 B: 140 Difference: (-6), NS Mean body mass index, kg/m^2 A: 30.6 B: 30.4 Difference: (-0.2), NS Subgroup analyses indicate largest change in HbA1c results in patients with diabetes mellitus >10 years and with higher HbA1c at baseline.	NR	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Genetic Counseling	Zilliacus, 2011[232] New South Wales and Australia 3 family cancer clinics 4 outreach genetic counseling services	Prospective cohort Moderate Real time One-Time A: Face to face, n=89 B: Telehealth, n=106	NR	Mean satisfaction score ± SD (54 point scale; higher= greater satisfaction) A: 40.8 ± 9.9 B: 45.6 ± 8.4, p=0.76 No difference in telegenetics vs. face-to-face: Knowledge gained, p=0.55 Generalized anxiety, p=0.42 Depression, p=0.96 Perceived empathy of genetic clinician, p=0.13 Perceived empathy of genetic counselor, p=0.12 Significant difference in telegenetics vs. face-to-face: **Meeting patients' expectations, p=0.009** **Promoting perceived personal control, p=0.031**	NR
Clinical Genetics	Gattas, 2001[220] Queensland, Australia 1 hospital	RCT High Real time One time A: No telehealth, n=23 B: Telehealth, n=44	NR	Numerical data not reported Provider satisfaction A vs. B Communication: no difference Ability to maintain eye contact: slightly lower Room comfortability: higher Satisfaction with clinic format: No difference Counselor satisfaction: higher satisfaction with face-to-face consultations	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Inflammatory Bowel Disease	Krier, 2011[74] CA, United States Patient location unclear 1 VA Hospital	RCT High Real time Continuing A: Usual care, n=19 B: Telehealth, n=15	NR	Mean duration ± SD (range), in minutes A: 59 ± 10 (26 to 73) B: 60 ± 14 (35 to 80), p=0.81 Mean wait time ± SD (range), in minutes A: 18 ± 14.5 (5 to 60) B: 25 ± 25 (5 to 90), p=0.31 Clinic experience, attention to patient concerns, bedside manner, and perceived skill level of the doctor rated excellent by both groups.	NR
Nephrology	Bernstein, 2010[248] Manitoba, Canada 1 hospital; 12 local centers	Retrospective cohort Moderate Real time Continuing A: No telehealth, n=2,196 B_1: Telehealth, near urban center, n=285 B_2: Telehealth, far from urban center, n=182	Hazard Ratios 2- to 5-year survival **B_1 vs A: 0.67, p<0.001** **B_2 vs. A: 0.72, p<0.05** Diabetic nephropathy **B_1 vs A: 0.63, p<0.001** **B_2 vs. A: 0.63, p<0.01**	NR	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Nephrology	Van Gelder, 2017[186] Netherlands 7 General practices Nephrologist location NR	RCT High Asynchronous One time A: Usual care, n=1,727 B: Telehealth, n=1,277	NR	Referral rate A: 3.0% B: 2.3% OR: 0.61 (95% CI 0.31 to 1.23) Consultation rate A: 5.0% B: 6.3% OR: 2.00 (95% CI 0.75 to 5.33)	NR
Neurology	Chua, 2001[194] Northern Ireland, UK 1 Regional Neuro Center 2 District Hospitals	RCT High Real time One time A: Usual care, n=65 B: Telehealth, n=76	NR	Number of investigations, n (%) A: 11 (17%) B: 46 (61%) Reviews after first consultation A: 14 (22%) B: 22 (29%)	Cost of consultation A: £49 B: £72
Pain	Frank, 2015[61] United States 47 medical centers 148 community-based outpatient clinics	Before-after Moderate Real time Continuing A: No telehealth, n=299,981 B: Telehealth, n=22,454	NR	HR (95% CI) Delivery of out-patient care: **Physical medicine: 1.10 (1.05 to 1.14)** Mental health: 0.99 (0.93 to 1.05) Substance use disorder: 0.93 (0.84 to 1.03) Specialty pain clinics: 1.01 (0.94 to 1.08) Medication initiation: **Anti-depressant: 1.09 (1.02 to 1.15)** **Anticonvulsant: 1.13 (1.06 to 1.19)** Opioid analgesics: 1.05 (0.99 to 1.10)	NR

Condition or Specialty	Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Cost Outcomes
Sleep	Baig, 2016[31] WI, United States 1 VA Medical Center Locations are not clear	Retrospective cohort High Asynchronous One time A: No telehealth, n=unclear B: Telehealth, n=unclear	NR	Sleep consults per year A: 150 B: 1,851 Number of sleep studies A: 282 B: 833 Wait time for positive airway pressure prescription A: >60 days B: <7 days	NR
Speech Pathology	Burns, 2017[217] Queensland, Australia 3 Regional Sites 1 Hospital	RCT Moderate Real time Continuing A: Usual care, n=39 B: Telehealth, n=43	NR	Mean days from response to management ± SD (range) A: 3.2 ± 3.7 (0 to 11) B: 3.1 ± 3.4 (0 to 14), p=0.928 Clinician satisfaction reached statistical significance for all parameters assessed in favor of telehealth.	NR
Urology	Chu, 2015[42] CA, United States 1 Tertiary care clinic 2 outpatient primary clinics	Retrospective cohort High Real time One time A: No telehealth, n=NR B: Telehealth, n=NR	NR	Estimated time savings Mean distance: 277 miles Mean time: 290 minutes	Estimated savings, in USD Expenses: $67 Lost opportunity cost: $126 Total patient savings 5 hours $193 per visit

CAD = Canadian dollars; CI = confidence interval; DBP = diastolic blood pressure; HbA1c = hemoglobin; HR = hazard ratio; LDL = low density lipoprotein cholesterol; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized control trial; SBP = systolic blood pressure; SD = standard deviation; UK = United Kingdom; USD = United States dollars

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Multiple Specialty Consultations

We identified 10 articles representing eight studies that evaluated telehealth programs facilitating outpatient consultations for multiple specialists (Table 23). Most of these programs created agreements between primary care practices, some within correctional facilities and others in remote locations, with a hospital or medical center that has multiple specialists available. The clinical outcomes are limited to avoiding inpatient, ED, or followup visits, and telehealth consultations resulted in significant reductions in one study[28] but did not result in significant changes in three other studies that reported these outcomes.[60,207,208,212] Satisfaction was generally high, but the impact on access was not frequently reported, and most studies did not find differences in management and treatment. The evaluation of costs was mixed, with the largest study reporting higher costs for telehealth.[212] The higher costs were due to equipment costs and the fact that both the primary care physician and the specialist were present for the telehealth consultation. This added physician time was not offset by cost savings despite a significant reduction in the number of tests and investigations. The range of disciplines and likely range of patient conditions and severity may contribute to the fact that the results across these studies are inconclusive.

Table 23. Multiple specialty telehealth consultations: selected outcomes

Author, Year Location **Number of Sites**	**Study Design Risk of Bias** **Timing Consultation Frequency** **Comparison, n**	**Clinical Outcomes**	**Intermediate Outcomes**	**Economic Outcomes**
Angstman, 2009[28] United States, MN Number of sites unclear; 1 medical organization	Retrospective cohort Moderate Both One time A: No telehealth, n=500 B: Telehealth, n=228	Unscheduled return visit within 2 weeks, any reason: ***A: 27.6%*** ***B: 38.2%, p<0.01*** ***OR: 1.88, p≤0.01*** Unscheduled return visit within 2 weeks, same reason: A: 19.6% B: 20.2%, NS OR: 1.18, NS	NR	NR
Brown-Connolly, 2002[38] United States, CA 34 primary care and 4 specialty sites	Prospective cohort High Real time Continuing A: No telehealth, n=NR B: Telehealth, n=NR	NR	**Distance to specialist** **A: 195 km** **B: 27 km** **Difference: -168 km, p<0.05** Travel time, in minutes A: 156 B: 26 Difference: -130 minutes, NS Patient response to survey Telemedicine again: 90% Telemedicine made it easier to get services: 91% Would get better care in person: 39%	NR

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Economic Outcomes
Fox, 2007[60] United States, TN 4 adolescent correctional facilities	Before-after Moderate Real time Continuous A: Year before telehealth, n=173 B_1: Year after telehealth, n=257 B_2: 2 years after telehealth, n=276	Before/after differences, IDR[a] ED visits per facility per month[b] Facility 1: 0.26, 1.30, NS Facility 2: -0.14, 0.87, NS ***Facility 3: 0.79, 2.21, p=0.0044*** Facility 4: 0.90, 2.45, NS Inpatient visits per facility per month[b] **Facility 1: -1.71, 0.18, p=0.0233** Facility 2: 0.17, 1.19, NS No visits in baseline year at Facilities 3 or 4 Outpatient visits per facility per month[b] **Facility 1: 0.86, 2.37, p<0.001** Facility 2: -0.05, 0.95, NS **Facility 3: 0.33, 1.39, p=0.0004** **Facility 4: 1.08, 2.93, p<0.0001**	Mean days from referral to psychiatric treatment A: 50.1 B_1: 24.86 B_2: 21.59 Time from referral to treatment HR, % change in time to referral[a] **Facility 1: 4.40, 77% reduction, p<0.001** Facility 2: 1.09, 8% reduction, p=0.622 **Facility 3: 2.29, 56% reduction, p=0.0006** Facility 4: 0.74, 35% increase, p=0.1326 Effect of telehealth volume usage on access[b] Estimate, incidence density ratio **Outpatient visits per center per month: 0.02, 1.02, p<0.0001** **ED visits per center per month**: **-0.05, 0.95, p<0.0001** Inpatient visits per center per month: -0.04, 0.96, NS	NR
Harno, 2000[152] Finland, Myyrmäki and Tuusula 2 hospitals, 3 health centers	Economic evaluation Moderate Asynchronous One time A: No telehealth, n=85 B: Telehealth, n=207	NR	Patients receiving appointments at outpatient clinic A: 79% B: 43% Consultations with diagnosis changes A: 25% B: 29% Want next appointment via TH A: 60% B: 80%	Variable cost for outpatient visits A: € 210.81 B: € 32.06

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Economic Outcomes
Jaatinen, 2002[157] Finland, Satakunta 4 clinics 1 Hospital	RCT High Asynchronous Continuous A: No telehealth, n=24 B: Telehealth, n=54	NR	Success relating patient history Good vs. Moderate vs. Bad A: 85% vs 10% vs 5% B: 62% vs 31% vs 8%, NS Success relating patient physical status Good vs. Moderate vs. Bad ***A: 90% vs 10% vs 0%*** ***B: 46% vs 33% vs 21%, p=0.01*** Success relating overall patient case Good vs. Moderate vs. Bad ***A: 85% vs 15% vs 13%*** ***B: 48% vs 39% vs 0%, p=0.02*** Median total time for visit A: 3.5 hours B: 1.0 hours	NR
Smith, 2002[229] Australia, Queensland 3 hospitals (Mackay, Hervey Bay, Royal Children's Hospital)	Before-after High Real time One time A: Before telehealth, n=NR B: After telehealth, n=NR	Change in pediatric admissions from Mackay region to Royal Children's Hospital A: 9.7 patients per month B: 6.0 patients per month Change in pediatric admissions From Hervey Bay region to Royal Children's Hospital A: 10.0 patients per month B: 12.5 patients per month	Patient referrals for outpatient appointments to Brisbane from Mackay A: 7.9 patients per month B: 5.7 patients per month Patient referrals for outpatient appointments to Brisbane from Hervey Bay A: 15.8 patients per month B: 15.4 patients per month	NR
Tsitlakidis, 2005[184] Greece, Lemnos and Skyros 2 remote health centers 1 hospital	Economic evaluation Moderate Real time One time A: No telehealth, n=NR B: Telehealth, n=NR	NR	Average consultation time, in minutes A: 30.0 B: 5.3 Post-consultation time requirements, in minutes A: 10.0 B: 2.6	Total cost per patient: A: €270 B: €203 Savings dependent on distance travelled and number of cases.

Author, Year Location Number of Sites	Study Design Risk of Bias Timing Consultation Frequency Comparison, n	Clinical Outcomes	Intermediate Outcomes	Economic Outcomes
Wallace, 2002[207] Jacklin, 2003[212] Wallace, 2004[208] United Kingdom 2 hospitals 29 practices	RCT Low Real time Continuous A: No telehealth, n=971 B: Telehealth, n=968	Mean difference at 6 months (95% CI) Tests and investigations: **-0.79 (-1.21 to -0.37)** Emergency visits: 0.002 (-0.02 to 0.03) Inpatient stays: -0.02 (-0.06 to 0.01) Day surgery and inpatient procedures: -0.01 (-0.04 to 0.02) Prescriptions 0.57 (-0.64 to 1.78)	Mean patient satisfaction (5 point scale; 1=poor) **A: 3.64** **B: 3.97; Difference: 0.33 (95% CI 0.23 to 0.43)** Mean patient enablement, higher score=improved enablement A: 2.4 B: 2.5; Difference: 0.07 (95% CI -0.24 to 0.43) SF-12 Physical Score A: 42.7 B: 43.1; Difference: 0.34 (95% CI -0.96 to 1.63) SF-12 Mental Score: A: 48.1 B: 47.5; Difference: -0.51 (95% CI -1.78 to 0.7) Difference between patients offered followup appointments **11%, AOR: 1.53, p<0.0001** Mean difference in outpatient visits (95% CI) 0.04 (-0.10 to 0.18) Mean difference in practice contacts (95% CI) 0.20 (-0.11 to 0.50)	Total mean NHS costs: ***A: £625.26*** ***B: £723.98*** ***Difference: £98.72, p=0.03*** ***NHS adjusted difference: £93.80 (7.34 to 180.40)*** Total patient costs: **A: £11.38** **B: £3.69** **Difference: £-7.70, p<0.0001** Costs higher due to equipment and requiring both GP and specialist time.

AOR = adjusted odds ratio; CI = confidence interval; ED = emergency department; GP = general practitioner; HR = hazard ratio; NHS = National Health Service; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized control trial; SF-12 = Short Form-12; TH = telehealth

[a] Combined 1+2 years after telehealth vs. before telehealth

[b] N=144

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.*** Regular type: not statistically significant.

Discussion

Key Findings and Strength of Evidence

These key findings are the result of our comprehensive systematic review and our prototype decision analyses. The systematic review focused on the effectiveness of telehealth consultations in terms of clinical and cost outcomes as well as intermediate outcomes and harms. We organized the results by setting (inpatient, emergency, and outpatient care) and completed the strength of evidence (SOE) assessments by setting as well. Within settings, we further divided the studies into subgroups by clinical focus, which varied across the three settings. Given the wide variety of study designs and outcome measures, we were not able to use meta-analysis and relied on qualitative approaches for summarizing and synthesizing results across studies.

Many of the SOE assessments are low due to a combination of study limitations, inconsistent results, and imprecise estimates of effect. There were a few moderate ratings and no high ratings. Additionally, there were cases in which the SOE was noted as insufficient, reflecting either a lack of studies addressing the specific question or that available evidence did not allow a conclusion to be drawn. In general, harms were not reported, and therefore the evidence is insufficient. The evidence about clinical outcomes and intermediate outcomes is mixed, and more details are provided below. Given our interest in cost modeling for the decision model portion of this project, we paid particular attention to the type of economic outcomes included in the studies, the sources of data, and the rigor of different approaches to assessing costs and utilizations. Overall, the strength of evidence about costs and other economic outcomes is low across the settings due to inconsistencies in both methods and results.

The strongest evidence across groups of studies are moderate SOE ratings for the following combinations of settings and outcomes. For inpatient care, remote intensive care units (ICUs) reduce ICU and hospital mortality while lengths of stay (LOS) are not significantly different. In emergency care, specialty remote consultations increase appropriate transfers and admissions while decreasing the time from presentation to decision and the amount of time spent in an emergency department (intermediate outcomes). When telehealth is used in emergency medical services, mortality is reduced for ST-elevation myocardial infarction (STEMI) patients, and treatment is more timely (clinical and intermediate outcomes). Use of telehealth consultations in outpatient care resulted in improved clinical outcomes for wound care, psychiatry and single chronic disease care, and in increased access to services across specialties (intermediate outcome).

In other combinations of settings and outcomes, the strength of evidence is low or the evidence is insufficient. These are described in the text and tables in the next section with more details provided in the Results sections above.

Inpatient Telehealth Consultations

To facilitate summarizing and synthesis we split the inpatient studies into remote ICU and specialist consultations for hospitalized patients. Table 24 provides the number of studies reporting each type of outcome, the main findings, and the strength of evidence for these two subgroups.

The results of the identified studies reported provide evidence that remote ICUs decrease mortality in the ICU and during the hospital stay (moderate strength of evidence). ICU and hospital length of stay are slightly shorter (less than one-half day mean difference), but the differences are not statistically significant (moderate strength of evidence). A subset of the studies (6) analyzed costs of remote ICUs or their impact on revenue but their methods and conclusions were inconsistent with costs measured in a variety of ways and half reporting savings or increased revenue and half reporting increased costs (insufficient evidence).

The studies of inpatient specialist consultations reported no significant differences in mortality (low strength of evidence), but other clinical outcomes defined as serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability) improved with telehealth, but these differences were not always statistically significant (low strength of evidence). The impact on intermediate outcomes such as hospital LOS or patient satisfaction is also mostly positive, but with differences that were close to significant and estimates that were less precise (low strength of evidence). Costs were compared in seven studies. Most studies reported savings due to avoided travel or transfers (low strength of evidence). Three studies of remote surgery were the only ones that explicitly examined harms, and while no harms were identified, the studies were small and rated as high risk of bias (insufficient evidence).

Limited information on the characteristics of what is studied (Key Question 4) made it difficult to assess variation in outcomes (Key Question 5), though we did look at hospital characteristics, remote ICU coverage, and the period for outcome measurement for the studies of remote ICUs. While these differed across studies there was no identifiable pattern of association of these characteristics with the results.

Table 24. Inpatient telehealth consultations: strength of evidence

Topic	**Outcome (KQ)**	**Number of Studies (N)**	**Main Findings**	**Strength of Evidence** (Insufficient, Low, Moderate, High)
Inpatient remote ICU	ICU Mortality (KQ1)[a]	11	Lower ICU mortality RR 0.69 (95% CI 0.51, 0.89)	Moderate
	Hospital Mortality (KQ1)[a]	12	Lower hospital mortality RR 0.76 (95% CI, 0.60, 0.95)	Moderate
	Cost (KQ1)	6	Unable to summarize across studies: different methods and inconsistent results.	Insufficient
	ICU LOS (KQ2)[a]	12	No significant difference in ICU LOS Mean difference (days) -0.39 (95% CI -0.99, 0.15)	Moderate
	Hospital LOS (KQ2)[a]	12	No significant difference in hospital LOS Mean difference (days) -0.14 (95% CI -0.96, 0.63)	Moderate
	Harms (KQ3)	0	None reported in identified articles	Insufficient
Inpatient specialty consultations	Mortality (KQ1)	12	No significant difference in mortality	Low
	Other clinical outcomes (KQ1)	6	Clinical outcomes better with telehealth but small differences and most not significantly different	Low
	Cost (KQ1)	7	Cost savings due to avoiding transfers or travel when telehealth is used but not in all studies	Low
	Intermediate outcome (KQ2)	27	Reductions in LOS and waiting time but all not significantly different; satisfaction measures good but not excellent	Low
	Harms (KQ3)	3	Complications or harms from telehealth in surgery was compared with standard procedures in small studies with high risk of bias	Insufficient

CI = confidence interval; ICU = intensive care unit; KQ = Key Question; LOS = length of stay; RR = risk ratio
[a] Based on studies included in the meta-analysis

Emergency Care Telehealth Consultations

We divided the emergency care studies into three categories: telestroke, specialist consultations for patients in an emergency department, and emergency medical services (EMS) and urgent care (Table 25).

Across the telestroke studies, there were no significant differences in mortality, either in-hospital or at 3 months (moderate strength of evidence). The rates of hemorrhage, the harm most likely to occur if a stroke is treated inappropriately, were also not significantly different with and without telehealth (moderate strength of evidence). Small differences in functional outcomes were not significant; tissue plasminogen activator (tPA) use increased, but the majority of studies reported this change did not rise to the level of statistical significance; and most studies found no significant difference in time to treatment (all low strength of evidence).

The studies of specialty consultations for emergency patients reported lower mortality; however, these differences were not always statistically significant. Similarly, four studies reported other clinical outcomes, with only one, lower complications during transport, achieving statistical significance. Four of five studies reported lower costs (low strength of evidence). Intermediate outcomes focused on the impact on decisions including transfers, hospital admissions and time spent in an emergency department (ED), and there were more consistent finding of benefits from telehealth consultations (moderate strength of evidence). None of the included studies in this category reported harms.

When telehealth is used by EMS to inform decisions on treatment and location of transport for patients with suspected heart attacks, mortality is lower (moderate strength of evidence). We did not identify sufficient evidence to reach a conclusion about harms when telehealth consultations are used in EMS or urgent care (insufficient evidence), though there is some evidence these consultations reduce transfers and referrals (intermediate outcomes; moderate strength of evidence) and costs (low strength of evidence).

Table 25. Emergency care telehealth consultations: strength of evidence

Topic	**Outcome (KQ)**	**Number of Studies (N)**	**Main Findings**	**Strength of Evidence** (Insufficient, Low, Moderate, High)
Emergency Care: Telestroke	In-hospital mortality (KQ1)	9	RR 0.89 (95% CI 0.63, 1.43) No difference	Moderate
	3-month mortality (KQ1)	7	RR 0.94 (95% CI 0.82, 1.16) No difference	Moderate
	tPA administration (KQ2)	13	Reported tPA use increases; four significant; majority not statistically significant or not tested	Low
	Time to Treatment (KQ2)	23	Time to treatment is shorter but not significant in the majority of studies; a minority report longer times	Low
	Harms (all Hemorrhage) (KQ3)	11	No difference in hemorrhage, the only potential harm reported	Moderate
Emergency Care: Specialty Consultations	Clinical outcomes (KQ1)	13	Lower mortality reported in most studies but not statistically significant; Four studies reporting other clinical outcomes that were better with telehealth; one reported significant differences	Low

Topic	Outcome (KQ)	Number of Studies (N)	Main Findings	**Strength of Evidence** (Insufficient, Low, Moderate, High)
	Cost (KQ1)	5	Lower costs with better or no change in clinical outcome in most (4) studies; one study reported higher costs	Low
	Intermediate outcomes (KQ2)	19	Increase in appropriate transfers, decrease in time to decision and time in ED with telehealth compared with standard care	Moderate
	Harms (KQ3)	0	No studies reported data on harms from telehealth	Insufficient
Emergency Care: EMS or Urgent Care	Clinical Outcomes (KQ1)	10	Telehealth reduced mortality for STEMI patients	Moderate
	Cost (KQ1)	5	Lower costs due to avoided transfers or lower staff costs when telehealth is used	Low
	Intermediate Outcomes (KQ2)	20	Treatment is more timely and fewer air transfers or referrals to higher level of care	Moderate
	Harms (KQ3)	1	One study reported data that could be interpreted as harms, but not defined as such by the authors	Insufficient

CI = confidence interval; EMS = emergency medical services; KQ = Key Question; RR = risk ratio; STEMI = ST-elevation myocardial infarction; tPA = tissue plasminogen activator

Outpatient Telehealth Consultations

We grouped the included articles evaluating telehealth consultations in the outpatient setting into 11 clinical topics (Table 26). In eight of the specific specialties we identified, we included three or more articles (i.e., dermatology, wound care, ophthalmology, orthopedics, dentistry, cancer, psychiatry, and infectious disease). The remaining three topics consist of programs designed to facilitate consultations with multiple specialists. The first involves the use of diagnostic technology such as echocardiograms, ultrasounds, endoscopies, and Dopplers. The second group includes articles about specific specialty consultations that do not involve diagnostic technology. These studies evaluated the use of telehealth consultations in the management of chronic conditions including hypertension, diabetes, arthritis and chronic pain. The final category includes studies of telehealth set up to provide consultations across multiple specialties.

Clinical outcomes were improved in several topic areas including wound care, psychiatry, and chronic conditions such as diabetes (moderate strength of evidence). In dermatology, clinical course was found to be similar with and without telehealth (low strength of evidence). For some specialties including ophthalmology, dentistry, cancer, infectious disease, and specialties combined with diagnostic technology, clinical outcomes were either not reported or the results were not sufficient to support a conclusion (insufficient evidence). Only two outpatient studies explicitly addressed harms. Lower costs were reported in most studies that assessed costs, but the methodologies used varied considerably, and most of the positive (cost savings) results hinged on patient savings of travel costs and time rather than cost savings for the health system (low strength of evidence).

Given that all of these studies addressed at least one intermediate outcome, we split the intermediate outcomes into three categories for the SOE assessment: access, management and utilization, and satisfaction. Access was improved with telehealth consultations across all specialties. For example, several studies in dermatology reported that time to diagnosis and time to treatment were reduced. Similarly, telehealth consultations using diagnostic technology allowed faster assessment of conditions or more patients to have the comprehensive assessment indicated (e.g., ultrasound for high risk pregnancies) (moderate strength of evidence).

In many cases, telehealth consultations were designed to influence how a condition was managed in terms of what services were utilized (e.g., a hospitalization or travel to a specialist for an in-person exam). Most of the studies reported telehealth consultations had the intended effect of reducing hospital admissions and specialist in-person visits while providing similar diagnoses and management plans, however, a few studies reported differences in diagnosis, planned management, or treatment as these studies assumed the in-person decisions were correct. Because of this inconsistency, the strength of evidence is low.

Satisfaction results differed for patients and family compared with providers, despite being generally positive. Patients appreciated greater access and savings in time, costs, and time off work that traveling for care would require. Clinicians' assessments were more varied, with many rating the telehealth consultations as the same or as good as face-to-face while others reported they were slightly worse (low strength of evidence).

Table 26. Outpatient care telehealth consultations: strength of evidence

Outcome (KQ)	**Number of Studies (N)**	**Main Findings**	**Strength of Evidence** (Insufficient, Low, Moderate, High)
Clinical Outcomes (KQ1): Dermatology	3	No significant different in clinical course	Low
Clinical Outcomes (KQ1): Wound Care	5	Better healing and fewer amputations	Moderate
Clinical Outcomes (KQ1): Ophthalmology	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Orthopedics	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Dental	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Cancer	1	Rate of serious side effects from chemotherapy reported in 1 study	Insufficient
Clinical Outcomes (KQ1): Psychiatry	3 (in 5 articles)	Decrease in symptoms and high remission rates	Moderate
Clinical Outcomes (KQ1): Infectious Disease	3	Inconsistent results for virologic suppression across studies	Insufficient
Clinical Outcomes (KQ1):): Single Conditions with Diagnostic Technology	0	No studies reported data on clinical outcomes	Insufficient
Clinical Outcomes (KQ1): Single Specialties	6	Positive effects on clinical outcomes such as response to treatment.	Moderate
Clinical Outcomes (KQ1):Multiple Specialties	4	Inconsistent results across studies for unanticipated or avoidable health services utilization	Insufficient
Cost (KQ1)	32	Most studies report cost saving with telehealth but calculations vary and most are dependent on patient avoided travel and loss of time	Low

Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
Intermediate Outcomes: Access (KQ2)	35	Access in terms of time to, or comprehensiveness of service is improved with telehealth	Moderate
Intermediate Outcomes: Management and Utilization (KQ2)	31	Mixed results with majority finding some benefit in terms of avoiding visits and similar diagnosis or management but a subset of studies report differences in diagnosis and management with telehealth compared with standard care	Low
Intermediate Outcomes: Satisfaction (KQ2)	22	Satisfaction generally the same; patients higher with telehealth if time/travel is avoided. Providers the same or slightly worse for telehealth.	Low
Harms (KQ3)	2	Rates of complications and serious adverse events reported in two studies	Insufficient

KQ = Key Question

Exploratory Cost Model for Telehealth Neurosurgical Consultations

During the systematic review of published studies we identified topics for which decision models and/or economic assessment studies had not been published. After reviewing the possibilities, we selected telehealth consultations in the acute management of patients with traumatic brain injury transported to hospitals not designated level I or II trauma centers. We considered the comparison of (1) immediate transfer after stabilization from the community hospital with no access to neurosurgical consultations to a level I or II trauma center (standard care model) and (2) telehealth consultation to determine if the patient can be managed at the local hospital or should be transferred to a level I or II trauma center (telemedicine model). Data from the literature were used as input parameters to calculate incremental costs for the two different possibilities from the perspective of the healthcare system.

The decision analytic model assumed equivalent patient outcomes (details provided in Appendix I). However, the framework was constructed to allow for future inclusion of differences in patient outcomes based on the Glasgow Outcome Scale (GOS) at 6 months: (1) death, (2) persistent vegetative state, (3) severe disability (lost independence) (4) moderate disability, and (5) good outcome (healthy post-traumatic brain injury) if and when this evidence becomes available.

Findings in Relationship to What Is Already Known

The literature on telehealth is large and included several systematic reviews of varying size and scope. We did not identify any existing reviews that exactly addressed our Key Questions or matched our requirements and inclusion criteria. We identified reviews that were broad, including telehealth for consultations as well as other functions (e.g., a review on the impact of telemedicine on professional practice and healthcare outcomes[259] and reviews on single clinical areas (e.g. dentistry[260] and psychiatry[261]). In total, we examined 34 systematic reviews that were related to our topic and used these to identify additional studies for inclusion in this review and to summarize according to our Key Questions.

Applicability

Our results and synthesis are based on a relatively large number of studies included in this review. While the largest group was conducted in the United States, many were conducted in

Europe, Asia, Australia, and New Zealand (see Table 1). Table 1 also demonstrates that the included studies represent a range of technologies or modes and both real time and asynchronous consultations. Some details, such as whether the patient was present at the consultation were not reported consistently, but they were reported frequently enough to know that it varied. These and other details about the studies are included in Appendixes F and G.

How we organized and analyzed the included studies was driven by our assessment of the applicability of different subgroups of the results. We analyzed and presented the studies by setting – inpatient, emergency, and outpatient care – because we believe consultations require different infrastructure and serve different purposes in these broad settings. We did not combine across these categories because we do not think the results from one setting are directly applicable to another. For instance, the results of studies about emergency care are not directly applicable to situations where time is not an essential factor and specific expertise is not needed quickly. Similarly, the results of asynchronous dermatology used to assess skin lesions are not as applicable to the use of telehealth to monitor and manage ICU patients as they may be to the use of other specialists for outpatient consultation.

Within settings, we created subgroups based on our assessment of when the results are applicable across conditions and uses. For inpatient care, we kept the remote ICU studies separate, as that is a very specialized, specific use. We combined other specialty consultations for inpatient care as they are similar in terms of the function of the consultation (e.g., to diagnose a condition or to provide direction during a surgery) and the types of outcomes. For example, even though the populations are different, remote neurological consultation or an adult with a traumatic brain injury and a neonate inpatient cardiology consultation are similar in that both are facilitating access to highly specialized expertise in order to make decisions about whether to transport the patient or how the patient should be managed. This similarity may transcend the fact that the populations are very different.

For emergency care we separated telestroke, specialty consults for ED patients, and EMS/urgent care for similar reasons. While time is important in all emergency care, it is the core consideration in telestroke and EMS/urgent care. The use of different specialist consultations in the ED, ranging from pediatrics to psychiatry are for different patients but for similar purposes: to inform the management of patients' presenting conditions, including whether the patient should be admitted, transferred, or discharged home. These patients are often more stable, and the technology necessary to connect consultants to an ED is likely different from that needed to connect consultants to ambulances and first responders.

Our approach and the issues of applicability for outpatient consultations were slightly different. We reported the details and clinical outcomes separately by specialty to allow readers to see the results in these groupings as people are often interested in a particular specialty. Then we combined the results across specialties when assessing costs and intermediate outcomes. We divided intermediate outcomes into three categories as all the studies of outpatient consultations included one or more intermediate outcome and to facilitate considerations of applicability in terms of whether the telehealth consultations were impacting access, management and utilization of health services, or satisfaction.

Applicability is often focused on the populations of patients to whom the results may apply. For this intervention, the setting is of primary importance. The setting, combined with the goal or nature of the intervention (i.e., what the purpose of the telehealth consultation is) and the intended outcome, drive applicability. More nuanced assessments by payment model or organizational characteristics would be useful as well but are not possible given the lack of published results.

Limitations of the Evidence Base

There are important limitations to the evidence base on the effectiveness of the use of telehealth for consultations. The most significant is the variation in study designs and the level of rigor of the research methodology. In our assessment, very few studies were rated as low risk of bias; most were moderate or high. Risk of bias criteria are specific to the study design, which can minimize the fact that some study designs are much more likely to be weak or biased than others. The literature on telehealth consultations consists primarily of studies that would be considered weaker designs such as before and after studies without comparison groups and retrospective cohort studies. In some cases, many of the studies for a specific clinical area would be considered weak designs. For example, most of the studies on remote ICU programs compared outcomes prior to the remote ICU program initiation to a period after implementation. Even though some studies did examine patient characteristics or considered risk adjusted outcomes, it is possible that several other elements of care changed that were not measured or accounted for. In the analyses of costs or other economic outcomes, the designs and approaches also varied and few were rigorous cost analyses. Many estimated costs or savings indirectly, some relying on hypothetical estimates of what would have been spent or saved absent a program. Importantly, the comparison treatment was poorly described in these studies; such that it was often impossible to know what type of care (e.g. in-person care by a consultant versus no consultation) was in the "usual care" groups.

Another limitation is the inconsistency in outcomes used to evaluate effectiveness. Outcomes ranged from mortality to time to diagnosis to avoided appointments. The variation in outcomes across clinical areas makes it difficult to assess the comparative impact of telehealth consultations. Based on the available evidence we are able to conclude that remote ICU reduces mortality and store and forward dermatology reduces time to diagnosis, but it is not possible to say if one is more effective or suggest which may have a larger impact on different types of stakeholders ranging from patients to health systems. Additionally, we found that detailed economic data was rarely provided, and this was a major barrier to decision analyses.

Another concern and potential limitation in this literature is that is it not always clear what the best or most appropriate outcome should be for these studies. Retrospective studies and some prospective studies can be limited by what data are routinely or easily collected. It is possible these are not the most important outcomes for telehealth consultations. For example, telestroke programs report mortality rates, but it is possible that telestroke provides appropriate and timely access to treatment that reduces long-term disability but not necessarily mortality. However, because this requires longer followup, data may not be readily available in existing records. Patient-reported outcomes may be underrepresented for similar reasons. While some studies did include patient satisfaction, these were a minority, and broader, comprehensive measures of patient experience, confidence, or engagement are not common in this literature.

While the range of clinical topics identified was broad, there were clinical topics we expected to find and did not. For example, antibiotic management, pain management, and opioid misuse are not well-represented. It is difficult to determine if these topics are the focus of studies that have not been published yet or if they have not been studied.

Finally, the studies provide very little information on the context or the environment in which telehealth for consultations was implemented. While most, but not all studies, provided at least minimal information on the type of technology used (e.g., two way video, mirroring of monitors, still image storage) very little or no information was provided on the details of the workflow, the staffing and other characteristics of the specific practice, department or parent organization. Perhaps most importantly, information was not provided about the type of payment model for the consultation or the followup or ongoing care after the consultation. This is particularly problematic as most studies were in only a single location and few involved multiple sites. Without information about payment models and costs, it is not possible to estimate the economic impact of telehealth as well as the impact on access. The lack of information about the context and environment is at the core of the issues with applicability mentioned above.

Limitations of Our Approach

There are also limitations to this combined review and decision modeling report that are the result of our processes and decisions. Searching for research about a specific function of telehealth, in this case provider to provider consultation, is difficult as the indexing terms in Medline and other citation databases do not exactly match our scope. We used the MeSH term "Remote Consultation" but as this did not identify several studies known to us, we augmented this with keyword searching and more general MeSH terms. As a result, our search identified citations on this specific function of telehealth but also telehealth more generally. We did not conduct searches using terms for specific clinical areas. Therefore, if the indexing, abstract or title did not include terms related to telehealth and only focused on the clinical topic, we may not have identified the study. We also checked reference lists of included articles, relevant systematic reviews, and reviewed what was submitted in response to our request for information published in the Federal Register, our request for public comments, and peer review. Despite these efforts it is possible that some existing relevant studies are not included.

As the focus of this review is on evidence related to the effectiveness of telehealth consultations, we required that studies include specific types of outcomes (clinical outcomes, costs, and intermediate outcomes including access, satisfaction, and utilization of health services/medical management of the condition). We did not include studies that only reported descriptions of implementation, assessments of technology (e.g., the reliability of transmissions or the quality of video or images), or diagnostic concordance. However, if these types of information were provided in a study along with included outcomes, we did not ignore it. This type of information was not reported consistently in our included studies, so our understanding of these factors and how they relate to included outcomes is limited.

Given the variation in study designs, environments, and outcomes, we used quantitative synthesis (i.e., meta-analysis), for only a small number of situations where the outcomes were mortality or length of stay and the interventions were similar across studies (remote ICU and stroke). For the rest we used a qualitative approach to the strength of evidence framework. We also provided summaries in the text by more specific clinical indications. Qualitative synthesis such as this is more open to interpretation and judgment. We have attempted to be transparent and provide enough detail to allow readers to examine our conclusions, but we acknowledge that there is a significant subjective component to this and that another group of investigators could review the same literature and provide different ratings.

An important limitation to the cost model is the assumption that patient outcomes are equivalent. Should systematic differences or uncertainty exist, then a different model incorporating outcomes would be needed to make valid comparisons of the economic value of the two approaches to care. The model was built to allow inclusion of patient outcomes following treatment for cost benefit analyses in the future. While outcomes were assumed to be equivalent in the model included in Appendix I, when more and better data become available, the impact on mortality or function could be used to inform judgements about the value of additional costs given the patient benefits.

Future Research Needs

While we identified 233 articles that evaluated the effectiveness of telehealth consultations, several questions remain to be addressed in future research. A key priority is the need for rigorous, multi-site studies of telehealth consultations in clinical areas and in the types of organizations where the lack of evidence may be a barrier to wider spread implementation. For example, most of the remote ICU studies were conducted in a single hospital, and the hospitals included urban and academic medical centers, while the suggestion is that rural or under-resourced hospitals may benefit most from this type of telehealth. Avoiding transport of critical care patients while still providing technically advanced care could keep patients closer to their families and keep revenue for care in the community. Another example is the use of outpatient teleconsultations involving technology such as echocardiograms, ultrasound, or endoscopy. The studies included in this review that had a remote specialist guiding the use of technology by an appropriate technician located with the patient appear promising. However, not enough studies or sites were included to determine when this might increase access to critical services, improve patient outcomes, and be cost effective.

Future studies are also needed that both expand and standardize outcomes and clarify their objectives. Agreeing on some common metrics across uses of telehealth for consultation would facilitate comparisons across clinical areas and help identify priorities for future expansion of telehealth consultations. Given the wide range of clinical topics, these common metrics may need to be intermediate outcomes, such as measures of access or satisfaction or cost effectiveness. While costs are not the only important outcome, collecting more economic data would allow more direct comparisons across clinical topics and both facilitate and inform additional decision analyses, whether these are done for publication of for organizations' internal consideration. At the same time this needs to be balanced with attention to the most important outcomes for a given condition. As mentioned in limitations of the literature, there are examples, such as telestroke where the most frequently reported outcome (mortality) may not be the most important, either to patients or in terms of the expected impact of changing care. The assessment of telehealth consultations would also be strengthened by more studies that include contemporary comparison groups, either groups of patients or other organizations, so that the effect of the telehealth consultations could be more successfully isolated from historical changes or the idiosyncrasies of a specific organization. This could involve adding comparisons or control sites to before/after telehealth studies.

The research on telehealth could have more impact if its objectives were clearer. Evaluations of telehealth consultations can consider different perspectives and different levels of implementation and evaluation, but failing to be clear leads to studies with confusing results and lessens the impact of positive results. For example, the work on the decision analyses highlighted the importance of clearly specifying the options being compared, or what is "usual care." For a decision analysis, it is important to decide if the alternative to a telehealth consultation is a face-to-face consultation, nonreceipt of a service, or service provided with no consultation. While all may be possible, this shapes the many factors for consideration. In the studies we evaluated for this systematic review, what the nontelehealth or "usual care" option consisted of was often not specified, and it was not always clear what care these patients received.

The decision analysis also highlighted the importance of perspective and the need for better information. The assessment of telehealth consultations is different from the perspective of a payer, a health system, a hospital, a practice group, or an individual provider. Most studies did not clearly state their perspective, though it was often implied that is was a single organization (e.g., a hospital or practice group). This seems unnecessarily limiting, and more studies at higher levels seem warranted. In many ways telehealth consultations could be viewed as a systems-level intervention, more similar to health information exchange and electronic health records, than to a condition-specific treatment. While a small subset of studies looked at the use of telehealth consultations across several specialties, they did not look at systems level implementation that would facilitate consultations throughout an organization and spread the cost of the technology, the workflow changes, and any needed training or new skills more broadly across a system. A more definitive test of the hypothesis that telehealth consultations provide better value could come from multi-site trial-based economic evaluations, where patients are randomized to either standard management or a telehealth consultation and cost as well as outcomes data is collected.

A major evolution of the research in this area would be to focus on hybrid studies, that is, studies that combine effectiveness and implementation assessments. While the results may be uneven across specific clinical areas, telehealth consultations do generally improve access and clinical outcomes and are likely to improve other outcomes. What is missing is much of the specific information asked for in Key Questions 4 and 5 of this review; that is, what are the characteristics of the context and how do they impact outcomes? Additionally, having more information on costs could be facilitated by collecting economic data alongside trials or observational studies. This would greatly increase the relevance and completeness of evidence. A hybrid approach to future research could focus on the information needed to promote successful implementation while still continuing to collect better data demonstrating effectiveness and economic impact.

Reviewing background material for this report and discussing telehealth with the Technical Expert Panel and other experts has convinced us that telehealth consultation are being used, particularly in smaller and rural health systems, and that data are often being collected. However, these organizations and data are not represented in the published literature due to lack of research and analysis capacity. Given the importance to policy and practice issues related to telehealth consultations (e.g., payment, scope of work, cross organization and state licensing), identifying and facilitating the analysis of these data should be a priority and may help strengthen what conclusions can be made about telehealth consultations.

Also, during the time period covered in the review and during our work, policies were changed that will likely facilitate telehealth consultation and, perhaps in response, the number of publications about telehealth increased. However, many of these publications are descriptive reports or evaluations using comparatively weak designs. Continuing in this vein, increasing volume without increasing rigor is unlikely to contribute to the next level of telehealth expansion. Given that increasingly more resources are being invested in telehealth, it is reasonable to suggest that research evaluating its effectiveness and impact should improve, employing better designs and better data. Important efforts include defining and delineating potential functions and appropriate outcomes. Clearly defining the function of telehealth in various clinical situation is essential so that future research can avoid combining and comparing across several functions, which may be one reason studies and reviews are often unable to reach conclusions or make recommendations. However, comparisons also require common measures, such as those based on the measurement framework produced by the National Quality Forum as a step toward developing common outcome measures for quality assessment, quality improvement, and research.[16]

The current situation seems to require an organized effort by telehealth advocates, researchers, and policymakers. We strove to identify where there are still gaps in the research base for one function of telehealth, but this needs to be done for other functions and then stakeholders need to prioritize identified research gaps in terms of their potential to move the field forward, toward increasing use of telehealth in those settings and instances where it is likely to be beneficial for patients, healthcare providers, health systems, or society.

Implications and Conclusions

Although the literature evaluating telehealth consultations is large, it is not possible to make a global, general statement about the clinical and economic effectiveness of telehealth consultations for several reasons. These include the diversity of settings, clinical topics and outcomes; the limited number of high-quality studies; different approaches to measurement, particularly of costs; and how the perspective may impact the estimation of outcomes. It is possible to conclude it is likely that telehealth is more effective than usual care in several specific situations: Remote intensive care units (ICUs) reduce ICU and in-hospital mortality; emergency medical services access to telehealth reduces mortality in patients having heart attacks; remote consultations in emergency care decrease time from presentation to decision, reducing emergency department (ED) time and increasing appropriate transfers and admissions; remote consultations as part of outpatient care improve clinical outcomes in some clinical disciplines and increase access to care in those that have been studied.

For other uses and outcomes the strength of evidence is less definitive. Telehealth consultations may improve inpatient care, emergency stroke care and the management of and satisfaction with outpatient consultations across several specialties. Potential harms or unintended consequences were rarely addressed and future research should address this, if only to confirm they are not significant. Studies of economic outcomes including costs produced mixed results due to major differences in definitions and methods as well as the fact that costs and savings may not accrue to the same organization in an interdependent healthcare system.

Decision models have the potential to build on systematic review results and use evidence in ways that would make it more applicable by tailoring the question, base case, and perspective to the decision maker’s situation. But our experience demonstrates that the literature may not be available to provide all the data needed to fully execute a functioning model for all topics of interest. However, decision modeling can provide some insight by quantifying differences in costs across settings and estimating where savings are likely to accrue in the system. While our exploratory assessment was limited to costs, expansion of this approach could allow more targeted identification of scenarios in which telehealth could improve the range of outcomes including clinical outcomes, access, and cost.

Future research about telehealth consultations needs to be more rigorous if it is to inform policy and practice decisions. Specifically, more studies should include multiple sites, collect information on the context and environment, and consistently measure a more comprehensive range of economic impacts and costs using standard practices.

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Abbreviations

AHRQ	Agency for Healthcare Research and Quality
AIRR	adjusted incidence ratio
AMI	acute myocardial infarction
AOR	adjusted odds ratio
APACHE	Acute Physiology and Chronic Health Evaluation
AUD	Australian dollars
CAD	Canadian dollars
CCRCT	Cochrane Central Register of Controlled Trials
CI	confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
DBP	diastolic blood pressure
DiD	difference in difference
DM	decision model
ED	emergency department
EEG	electroencephalogram
ENT	ear, nose, and throat
EMS	emergency medical services
EPC	Evidence-based Practice Center
FIM	Finnish markka
GBP	British Pound
GOS	Glasgow Outcome Scale
GP	general practitioner
HCV	hepatitis C virus
HgbA1C	hemoglobin A1c
HR	hazard ratio
ICU	intensive care unit
IQR	interquartile range
IV tPA	intravenous tissue plasminogen activator
K	Kappa
KQ	Key Question
LDL	low-density lipoprotein cholesterol
LOS	length of stay
MCS	Mental Component Summary
MD	medical doctor
MI	myocardial infarction
mRS	Modified Rankin Sale
NA	not applicable

NHS	National Health Services
NICU	neonatal intensive care unit
NIHSS	National Institutes of Health Stroke Scale
NQF	National Quality Forum
NR	not reported
NS	not significant
OR	odds ratio
PCI	percutaneous coronary intervention
PCS	Physical Component Summary
PCU	progressive care unit
PICOTS	population, intervention, comparator, outcomes, timing, and setting
PICU	pediatric intensive care unit
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTSD	posttraumatic stress disorder
QWB	quality of well-being score
RCT	randomized controlled trial
RR	risk ratio
SAPS	Simplified Acute Physiology Score
SBP	systolic blood pressure
SD	standard deviation
SEK	Swedish Krona
SEM	standard error of the mean
SF-12	Short Form-12
SOE	strength of evidence
SR	systematic review
STEMI	ST-elevation myocardial infarction
TEP	Technical Expert Panel
TIMI	thrombolysis in myocardial infarction
TMJ	temporomandibular joint disorder
tPA	tissue plasminogen activator
UAMS	University of Arkansas for Medical Sciences
UK	United Kingdom
USD	United States Dollars
VA	Veterans Affairs

Appendix A. Literature Search Strategies

Search strategies – Telehealth consultation

Database: Ovid MEDLINE(R) without Revisions 1996 to May Week 4 2018

Systematic reviews

1 exp Telemedicine/
2 Mobile Applications/
3 telemedicine journal & e health.jn.
4 "journal of telemedicine & telecare".jn.
5 or/1-4
6 limit 5 to (meta analysis or systematic reviews)
7 meta-analysis.pt.
8 meta-analysis/ or systematic review/ or meta-analysis as topic/ or "meta analysis (topic)"/ or "systematic review (topic)"/ or exp technology assessment, biomedical/
9 ((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab.
10 ((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab.
11 ((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*)).ti,ab.
12 (data synthes* or data extraction* or data abstraction*).ti,ab.
13 (handsearch* or hand search*).ti,ab.
14 (mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab.
15 (met analy* or metanaly* or technology assessment* or HTA or HTAs or technology overview* or technology appraisal*).ti,ab.
16 (meta regression* or metaregression*).ti,ab.
17 (meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw.
18 (medline or cochrane or pubmed or medlars or embase or cinahl).ti,ab,hw.
19 (cochrane or (health adj2 technology assessment) or evidence report).jw.
20 (meta-analysis or systematic review).ti,ab.
21 (comparative adj3 (efficacy or effectiveness)).ti,ab.
22 (outcomes research or relative effectiveness).ti,ab.
23 ((indirect or indirect treatment or mixed-treatment) adj comparison*).ti,ab.
24 or/7-23
25 5 and 24
26 6 or 25
27 limit 26 to yr="2018 - current"

Randomized controlled trials and controlled observational studies – Broad search strategy

1 exp Telemedicine/
2 Mobile Applications/
3 telemedicine journal & e health.jn.

4 "journal of telemedicine & telecare".jn.
5 or/1-4
6 limit 5 to (clinical trial, all or comparative study or controlled clinical trial or pragmatic clinical trial or randomized controlled trial)
7 5 and (random* or control* or cohort).ti,ab.
8 6 or 7
9 limit 8 to yr="2018 - current"

All study designs – Narrow search strategy
1 exp Telemedicine/
2 Mobile Applications/
3 telemedicine journal & e health.jn.
4 "journal of telemedicine & telecare".jn.
5 exp Remote Consultation/
6 consult*.mp.
7 (or/1-4) and (5 or 6)
8 limit 7 to yr="1996 - 2018"
9 limit 8 to (meta analysis or systematic reviews)
10 meta-analysis.pt.
11 meta-analysis/ or systematic review/ or meta-analysis as topic/ or "meta analysis (topic)"/ or "systematic review (topic)"/ or exp technology assessment, biomedical/
12 ((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab.
13 ((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab.
14 ((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*)).ti,ab.
15 (data synthes* or data extraction* or data abstraction*).ti,ab.
16 (handsearch* or hand search*).ti,ab.
17 (mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab.
18 (met analy* or metanaly* or technology assessment* or HTA or HTAs or technology overview* or technology appraisal*).ti,ab.
19 (meta regression* or metaregression*).ti,ab.
20 (meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw.
21 (medline or cochrane or pubmed or medlars or embase or cinahl).ti,ab,hw.
22 (cochrane or (health adj2 technology assessment) or evidence report).jw.
23 (meta-analysis or systematic review).ti,ab.
24 (comparative adj3 (efficacy or effectiveness)).ti,ab.
25 (outcomes research or relative effectiveness).ti,ab.
26 ((indirect or indirect treatment or mixed-treatment) adj comparison*).ti,ab.
27 or/10-26
28 8 and 27
29 9 or 28
30 8 not 29

31 limit 30 to (english language and humans)
32 7 and 27
33 7 not 32
34 limit 33 to yr="2018 - current"

Database: EBM Reviews - Cochrane Central Register of Controlled Trials May 2018
1 exp Telemedicine/
2 (telemedicine or telehealth or teleconsult*).mp.
3 1 or 2
4 3 and (random* or control* or cohort).ti,ab.
5 limit 4 to english language

Database: EBM Reviews - Cochrane Database of Systematic Reviews 2005 to May 31, 2018
1 (telemedicine or telehealth or teleconsult*).mp.
2 limit 1 to new reviews

Database – CINAHL Plus with Full Text
S1 (MM "Telemedicine +")
S2 consult*
S3 S1 AND S2

Appendix B. Inclusion and Exclusion Criteria

Full-Text Paper Inclusion/Exclusion Codes: Reasons for full text paper inclusion or exclusion

Inclusion

1 = Include in the report

Exclusion

2 = Background or discussion paper only
3 = Ineligible population (nonhuman, patients without known or suspected acute or chronic conditions)
4 = Ineligible intervention (not a consultation; example: direct patient care, educational/training sessions)
5 = Ineligible comparison or no comparison (descriptive)
6 = Ineligible outcome; does not have an included outcome (e.g., feasibility only, no outcome/just description)
7 = Ineligible timing (studies with outcome measures that occur before telehealth consultation)
8 = Ineligible setting (exclude nonhealth care and training/education setting unless there is a consultation)
9 = Ineligible study design (nonsystematic reviews, evaluation of hypothetical uses or needs assessments)
10 = Ineligible publication type (opinion, editorial, letter, guideline document not used for background)
11 = Wrong years (studies published before 1996)
12 = Not in English
13 = No new data
14 = Systematic review used to identify primary studies
15 = Modeling study, no original data

Table B-1. Inclusion and exclusion criteria

PICOTS	Include	Exclude
Populations	Patients of any age, with medical care needs for prevention, treatment or management of chronic or acute condition. Providers (clinicians or health care organizations). Dentistry may be added only if it fits our criteria for consultation. Payers for health care services (public, private, insurers, or patients).	Consultations about people, non-health care services (e.g., housing or social services).
Interventions	Telehealth consultations, defined as the use of telehealth designed to facilitate collaboration among providers, often involving a specialist, or assessment between clinical team members, across time and/or distance, on the assessment, diagnosis, and/or clinical management of a specific patient or group of patients. Telehealth consultations can be for any acute or chronic conditions. The search will be both general as well as focused on conditions identified as infectious disease, dermatology and critical care. Telehealth consultations can use any technology (e.g., real-time video, store and forward).	Provision of direct, ongoing patient care (telehealth for patient visits) Strictly educational/training sessions that do not have a consultation about a specific patient or patients. Simple referral for ongoing management with no collaboration. Telephone-only consultations do not constitute telehealth.
Comparators	Other locations, patients, or timeperiods that use in-person consultations or provide usual care (which could include no access to specific services).	Comparisons of in-person and telehealth assessments by the same provider No comparison/simple reporting of events or characteristics

PICOTS	Include	Exclude
Outcomes Clinical KQ1	Clinical outcomes such as mortality, morbidity, function, recovery and access to services (e.g., improved medical condition, access to telepsychiatry evaluation with psychiatrist in primary care office)	Descriptive statistics without comparison. For example, the number of telehealth encounters, the conditions treated or the actions taken if these are not compared somehow (across groups, time periods or raters)
Outcomes Economic KQ1	Economic outcomes such as return on investment, cost, volume of visits, and resource use	
Outcomes Intermediate KQ2	Patient satisfaction, behavior, and decisions such as completion of treatment, or satisfaction with less travel to access health care Provider satisfaction, behavior, and decisions such as the choice of treatment or antibiotic stewardship Improved time to diagnosis and treatment	Studies looking only at diagnostic concordance or accuracy or other measures of agreement between in-person and telehealth consultations
Adverse Effects or Unintended Consequences KQ3	Loss of privacy or breech of data security Misdiagnosis or delayed diagnosis Inappropriate treatment Increase in resource costs, negative return on investment	
Timing	Telehealth consultations can be used at any point in the diagnosis, treatment, or management of patient. Outcomes measurement needs to occur after the telehealth consultation	Studies with outcome measures that occur before the telehealth consultation.
Setting	The consultation can involve providers and patients in any location. These could include inpatient, outpatient, long-term care and could be in civilian, VA, or military facilities.	Not in a training/educational setting (unless there truly is consultation between providers) Settings that are not health care related
Study Design and Publication Type	Comparative studies, including trials and observational studies (cohorts or pre/post historical controls may be considered). Descriptive studies may be used to inform the DM as needed but will not be used to inform the SR.	Nonsystematic reviews, commentaries, or letters. Evaluations of hypothetical situations (e.g., would teleconsultation be used if it was available?) Feasibility assessments (if it was possible to set it up) Survey studies are included only if they are about things that actually happened (no hypothetical survey studies)
Years	1996 to present	1995 and earlier
Language	English	Non-English

Key Questions for the Systematic Review

1. Are telehealth consultations effective in improving clinical and economic outcomes?
   Clinical and economic outcomes may include, but are not limited to, mortality and morbidity, utilization of health services, cost of services, and access to services.
2. Are telehealth consultations effective in improving intermediate outcomes?
   Intermediate outcomes include both outcomes that precede the ultimate outcomes of interest and secondary outcomes. These may include, but are not limited to, patient and provider satisfaction, behavior, and decisions; volume of services; and health care process.

3. Have telehealth consultations resulted in harms, adverse events, or negative unintended consequences?
4. What are the characteristics of telehealth consultations that have been the subject of comparative studies?
   The characteristics include:
   a. Clinical conditions addressed
   b. Characteristics of the providers and patients involved
   c. Relationships among the providers and patients involved
   d. Telehealth modalities and/or methods for sharing patient data used
   e. Whether specifics in (d) meet Medicare's coverage and HIPAA requirements
   f. Settings such as type of health care organization, country, or urban or rural area
   h. Other circumstances (e.g., appropriate transportation, climate)
   g. Payment models or requirements or limits for payment
5. Do clinical, economic, intermediate, or negative outcomes (i.e., the outcomes in KQs 1, 2, and 3) vary across telehealth consultation characteristics (KQ4)?

Outcomes for Each Key Question

- KQ1: Clinical and economic outcomes
  - Clinical outcomes such as mortality, morbidity, function, recovery, infection, and access to services.
  - Economic outcomes such as return on investment, cost, volume of visits, and resource use.
- KQ 2: Intermediate outcomes
  - Patient satisfaction, behavior, and decisions
  - Provider satisfaction, behavior, and decisions
  - Time to diagnosis and time to treatment
- KQ 3: Adverse effects or unintended consequences
  - Loss of privacy or breech of data security
  - Misdiagnosis or delayed diagnosis
  - Inappropriate treatment
- KQ 4: Not applicable (this is a descriptive question)
- KQ5: Clinical and economic outcomes (see KQ1), intermediate outcomes (see KQ2), and adverse effects or unintended consequences (see KQ3)

Timing

- Telehealth consultations can be used at any point in the diagnosis, treatment, or management of a patient.
- Outcome measurement needs to occur after the telehealth consultation.

Setting

- The consultation can involve providers and patients in any location.

Study Designs

- Comparative studies, including trials and observational studies.

- Descriptive studies may be used to inform the decision model as needed but will not be included in the systematic review.

Appendix C. Included Studies

1. Alemi AS, Seth R, Heaton C, et al. Comparison of video and in-person free flap assessment following head and neck free tissue transfer. Otolaryngol Head Neck Sur. 2017 Jun;156(6):1035-40. doi: 10.1177/0194599816688620. PMID: 28140835.

2. Amorim E, Shih MM, Koehler SA, et al. Impact of telemedicine implementation in thrombolytic use for acute ischemic stroke: the University of Pittsburgh Medical Center telestroke network experience. J. Stroke Cerebrovasc. Dis. 2013 May;22(4):527-31. doi: 10.1016/j.jstrokecerebrovasdis.2013.02.004. PMID: 23489955.

3. Angstman KB, Rohrer JE, Adamson SC, et al. Impact of e-consults on return visits of primary care patients. Health Care Manag (Frederick). 2009 Jul-Sep;28(3):253-7. doi: 10.1097/HCM.0b013e3181b3efa3. PMID: 19668067.

4. Armaignac DL, Saxena A, Rubens M, et al. Impact of telemedicine on mortality, length of stay, and cost among patients in progressive care units: experience from a large healthcare system*. Crit. Care Med. 2018 04/13;46(5):728-35. doi: 10.1097/CCM.0000000000002994. PMID: 29384782.

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Appendix D. Excluded Studies

1. Army tests battlefield medical systems. Telemed Virtual Real. 1997 Dec;2(12):134. PMID: 10174645. **Exclusion reason:** Ineligible comparison

2. Abu Dhabi Hospital links to WorldCare Gulf. Telemed Virtual Real. 1997 Sep;2(9):106. PMID: 10170469. **Exclusion reason:** Ineligible publication type

3. New York doctor goes on the 'Net to save a baby in Argentina. Telemed Virtual Real. 1997 Sep;2(9):105. PMID: 10170467. **Exclusion reason:** Ineligible study design

4. PhysiTel announces "One World" program for developing nations. Telemed Virtual Real. 1998 Aug;3(8):93. PMID: 10182127. **Exclusion reason:** Ineligible publication type

5. Industry donations complete "last mile" so tiny hearts can get expert care. Telemed Virtual Real. 1998 Jul;3(7):81. PMID: 10180768. **Exclusion reason:** Ineligible comparison

6. Italian hospitals connect to Bosnia, Albania. Telemed Virtual Real. 1998 Jun;3(6):70. PMID: 10180761. **Exclusion reason:** Ineligible comparison

7. Navy uses telemedicine to save sailors, money. Telemed Virtual Real. 1998 Mar;3(3):29. PMID: 10177466. **Exclusion reason:** Ineligible publication type

8. Report of the Joint Working Group on telemammography/teleradiology and information management. Washington DC, USA. March 15-17, 1999. Acad Radiol. 1999 Nov;6 Suppl 7:S303-24. PMID: 10894305. **Exclusion reason:** Ineligible publication type

9. Telemedical consultation system: how to choose. Emerg Nurse. 1999;7(6):11-3. **Exclusion reason:** Ineligible publication type

10. Online second opinion services allow doctors and hospitals to treat patients outside their local markets. Internet Healthc Strateg. 2003 Aug;5(8):7-9. PMID: 12961838. **Exclusion reason:** Ineligible publication type

11. Comprehensive care is put to the test in CMS demo. Dis Manag Advis. 2004 Aug;10(8):85-8. PMID: 15473181. **Exclusion reason:** Ineligible intervention

12. Web-based consults save money, boost satisfaction: members, docs communicate on nonurgent matters. Case Management Advisor. 2005;16(8):88-90. **Exclusion reason:** Ineligible study design

13. Mobile health technologies facilitate efficient communication in ophthalmology. Ocular Surgery News. 2013;31(4):1-12. **Exclusion reason:** Ineligible comparison

14. Telehealth tackles elderly health care. Aust Nurs J. 2013 Jul;21(1):41. PMID: 23936932. **Exclusion reason:** Ineligible intervention

15. Women linked with maternity services. Midwives. 2014;17(4):8. PMID: 25145078. **Exclusion reason:** Ineligible intervention

16. National Quality Forum. Creating a Framework to Support Measure Development for Telehealth Department of Health and Human Services. Contract HHSM-500-2012-00009I, Task Order HHSM-500-T0022. Washington, DC: 2017. **Exclusion reason:** Background information only

17. Aanesen M, Lotherington AT, Olsen F. Smarter elder care? A cost-effectiveness analysis of implementing technology in elder care. Health Informatics J. 2011 Sep;17(3):161-72. doi: 10.1177/1460458211409716. PMID: 21937460. **Exclusion reason:** Ineligible intervention

18. Aarnio P, Lamminen H, Lepisto J, et al. A prospective study of teleconferencing for orthopaedic consultations. J Telemed Telecare. 1999;5(1):62-6. doi: 10.1258/1357633991932405. PMID: 10505371. **Exclusion reason:** Ineligible comparison

19. Aboujaoude E, Salame W. Technology at the service of pediatric mental health: review and assessment. J Pediatr. 2016 Apr;171:20-4. doi: 10.1016/j.jpeds.2015.12.009. PMID: 26743496. **Exclusion reason:** Ineligible intervention

20. Adams SJ, Burbridge BE, Badea A, et al. Initial experience using a telerobotic ultrasound system for adult abdominal sonography. Can Assoc Radiol J. 2017 Aug;68(3):308-14. doi: 10.1016/j.carj.2016.08.002. PMID: 28159435. **Exclusion reason:** Ineligible intervention

21. Agarwal S, Day DJ, Sibson L, et al. Thrombolysis delivery by a regional telestroke network--experience from the U.K. National Health Service. J Am Heart Assoc. 2014 Feb 26;3(1):e000408. doi: 10.1161/JAHA.113.000408. PMID: 24572251. **Exclusion reason:** Ineligible intervention

22. Agarwal S, Tamrat T, Glenton C, et al. Decision-support tools via mobile devices to improve quality of care in primary healthcare settings. Cochrane Database of Syst Rev. 2018(2) PMID: 00075320-100000000-11357. **Exclusion reason:** Ineligible study design

23. Agasthya N, Foo K, Smith T, et al. Use of telemedicine in the pediatric intensive care unit. Crit Care Med. 2018;Conference: 47th society of critical care medicine critical care congress, SCCM. 2018. United states 46(Supplement 1):189. PMID: CN-01452195. **Exclusion reason:** Ineligible publication type

24. Ahmed A, Slosberg E, Prasad P, et al. The successful use of telemedicine in acute variceal hemorrhage. J Clin Gastroenterol. 1999 Sep;29(2):212-3. PMID: 10478893. **Exclusion reason:** Ineligible study design

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26. Akbik F, Hirsch JA, Chandra RV, et al. Telestroke-the promise and the challenge. Part one: growth and current practice. J Neurointerv Surg. 2017 Apr;9(4):357-60. doi: 10.1136/neurintsurg-2016-012291. PMID: 26984868. **Exclusion reason:** Ineligible publication type

27. Akematsu Y, Nitta S, Morita K, et al. Empirical analysis of the long-term effects of telecare use in Nishi-aizu Town, Fukushima Prefecture, Japan. Technol Health Care. 2013;21(2):173-82. doi: 10.3233/THC-130728. PMID: 23510979. **Exclusion reason:** Ineligible intervention

28. Akematsu Y, Tsuji M. Does telecare reduce the number of treatment days? Stud Health Technol Inform. 2012;180:507-11. PMID: 22874242. **Exclusion reason:** Ineligible intervention

29. Akematsu Y, Tsuji M. Measuring the effect of telecare on medical expenditures without bias using the propensity score matching method. Telemed J E Health. 2012 Dec;18(10):743-7. doi: 10.1089/tmj.2012.0019. PMID: 23072633. **Exclusion reason:** Ineligible intervention

30. Akematsu Y, Tsuji M. Relation between telecare implementation and number of treatment days in a Japanese town. J Telemed Telecare. 2013 Jan;19(1):36-9. doi: 10.1177/1357633X12474743. PMID: 23390215. **Exclusion reason:** Ineligible intervention

31. Al Kasab S, Harvey JB, Debenham E, et al. Door to needle time over telestroke- a comprehensive stroke center experience. Telemed J E Health. 2018 Feb;24(2):111-5. doi: 10.1089/tmj.2017.0067. PMID: 28753069. **Exclusion reason:** Ineligible intervention

32. AlAzab R, Khader Y. Telenephrology application in rural and remote areas of Jordan: benefits and impact on quality of life. Rural Remote Health. 2016 Jan-Mar;16(1):3646. PMID: 26745230. **Exclusion reason:** Ineligible comparison

33. Allen A, Wheeler T. Telepsychiatry background and activity survey. The development of telepsychiatry. Telemed Today. 1998 Apr-May;6(2):34-7. PMID: 10181178. **Exclusion reason:** Ineligible comparison

34. Amarenco P, Nadjar M. Telemedicine for improving emergent management of acute cerebrovascular syndromes. Int J Stroke. 2007;2(1):47-50. doi: 10.1111/j.1747-4949.2007.00087.x. PMID: 18705988. **Exclusion reason:** Ineligible outcome

35. Amoakoh-Coleman M, Borgstein AB, Sondaal SF, et al. Effectiveness of mHealth interventions targeting health care workers to improve pregnancy outcomes in low- and middle-income countries: A systematic review. J Med Internet Res. 2016 Aug 19;18(8):e226. doi: 10.2196/jmir.5533. PMID: 27543152. **Exclusion reason:** Systematic review used to identify primary studies

36. Andonegui J, Aliseda D, Serrano L, et al. Evaluation of a telemedicine model to follow up patients with exudative age-related macular degeneration. Retina. 2016 Feb;36(2):279-84. doi: 10.1097/IAE.0000000000000729. PMID: 26383707. **Exclusion reason:** Ineligible comparison

37. Andrews V. Using telemedicine in clinical decision-making. Practice Nursing. 2014;25(1):42-6. **Exclusion reason:** Ineligible comparison

38. Anogianakis G, Maglavera S. Medical emergency aid through telematics (MERMAID). Stud Health Technol Inform. 1996;29:255-64. PMID: 10163758. **Exclusion reason:** Ineligible comparison

39. Anonymous. Saving sight and lives online. BMJ. 2017 Jan 09;356:j42. doi: 10.1136/bmj.j42. PMID: 28069579. **Exclusion reason:** Ineligible publication type

40. Arba F, Piccardi B, Baldereschi M, et al. Telemedicine for acute ischaemic stroke. Cochrane Database Syst Rev. 2016(2) PMID: 00075320-100000000-10477. **Exclusion reason:** Ineligible publication type

41. Armfield NR, Coulthard MG, Slater A, et al. The effectiveness of telemedicine for paediatric retrieval consultations: rationale and study design for a pragmatic multicentre randomised controlled trial. BMC Health Serv Res. 2014 Nov 11;14:546. doi: 10.1186/s12913-014-0546-9. PMID: 25381774. **Exclusion reason:** Background information only

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44. Armstrong IJ, Haston WS, Maclean JR. Telepresence for decision support offshore. J Telemed Telecare. 1996;2(3):176-7. PMID: 9375055. **Exclusion reason:** Ineligible publication type

45. Arora S, Geppert CM, Kalishman S, et al. Academic health center management of chronic diseases through knowledge networks: Project ECHO. Acad Med. 2007 Feb;82(2):154-60. doi: 10.1097/ACM.0b013e31802d8f68. PMID: 17264693. **Exclusion reason:** Background information only

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Appendix E. Telehealth for Consultations Risk of Bias Instructions

Step 1: Determine Study Design

Table E-1. Description of study design categorization

Category	**Details**
Randomized Controlled Trial	Key characteristic: People or groups (hospitals/clinics) are assigned by the researchers and assignment is random, not based on assessment/need or other non-random criteria. Maybe called RCT, Randomized Trial, Randomized Study - Randomization is about *Random Assignment* to different treatments. Random Sampling is different and does NOT make something an RCT.
Observational Cohort	Key characteristics: 1. The study **compares different people**—usually some treated with telehealth and some without. 2. How patients are treated. This is observed as it happens, it is not controlled by the study, i.e., the researchers do not determine who receives the intervention We are including 3 types of studies in this category: <u>Prospective cohorts</u>: Patients are identified and followed into the future to obtain data <u>Retrospective cohort</u>: Patient are identified, but all the data already exists and the researchers look back into the past to collect it <u>Before-after cohorts</u>: A group of patients from before an intervention/system change are compared to a different group of patients after a change. These may be called Pre Post by the authors, but we are distinguishing studies that compare different groups of patients from those that compare the same patients at different times.
Pre-Post	The same patients are compared at different points in time or under different conditions. Patients serve as their own controls. This includes studies where the telehealth consultation is done twice on the same patient, once using telehealth and once face-to-face.
Economic evaluations	Key characteristics: 1. The study assesses the economic impact of one intervention compared to another or to usual care. 2. The study uses economic or cost data from primary research. This is to differentiate between studies that use hypothetical data or data that was derived from other published sources. Studies that do not use full economic analysis methods, but assess a certain cost as a direct outcome (e.g., patient costs incurred in telehealth versus not telehealth), can be assessed using the appropriate criteria related to its study design (i.e., RCT, cohort, pre-post)

RCT = randomized controlled trial

Step 2: Assess Criteria for the Study Design

Responses are:

Yes: indicating the criteria is met, bias is reduced
No: indicating the criteria is not met; bias may be introduced
Unclear: article has some mention, but not clear what was done; bias may be present
NR: indicating the article did not report on the criteria; bias may be present
NA: not applicable

Table E-2. Criteria for randomized controlled trials

Criteria	Details
Was randomization sequence generated adequately?	Adequate: computer generated, random number table, coin flip Key: truly random, not a characteristic of the patient or the situation Inadequate examples: day of week, patient's birthday, last two digits of medical record number (may be based on something)
Was allocation concealment adequate?	Adequate: assignment to groups is not evident in advance to the person recruiting and assigning the patient. Examples: centralized call in to another location; computer generated; opaque sealed envelopes (maybe) Inadequate examples: An open list, envelopes
Were eligibility criteria specified?	Specified: list of key characteristics stated and applied Not specified: information not provided about who would be included or excluded
Were groups similar at baseline or did the analysis control for any important baseline differences?	Look for a Table 1 that compares key characteristics. Adequate: Most differences not statistically significantly different; small differences between groups, OR if there is a difference despite randomization that seems important, they control for that characteristic in analysis.
Were participants analyzed in the groups they were originally assigned to?	This may be called "intention to treat." This means people stay in the group to which they were assigned for analysis even if they get the other treatment.
Was attrition low and/or adherence high?	We want YES to be positive. We want most people to remain in the study. A cut off often used is losing fewer than 20% of the people. Another question to consider is, do people complete the intervention as intended?
Were outcome assessors and/or data analyst blinded? Or are primary outcome measures unlikely to be biased?	For *Yes* they should say the person measuring the outcome or analyzing the data does not know which groups patients or organizations are in. This may be *No* for many telehealth studies. Outcomes unlikely to be biased include death, hospitalization and service utilization. Outcomes that might be biased might be functional assessment, quality of life, and satisfaction.
Were reliable measures of outcomes and confounders used and implemented consistently across all study participants/groups?	This is about using measures that provide consistent information and in most cases have been tested or evaluated.
Were the outcomes prespecified and were all the prespecified outcomes reported?	This may be hard to tell from a journal article. Ideally they should specify their outcomes in methods and then give data for all that were mentioned.

Table E-3. Criteria for cohort (must compare different patients - includes different patients before and after telehealth)

Criteria	Details
Study Design	Specify: (see definitions above) Retrospective Cohort Prospective Cohort Before After
Were eligibility or selection criteria for the study population pre-specified and clearly described?	For Yes: It should be clear who is included in the study and who is excluded
Did the study attempt to enroll a random sample or consecutive or all patients meeting inclusion criteria in a defined period?	For Yes: Articles should say “all” or consecutive and be specific. For No: Anything that suggests the study picked a subgroup based on a criteria that might influence outcomes.
Were groups similar or did the design and analyses account for important potential confounding and modifying variables appropriately?	For Yes: The study should specify what confounders or modifiers are important and how they are addressed. You should be convinced that how confounders were addressed was done well. Confounding is when a variable is related to both the intervention and the outcome. Example: *health status if sicker patients use telehealth and healthier use in-person visits and your outcome is hospitalizations.* In Before After studies one thing to consider is whether there was a major change or something different likely to affect the outcome in the different time periods and whether the researchers try to address this. Modifying variables: When the effect of the intervention is different for different groups. Example: *Older patients are less satisfied with telehealth than younger people.* Modifiers may be adjusted for or the results may be presented by subgroups (subgroups is an acceptable approach).
Were valid and reliable measures used and were they adequately ascertained? (inclusion/exclusion, confounding, outcomes)	This is about using measures that provide consistent information and in most cases have been tested or evaluated. It is also important to consider how the outcomes were ascertained. That is, does the study describe how they got the outcomes they were studying? For example, does the study tell you how they determined diagnosis outcomes or how they got the data for costs?
Were outcome assessors and/or data analysts blinded to treatment or are the outcomes objective and unlikely to be biased?	For Yes: Studies should state that the person measuring the outcome or analyzing the data does not know which groups patients or organizations are in. This may be NO for many telehealth studies. Outcomes unlikely to be biased include death, hospitalization and service utilization. Outcomes that might be biased include functional assessment, quality of life, and satisfaction.
Was there NO or only small amounts of missing data? Or if there was missing data, was it handled appropriately?	Missing data is about specific variables missing, NOT about patients dropping out (that is the next criteria). NA is an option if the study is retrospective. If data is missing, they may describe analytic methods for addressing this. If they are complex, make a note and ask. In general, dropping cases or carrying the last value forward are not acceptable. Acceptable approaches might be using “bootstrapping,” near neighbor, or matching; that is, some methods attempt to estimate the missing data and are clear about their assumptions.
Is there NO important differential loss to followup or overall low loss to followup or attrition?	No: If a large number of people are lost to followup or if a smaller number are lost but there are more in one group than another or result in the groups being different (for example, all the men drop out of one group). NA is an option here for Retrospective Cohorts. NA is not negative for retrospective studies.
Were outcomes prespecified and were prespecified outcomes reported?	This may be hard to tell from a journal article. Ideally they should specify their outcomes in methods and then give data for the all that were mentioned.

Table E-4. Criteria for pre-post (same patients, different time periods)

Criteria	Details
Study Design	Confirm Pre Post (same people; different time periods)
Were eligibility or selection criteria for the study population prespecified and clearly described?	For Yes: It should be clear who is included in the study and who is excluded it should be clear who is in and who is out.
Did the study attempt to enroll a random sample or consecutive or all patients meeting inclusion criteria in the Pre Period?	For Yes: Articles should say "all" or consecutive and be specific. For No: Anything that suggests the study picked a subgroup based on a criteria that might influence outcomes.
Did the design and analyses account for important potential confounding and modifying variables appropriately?	For Yes: The study should specify what confounders are important and how they are addressed. You should be convinced that how they were addressed was done well. For these studies the confounders are what might be different in the Pre and Post time periods. In Pre Post studies one thing to consider is whether there was a major change or something different likely to affect the outcome in the different time periods and did the researchers try to address this.
Were valid and reliable measures used and were they adequately ascertained? (inclusion/exclusion, confounding, outcomes)	This is about using measures that provide consistent information and in most cases have been tested or evaluated. It is also important to consider how the outcomes were ascertained. That is, does the study describe how they got the outcomes they were studying? For example, does the study tell you how they determined diagnosis outcomes or how they got the data for costs?
Were outcome assessors and/or data analysts blinded to treatment or are the outcomes objective and unlikely to be biased?	For Yes: Studies should state that the person measuring the outcome or analyzing the data does not know which groups patients or organizations are in. This may be NO for many telehealth studies. Outcomes unlikely to be biased include death, hospitalization and service utilization. Outcomes that might be biased include functional assessment, quality of life, and satisfaction.
Was there NO or only small amounts of missing data? Or if there was missing data, was it handled appropriately?	Missing data is about specific variables missing, NOT about patients dropping out (that is the next criteria). If data is missing, they may describe analytic methods for addressing this. If they are complex, make a note and ask. In general, dropping cases or carrying the last value forward are not acceptable. Acceptable approaches might be using "bootstrapping," near neighbor, or matching; that is, some methods attempt to estimate the missing data and are clear about their assumptions.
Is there low loss to followup or attrition?	No: If a large number of people are lost from baseline to end point—usually less than 20%. You may need to look at the numbers included at the two points in time if the article does not tell you this.
Were outcomes prespecified and were prespecified outcomes reported?	This may be hard to tell from a journal article. Ideally they should specify their outcomes in methods and then give data for the all that were mentioned.

Criteria and details for economic evaluations adapted from Consensus Health Economic Criteria – CHEC List.[1,2]

Table E-5. Criteria for economic evaluations

Criteria	Details
Study Design	Confirm Economic Evaluation
Are competing alternatives clearly described?	A detailed description should be given of the competing interventions. This should encompass a clear and specific statement of the primary objective of each alternative, as well as relevant factors, such as intensity, duration, and frequency.
Is the economic study design appropriate to the stated objective?	An appropriate economic study design is a full economic evaluation (comparison of costs and effects of two or more interventions) based on primary research (cohort, case-control, randomised controlled trial).
Are all important and relevant costs for each alternative identified?	The costs should be measured appropriately in physical units. The instrument by which the costs are measured should be valid and clearly stated (e.g., interview, questionnaire, cost-diary).
Are all costs measured appropriately in physical units?	The sources of valuation should be clearly stated for each cost price of every volume parameter and their reference year. The main cost should be calculated based on depleted sources, no tariffs should be used.
Are costs valued appropriately?	A full identification of all important and relevant outcomes should be given in relation to the perspective and the research question.
Are all important and relevant outcomes for each alternative identified?	The outcome measurement should result from the outcome identification and this should be straightforward (e.g., if mortality is a main outcome measure this should be taken into account in the analysis). The instrument by which the outcomes are measured should be valid and clearly stated.
Are all outcomes measured appropriately?	The method of outcome valuation should be clearly stated. Examples of valuation methods are Discrete Choice Experiments (e.g., Conjoint analysis, Contingent valuation), direct utility assessment (e.g., VAS, TTO, SG), Indirect utility assessment (e.g., HUI, EQ-5D, QWB), Person trade off, etc.
Are outcomes valued appropriately?	An incremental analysis should examine the additional costs from one intervention over another, compared to the additional outcomes that it delivers. The incremental costs-effectiveness ratio is obtained by dividing the costs differences by the outcome differences for the alternatives.
Is an incremental analysis of costs and outcomes of alternatives performed?	Discounting is done appropriately if all costs and outcomes are converted to one single year, based on a motivated discount rate.
Are all future costs and outcomes discounted appropriately?	All variables in the analysis are potential candidates for the sensitivity analysis. Only variables that are certain or which have a minimal impact on the study results (based on the preliminary analysis) can be excluded from the sensitivity analysis. Furthermore, a justification should be given over the range of the variables used in the sensitivity analysis.
Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	This can be done by being explicit about the viewpoint of analysis and by indicating how particular costs and outcomes vary by location, setting, patient population, care provider, etc.

HUI = health utilities index; QWB = quality of well-being scale; SG = standard gamble; TTO = time trade-off; VAS = visual analogue scale

Step 3: Overall Rating

Key points

- All criteria are not created equal. Just adding up the Yes/No counts is not the goal.
- Considerations vary by study design
    - RCTs: if the randomization is not done well, a study cannot be low risk of bias as the benefits of randomization may be void.

- Observational and Pre Post: It is important that confounding and selection are addressed in the design and analysis because the groups are not created through randomization.

Appendix E References

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Appendix F. Evidence Tables

Table F-1. Inpatient evidence table: study characteristics

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Alemi, 2017	San Francisco, California USA	September 2015 to May 2016	Prospective Cohort	A: In person B: Remote assessment
Armaignac, 2018	Coral Gables, Florida USA	December 2011 to August 2016	Retrospective Cohort	A: Usual care B: Telehealth
Audebert, 2009	Germany	July 2003 to March 2005	Prospective Cohort	A: Hospitals not part of TEMPIS: without stroke telehealth consultation availability and no stroke ward B: Hospitals with a stroke telemedicine consultation availability and a stroke ward set up with a multidisciplinary team educated earlier by stroke MD and RNs.
Breslow, 2004	Virginia USA	A: July 1999 to June 2000 B: Jan 1, 2000 to June 2001	Before-After	A: Before telehealth B: After telehealth
Buckley, 2012	Murrumbidgee Local Health District New South Wales	January 2002 to December 2010	Before-After	A: Before telehealth B: After telehealth
Burgess, et al., 2002	Honolulu, Hawaii USA	NR	Prospective Cohort	A: Conventional sinus surgery B: Teleproctored sinus surgery
Chan, et al., 2001	Hong Kong	August 1998 to July 1999	Before-After	A: Before telehealth B: After telehealth
Chu-Weininger, 2010	Houston, Texas USA	June 2005 to October 2005	Pre/Post	A: Pre-telehealth B: Post-telehealth
Collins, 2017	Pennsylvania, Philadelphia USA	January 2008 to July 2011	Retrospective Cohort	A: Surgical intensive care unit B: Virtual intensive care unit
Craig, 2004	United Kingdom	January 1999 to June 1999	Prospective Cohort	A: Hospital without a teleneurology consultation B: Hospital with a teleneurology consultation
Dharmar, 2013	Northern California USA	July 2003 to December 2010	Retrospective Cohort	A: No telehealth B: Telehealth
Engel, 2011	Taoyuan, Taiwan 1 hospital	May and June 2009	Prospective Cohort	A: In person B: Telehealth
Fortis, 2014	Minneapolis, Minnesota USA	2011 and 2012	Retrospective Cohort	A: No tele-ICU B: Tele-ICU
Franzini, 2011 same patients as Thomas, 2009	Gulf Coast region USA	A: January 2003 to August 2005 B: July 2004 to July 2006	Economic Evaluation, Before-After	A: Before tele-ICU B: After tele-ICU

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Fuertes-Guiró, 2016	Barcelona, Spain 2 community hospitals 1 University hospitals	March 2013 and March 2014	RCT	A: No mentor B: Telementoring
Grabowski, 2014	Massachusetts USA	October 2009 to September 2011	RCT	A1: Nursing homes without telehealth, pre-intervention A2: Nursing homes without telehealth, post-intervention B1: Nursing homes with telehealth, pre-intervention B2: Nursing homes with telehealth, post-intervention
Gray, 2009	Australia	January 2007 to September 2008	Economic Evaluation	A: In-person visits B: Telehealth videoconferencing
Gupta, 2014	Dehradun India	Before: April 2012 to March 2013 After: April 2013 to March 2014	Before-After	A: Before telehealth B: After telehealth
Huang, 2008	California USA	2001 to 2006	Before-After	A: NICU echocardiograms before telehealth B: NICU echocardiograms after telehealth
Kahn, 2016	USA	2001 to 2010 (4 years of data in each hospital)	Retrospective Cohort	A: Hospitals without ICU telehealth B: Hospitals with ICU telehealth
Kalb, 2014	NR	January 2010 to March 2012	Before-After	A: Before tele-ICU implementation B: After tele-ICU (2011, Quarter 3) C: After tele-ICU (2012, Quarter 1)
Kim, 2013	Arkansas USA	March 2009 to March 2010	Prospective Cohort	The following hospitals were compared before and after implementation of TH: 1. Non-TH hospital, non-NICU 2. Non-TH hospital, with NICU 3. TH-hospital - non-NICU 4. TH-hospital, with NICU 5. University hospital 6. Statewide infant mortality Outcomes comparison: A: Nontelehealth hospital, without NICU B: Telehealth hospital, without NICU
Klein, 2010	Israel	January 1, 2005 to December 31, 2006	Retrospective Cohort	A1: Transfer all patients with traumatic ICB to trauma center with neurosurgical service A2: Transfer decisions made by clinical algorithm B: Transfer decisions made by telehealth
Kohl, 2012	Philadelphia, Pennsylvania USA	April 2003 to June 2006	Retrospective Cohort	A1: No telehealth, prior to implementation A2: No telehealth, post telehealth implementation B1: Telehealth, prior to implementation B2: Telehealth, post telehealth implementation

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Labarbera, 2013	Oregon USA	January 2006 to October 2009	Before-After	A: Before implementation of telehealth (consults only via telephone) B: After implementation of telehealth (consults mostly via videoconference, some by telephone), but before pediatric hospitalist program in community hospital C: After telehealth and after pediatric hospitalist program at community hospital
Lilly, 2011	Massachusetts USA	April 2005 to September 2007	Prospective Cohort	A: Pre-telehealth B: Telehealth
Lilly, 2017	Massachusetts USA	January 2004 to May 2013	Economic Evaluation	A: Pre-telehealth B: Post-telehealth C: Post-telehealth with added Logistics Center
Marcin, 2004a	USA California	April 2000 to April 2002	Retrospective Cohort	A1: Pre-telehealth control group A2: Patients transferred, control group B1: Patients receiving telehealth B2: All ICU patients during telehealth period
Marcin, 2004b	USA California	April 2000 to April 2002	Retrospective Cohort	A: Patients who received telemedicine consultations B: Patients who were in ICU who did not receive telemedicine consultations
Marcin, 2004c	Redding, California USA	February 1998 to September 2000	Retrospective Cohort	A1: Patients cared for in ICU prior to telemedicine A2: Patients who did not have telehealth consult after telehealth program initiated B: Patients who had telehealth consult C: All trauma patients admitted to adult ICU during telehealth program regardless of if they had telehealth consult
Martin-Khan, 2016	Australia	Unclear	RCT	A: Usual care B: Telehealth
McCambridge, 2010	USA	A: September 2002 to December 2003 B: January 2004 to September 2004	Before-After	A: Before implementation of health information technology with remote intensivist coverage (HITB-RIC) B: After implementation of HITB-RIC
Mielonen, 2000	Finland	November 1997 to 1998	Prospective Cohort	A: Conventional consults B: Telehealth consults
Migliaretti, 2013	Italy	2009	Prospective Cohort	A: Patients admitted to the same hospital in 2009 who did not receive a neurosurgery teleconsultation B: Patients admitted in 2009 for whom a neurosurgery teleconsultation was obtained
Miyamoto, 2014	California USA	January 2004 to December 2009	Retrospective Cohort	A: Comparison site B: telehealth site (hospital access to telehealth consultations during forensic examinations)

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Morrison, et al., 2010	Chicago, Illinois USA	December, 2002 to October 2004	Before-After	A: Baseline (before telehealth; 12/1/2002 to 3/1/2003) B: eICU Wave 1 (12/1/2003 to 3/1/2004) C: eICU Wave 2 (7/1/2004 to 10/31/2004)
Nagayoshi, 2016	Kumamoto, Japan	January 2010 to December 2014	Before-After	A: Before telehealth B: After telehealth
Nassar, 2014	Upper Midwest USA 7 VA Hospitals	2011 to 2012	Before-After	Usual care A1: Usual care before telehealth period A2: Usual care after telehealth period Telehealth B1: Telehealth, before telehealth period B2: Telehealth, after telehealth period
Panlaqui, 2017	Australia and New Zealand	2010 to 2015	Before-After	A: Before telehealth B: After telehealth
Rendina, 1997	Chapel Hill, North Carolina USA	1994 and 1995	Economic Evaluation	A: Usual care B: Telehealth
Rendina, 1998	USA, North Carolina	3 years, 1994 to 1996	Retrospective Cohort	A: Hospital without telehealth B: Hospital with telehealth
Rincon, 2012	Philadelphia, Pennsylvania USA	January to February 2011	Before-After	A: Before telehealth B: After telehealth
Robison, 2016	Wilmington, Delaware USA	February 2014 to October 2014	Prospective Cohort	A: Usual care B: Telehealth
Romig, 2012	Baltimore, Maryland USA	January 2010 to April 2010	Before-After, Prospective Cohort	A: No telehealth, n=612 B: Telehealth, n=793; 403 received telehealth Nurse survey: Before telehealth, n=11 After telehealth, n=27
Rosenfeld, 2000	Baltimore, Maryland USA	September 1997 to December 1997	Before-After (two time periods before telehealth)	A: Surgical ICU without onsite ICU physician staff directly responsible for patient care. Two baseline periods to control for seasonal variations: A.1: 9/1/96 - 12/18/96 and A-2: 2/1/97 - 5/18/97 B Intervention: 9/1/97 to 12/18/97 during which one of 4 intensivists provided round-the-clock monitoring of ICU patients from their homes
Ruesch, 2012	Alaska USA	A: NR B: January 2009 to December 2009	Before-After	A: Before telemedicine B: Telehealth with nurse support C: Telehealth with nurse support and physician support

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Sadaka, 2013	Missouri USA	July 2009 to March 2011	Before-After	A: Before teleICU B: After teleICU
Sharma, 2016	Philadelphia, Pennsylvania USA	March 2014 to July 2014	Before-After	A: Before telehealth B: After telehealth
Shin, 2015	Los Angeles, California USA	October 2013 to May 2014	Prospective Cohort	A: In-room mentoring B: Tele-mentoring
Steinman, 2015	Sao Paulo Brazil	May 2012 to May 2013	Before-After, Prospective Cohort	A: 1 year before telehealth B: 1 year after telehealth Once telehealth established C: Nontelehealth consultations D: Telehealth consultations n=unclear
Thomas, 2009 same patients as Franzini, 2011	USA	A: January 2003 to August 2005 B: July 2004 to July 2006	Economic Evaluation, Before-After	A: Before remote monitoring of ICU patients B: After remote monitoring of ICU patients
Wallace, 2008	United Kingdom	March 2003 to May 2003	Prospective Cohort	A: Site without telehealth B: Site with telehealth
Webb, 2013	9 sites: Ann Arbor MI, Chicago IL, Denver CO, Wash DC, Winston-Salem NC, Detroit MI, Pittsburg PA, Charlottesville VA, Houston TX, Portland OR USA	July 1999 to Dec 2001	Prospective Cohort	A: Babies born at hospital without access to telehealth B: Babies born at hospital with access to telehealth
Willmitch, 2012	Florida USA	December 2004 to July 2007	Before-After	A: Before telehealth B: 1 year after telehealth C: 2 years after telehealth D: 3 years after telehealth

eICU = electronic intensive care unit; ICU = intensive care unit; NICU = neonatal intensive care unit; NR = not reported; RCT = randomized control trial; TEMPIS = Telemedic Pilot Project for Integrative Stroke Care; TH = telehealth

See Appendix C. Included Studies for full citations

Table F-2. Inpatient evidence table: patient characteristics

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Alemi, 2017	60 A: 31 B: 29	Adults	ICU nurse	On-call resident	Yes	Inpatient	Video	Real-time
Armaignac, 2018	16,091 A: 8,000 B: 8,091	Adults	Physicians and nurses	Physicians and nurses	Yes	Inpatient	NR	Real-time
Audebert, 2009	3,060 A: 1,938 B: 1,122	Any patients with stroke	Local physicians at the hospital that are involved in caring for stroke patients	Neurology	Yes	Inpatient	Videoconference and review of CT/MRI brain images	Mixed
Breslow, 2004	2,140 A: 1,396 B: 744	Not specified	ICU attending physician	Intensivist	Unclear	Inpatient (ICU)	Mixed (videoconference, records, bedside monitoring)	Mixed
Buckley, 2012	1,943 A: 1,153 B: 790	Adults	Community mental health clinicians	Psychiatrist or senior mental health professionals	Yes	Inpatient	videoconference	Real-time
Burgess, et al., 2002	87 A: 42 patients (83 sinus sides) B: 45 patients (83 sinus sides)	NR	Otolaryngology residents	Attending surgeon	Yes	Inpatient	Videoconference	Real-time
Chan, et al., 2001	198 A: NR B: NR	Adults in nursing facility	Skilled nursing	Geriatrics	Yes	Inpatient (residential nursing home)	Videoconference	Real-time
Chu-Weininger, 2010	84, same patients A: 84 B: 71	Nurses and doctors	ICU nurse	Intensivist	Yes	Inpatient	Videoconference	Real-time
Collins, 2017	7,689 A: 6,652 B: 1,037	Adult	Nurse practitioner	Intensivist	Yes	Inpatient	Videoconference	Real-time
Craig, 2004	292 A: 128 B: 164	≥12	Junior general physician	Neurologist	Yes	Inpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Dharmar, 2013	2,029 A: 515 B: 1,514	Pediatric	ED physician	Pediatric critical care	Yes	Inpatient	Video	Real-time
Engel, 2011	103 flaps A: 57 B: 46	Age range (13 to 83 years)	Nurses and house officers	Plastic surgeon	Yes	Inpatient	Remote smartphone photographic assessments	Real-time
Fortis, 2014	12,160 A: 6,063 B: 6,097	ICU patients	Nurse hospitalist	Intensivist	Yes	Inpatient	Videoconference	Real-time
Franzini, 2011 same patients as Thomas, 2009	3,970 A: 2,034 B: 2,108	NR	ICU intensivists	ICU intensivists	Yes	Inpatient	Videoconference	Real-time
Fuertes-Guiró, 2016	36 A: 16 B: 20 2 conversions in nonmentored group A	Rural	Surgeon	Mentoring surgeon	Yes	Inpatient	Videoconference	Real-time
Grabowski, 2014	A1 and A2: same 5 nursing homes B1 and B2: same 6 nursing homes	Adults	Nurse	On-call physician	Yes	Nursing Home	Videoconference	Real-time
Gray, 2009	NR A: NR B: 12	Rural geriatric patients	Junior house doctor and nurses	Geriatrician	Yes	Inpatient	Videoconference (pathology results viewed online)	Real-time
Gupta, 2014	279 A: 13 B: 145	Adult	ICU Physician	Cardiologist	Yes	Inpatient	Audiovisual	Real-time
Huang, 2008	665 A. 280 B. 385	NICU patients	Neonatologist	Cardiologist	Yes, occasionally	Inpatient	Videoconference, telephone for recommendations	Mixed

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Kahn, 2016	521 sites 1,123,563 patients A: No telehealth Before-telehealth, n=419,466 After telehealth, n=411,461 B: Telehealth Before telehealth, n=147,517 After telehealth, n=145,119	Medicare fee-for-service beneficiaries over 65 years old	ICU provider	Support nurses and physicians	NR	Inpatient, ICU	Videoconference, data streaming, alarms, and EHR	Real-time
Kalb, 2014	11 Hospitals A: NR B: NR C: NR	Moderate-sized community hospital ICUs	ICU nurses	ICU physicians	Yes	ICU	Clinical monitoring, patient data, and videoconference	Real-time
Kim, 2013	767 A. Non-TH - non-NICU - pre: 90 B. Non-TH- non-NICU- post: 91 C. Non-TH-NICU - pre - 102 D. Non-TH-NICU-post - 111 E. TH hospital non-NICU - pre: 50 F. TH hospital non-NICU - post: 27 G. TH hospital with NICU - pre: 25 H. TH hospital with NICU - post: 33 I. University pre-116 J. University post - 122	VLBW neonates	Physicians	Obstetric faculty at university hospital, Neonatology faculty at university hospital	Yes, for some	Inpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Klein, 2010	323 A1: 152 A2: 73 B: 98	General	Trauma	Neurosurgery	Unclear	EMS/ED	Telephone, test results	Mixed
Kohl, 2012	2,250 A1: 220 A2: 285 B1: 246 B2: 1,499	NR	Nurse	Nurses and intensivists	Yes	Inpatient ICU	Videoconference	Real-time
Labarbera, 2013	153 A. 41 B. 56 C. 56	Pediatrics (<18)	Physician	Pediatric intensivist	Unclear if for all video-conference consults	EMS/ED	Videoconference or telephone	Real-time
Lilly, 2011	6,290 A: 1,529 B: 4,761	Adults	Nurse	Intensivists	Yes	Inpatient ICU	Videoconference	Real-time
Lilly, 2017	17,068 A: 4,752 B: 5,735 C: 6,581	Adults	Nurse	Intensivists	Yes	Inpatient ICU	Videoconference	Real-time
Marcin, 2004a	429 A1: 116 A2: 86 B1: 47 B2: 180	Pediatrics	Attending physician	Pediatric intensivist	Yes	Inpatient	Videoconference	Real-time
Marcin, 2004b	137 A: 47 B: 90	Pediatrics	Physician	Pediatric intensivist	Yes	Inpatient	Videoconference	Real-time
Marcin, 2004c	321 A1: 127 A2: 80 B: 17 C: 97	Pediatrics (<16)	Community hospital physicians	Pediatric intensivist	Yes (unclear if for every consult)	Inpatient	Videoconference	Real-time
Martin-Khan, 2016	166 A: 81 B: 85	Adult	RN	Geriatricians	No	Inpatient	Web-based	Asynchronous

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
McCambridge, 2010	1,913 A: 954 B: 959	Adults	Critical care	Critical care, intensivists	Yes	Inpatient (ICU)	Electronic records, digitally generated alerts, computer assisted order entry, radiological information, two-way audio, one-way video system	Real-time
Mielonen, 2000	34 A: 20 B: 14 Satisfaction survey, n=124	Psychiatric inpatients	NR	Health care staff at department of psychiatry	Yes	Inpatient	Videoconference	Real-time
Migliaretti, 2013	2,357 A: 1,895 B: 462	Diagnosis of head injury (194 females and 268 males) with a diagnosis of head injury. The majority of the patients were over 70 years old (67% over 70 years)	Not clear/ admitting physicians/ non neuro-surgeons	Neurosurgery	No	Inpatient	Mixed-telephone and transmitting CT images via telemedicine system	Mixed
Miyamoto, 2014	183 A: 82 B: 101	Children, rural	NR	Advanced practice nurse practitioners (certified pediatric and adult sexual assault nurse examiners)	No	Outpatient	Commercially available telemedicine unit with an integrated colposcope and high definition digital video camera; videoconference	Real-time
Morrison, et al., 2010	4,088 A: 1,371 B: 1,287 C: 1,430	Adults	Physicians and surgeons	Intensivists and critical care nurses	Unclear	Inpatient (ICU)	NR	Real-time
Nagayoshi, 2016	66 A: 18 B: 48	Adult	Cardiologist	Cardiologist with on-site cardiac surgery	No	Inpatient	Central server	Asynchronous

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Nassar, 2014	6,654 A: 3,584 A1: 1,664 A2: 1,920 B: 3,355 B1: 1,708 B2: 1,647	Adults	ICU staff	Intensivist	Yes	Inpatient	Videoconference	Real-time
Panlaqui, 2017	525 A: 337 B: 188	Adult	General practitioner and nurses	Intensivist	Yes	Inpatient	Videoconference	Real-time
Rendina, 1997	86 A: 38 B: 48	Pediatric	NR	Cardiologist	Yes	Inpatient	Videoconference and digital images	Real-time
Rendina, 1998	314 A: 137 B: 177 (75 born before telehealth system available)	Neonates	Not specified	Cardiology	Unclear	Inpatient, ICU	Not specified	Not specified
Rincon, 2012	74 A: 34 Nurses B: 40 Nurses	Nurses	ICU nurse	ICU specialist	Yes	Inpatient	Videoconference	Real-time
Robison, 2016	91 A: 43 B:48	Pediatric	ICU nurse	Critical care intensivist	Yes	Inpatient	Videoconference	Real-time
Romig, 2012	1405 A: 612 B: 793; 403 received telehealth Nurse survey: Pre-telehealth, n=11 Post-telehealth, n=27	ICU	ICU specialist	ICU intensivist	Unclear	ICU	Videoconference and physiologic monitoring	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Rosenfeld, 2000	628 A1: 225 A2: 202 B: 201	All patients in ICU during study period (exclusion criteria <16 years old, <4-hour stay in ICU, transfer to another hospital ICU, missing APACHE III data)	ICU attending and house staff physicians; also some interaction with nursing staff.	ICU intensivist	Yes	Inpatient (ICU)	Videoconference, bedside monitoring as well as lab data (via telephone access system), ECGs, radiology, consultant notes, and bedside data flowsheets were scanned and transmitted daily.	Real-time
Ruesch, 2012	1,308 A: NR B: NR C: NR	NR	Nurse	Intensivist, critical care	Unclear	Inpatient (ICU)	Digitally generated alerts, presumably others because collaboration is discussed but not specified	Real-time
Sadaka, 2013	2,823 A: 630 B: 2,193	Adults	Intensivist	Intensivist	Yes	Inpatient (ICU)	Digitally generated alerts, videoconference, still images	Real-time
Sharma, 2016	63 A: 38 B: 25	NR	Resident	Attending dermatologist	Unclear	Inpatient	Smartphone and internet-based app	Unclear
Shin, 2015	55 A: 29 B: 26	NR	Robotic surgery trainees	Robotic fellows or attending physicians from the Urology Department who had completed at least 150 console cases as primary surgeon	Yes	Inpatient	Videoconference and telestrate	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/ Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Steinman, 2015	Unclear	Patient diagnosis with: stroke, sepsis, acute MI, trauma, cardiac arrest, acute hepatic failure, diabetic ketoacidosis, heart failure, brain tumor, pulmonary thrombo-embolism, cardiac arrhythmia, acute mesenteric ischemia, hemorrhagic shock, exogenous intoxication.	ED and ICU	ED and ICU	Yes	ED or ICU	Videoconference and PACS	Real-time
Thomas, 2009 same patients as Franzini, 2011	4,142 A: 2,034 B: 2,108	NR	NR	Intensivist	Yes	Inpatient (ICU)	Videoconference, digitally generated alerts, fax	Real-time
Wallace, 2008	996 A: 607 B: 389 TH available; 243 used TH	Various adults and children	NR	Plastic surgery trauma and burn specialists	No	Referring hospitals or minor injury units	Store and forward images	Asynchronous
Webb, 2013	674 Matched pairs A: 337 B: 337	Infants aged <6 weeks with mild or no heat disease	OB	Neonatology	Yes	Inpatient	Mixed: echocardiology studies and telephone consultations between providers	Asynchronous
Willmitch, 2012	24,656 A. 6,504 B. 6,353 C. 6,018 D. 5,781	Adults	Critical care	Intensivist, critical care	Yes	Inpatient (ICU)	Digitally generated alerts, two way voice, one way video	Real-time

CT = computed tomography; ED = emergency department; EHR = electronic health record; EMS = emergency medical services; ICU = intensive care unit; NICU = neonatal intensive care unit; NR = not reported; PACS = picture archiving and communication system; TH = telehealth; VLBW = very low birth weight

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-1

See Appendix C. Included Studies for full citations

Table F-3. Inpatient evidence table: results

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Alemi, 2017	NR	Time for assessment (range) (SD), in minutes A: 34 (10 to 60), (16) B: 13 (5 to 35), (8) p<0.001	None
Armaignac, 2018	PCU mortality, n (%) A: 83 (1%) B: 60 (0.7%) p=0.048 Hospital mortality, n (%) A: 410 (5.2%) B: 342 (4.4%) p=0.013 Unadjusted HR: 0.79 (0.68 to 0.91) Adjusted HR: 0.56 (0.41 to 0.76) Overall mean direct cost, in USD A: $12,301 B: $13,180, p<0.0001	Mean LOS (95% CI), in days PCU A: 3.2 (3.1 to 3.3) B: 2.6 (2.5 to 2.7) p<0.0001 Hospital A: 6.8 (6.6 to 6.9) B: 7.3 (7.2 to 7.5) p<0.0001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Audebert, 2009	Mortality: The cumulative survival rates after 30 months were 68.0% in the intervention group and 65.5% in the control group (log rank test: p=0.271). Reduced death or institutional care, AOR (95% CI), p-value 12 months: 0.89 (0.75 to 1.07), p=0.223 30 months: 0.93 (0.78 to 1.1), p=0.400 Poor outcome (death, institutional care, severe disability), AOR (95% CI), p-value 12 months: 0.65 (0.54 to 0.78), p<0.001 30 months: 0.82 (0.68 to 0.98), p=0.031 Combined mortality and institutional care: The statistically significant difference in univariate analysis at 12 months in favor of the TEMPiS group did not remain significant after correction for possible confounders. There was only a trend in favor of the intervention group at 30 months without significance in multivariable analysis. Followup rates (combined death, institutional care, or severe disability) 6 months: A: 96.0% B: 96.8% 30 months: A: 95.6% B: 95.7% The outcome death and dependency was significantly less frequent in the intervention group at both followup times	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Breslow, 2004	Mortality, p-value; relative risk (95% CI) Aggregate ICU mortality: A: 8.6% B: 6.3%, p<0.05; 0.73 (0.53 to 1.02) Aggregate hospital mortality: A: 12.9% B: 9.4%, p<0.05; 0.73 (0.55 to 0.95) MICU ICU mortality: A: 13.9% B: 9.5%, p<0.05; 0.68 (0.46 to 0.98) MICU hospital mortality: A: 19.8% B: 13.9%, p<0.05; 0.71 (0.52 to 0.95) SICU ICU mortality: A: 4.2% B: 3.4%, NS; 0.81 (0.43 to 1.55) SICU hospital mortality: A: 7.2% B: 5.5%, NS; 0.75 (0.46 to 1.23) Mean LOS, in days (95% CI) Aggregate ICU: A: 4.3 (3.93 to 4.78) B: 3.63 (3.21 to 4.04), p<0.05 Aggregate hospital ICU: A: 12.77 (11.89 to 13.65) B: 11.4 (10.26 to 12.03), NS MICU ICU: A: 5.62 (4.88 to 6.35) B: 4.84 (4.16 to 5.51), p<0.05 MICU hospital: A: 14.93 (13.4 to 16.45) B: 13.61 (12.11 to 15.17), NS SICU ICU: A: 3.30 (2.83 to 3.78) B: 2.49 (2.2 to 2.97), p<0.05 SICU hospital: A: 11.00 (10.01 to 11.98) B: 8.83 (7.89 to 9.76), p<0.05	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Breslow, 2004 (continued)	Percent patients with LOS ≥7 days, median ICU LOS (IQR) All patients: A: 13.9%, 14.0 (10.0 to 25.8) B: 11.6%, 14.1 (9.4 to 21.0), NS MICU patients: A: 19.3%, 14.0 (10.0 to 19.5) B: 17.5%, 13.9 (9.3 to 19.5), NS SICU patients: A: 9.4%, 14.5 (10.0 to 25.3) B: 5.9%, 15.0 (10.3 to 23.7), p<0.05 Revenue, contribution per month, in USD All patients: A: $795,245 B: $1,319,236 MICU: A: 334,273 B: $505,669 SICU: A: $483,221 B: $862,591	(continued)	(continued)
Buckley, 2012	Patients transferred (95% CI) A: 66.8% (64.0 to 69.5) B: 59.6% (56.1 to 63.1) (χ^2=10.42, p=0.001). After adjusting for age, sex, clustering in hospitals and repeat visits the odds of transfer were 0.69 (95%CI 0.49 to 0.97) of previous.	NR	NR
Burgess, et al., 2002	NR	Average time to complete operative case, in minutes A: 24.67 B: 28.54, p<0.027	No cases of complications/harms
Chan, et al., 2001	89% of visits accomplished via telemedicine; 11% needed onsite visit	Failed inhaler technique A: 93% B: 50% Waiting time for consult, in weeks A: 4 to 13 B: $\geq$ 2 Patient satisfaction: 96% favorable	Mean monthly falls A: 9.8 B: 6.8, NS

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Chu-Weininger, 2010	NR	Mean teamwork climate score (SD) A: 69.7 (25.3) B: 78.8 (17.2) p=0.009 Mean safety climate score (SD) A: 66.4 (24.6) B: 73.4 (18.5) p=0.045 Overall hospital safety climate score A: 69.0 B: 65.4	NR
Collins, 2017	NR	ICU mortality, n (%) A: 364 (5.5%) B: 3 (0.3%)	NR
Craig, 2004	Inpatient mortality A: 10.2% B: 4.9%, p=0.013 3-month mortality A: 11.7% B: 8.6%, p=0.558 Mean LOS (SD), in days A: 11.6 (22.3) B: 8.1 (16.9), p=0.016 HR 1.13 (95% CI 1.003 to 1.282), p=0.045	No differences in measures comparing quality of care, the use of inpatient hospital resources, and medical services in the followup period between TCH and Erne patients. Hospital readmissions A: 16.8% B: 15.0%, p=0.862 Mean number primary care visits at 3-months A: 2.49 B: 2.14, p=0.519	NR
Dharmar, 2013	Mean hospital revenue per year, in USD A: $2.4 million B: $4.0 million Mean professional billing revenue per year, in USD A: $313,977 B: $688,443	Mean number of patients transferred per year A: 143 B: 285 Mean LOS of transferred children (SD), in days A: 7.7 (14.2) B: 9.2 (15.4) p<0.05	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Engel, 2011	Surgery success rate A: 95.1% B: 97.8%, p=0.4	Return to operating room A: 5 (8.8%) B: 4 (8.7%) Mean response time ± SD, in minutes A: 180 ± 104 B: 8 ± 3, p=0.01	NR
Fortis, 2014	Mortality (unadjusted) A: 6.5% B: 4.9% p<0.0002	Patients readmitted to ICU (%) A: 54 (0.89%) B: 29 (0.49%), p=0.0064	NR
Franzini, 2011 same patients as Thomas, 2009	Overall: no difference SAPS II ≤ 50 (less serious): no difference SAPS II > 50 (17% of patients) ICU: 40% reduction Hospital: 37% reduction Cost (% increase), in USD Average daily cost A: $2,851 B: $3,653 (28% increase) Overall ICU cost per case: A: $13,029 B: $19,324 Difference: $6295 (48% increase) Average cost per patient: A: $20,231 B: $25,846 Difference: $5615 (28% increase) SAPSII ≤50: increase cost by $6415 with no change in mortality SAPS II > 50: increase cost $2985 with 11.4% decrease in mortality	NR	NR
Fuertes-Guiró, 2016	Mean length of surgery (SD), in minutes A: 200 (46) B: 139 (33), p<0.01. Mean hospital stay (SD), in days A: 6.7 (0.5) B: 4.6 (0.5), p<0.01	NR	Three patients (12.5%) who underwent surgery without telementoring suffered from minor complications (bleeding of surgical wounds, two cases, and urological infection, one case)

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Grabowski, 2014	Only estimated cost savings	Hospitalization rate per 1,000 nursing home resident days A1: 3.78 A2: 3.58 B1: 3.50 B2: 3.16 Reduction in hospitalizations A1 and A2: 5.3% B1 and B2: 9.7% Telehealth only More engaged: 11.3% Less engaged: 5.2%	NR
Gray, 2009	Costs per year, in AUD (including salary, office space, travel time, DSL costs, travel costs, and set up costs of $30,000 amortized over 3 years with depreciation rate of 25%) A: $73,078 B: $90,909 In the base-case, cost savings became effective when roundtrip travel time is ≥125 km between locations.	Mean consultation time (95% CI), in minutes A: 13.7 (11.5 to 15.9) B: 15.3 (13.6 to 16.09) Mean consultation time for new patients (95% CI), in minutes A: 19.0 (15.2 to 22.8) B: 19.7 (17.0 to 22.4)	NR
Gupta, 2014	30-day mortality A: 16.4% B: 4.8% 70% reduction p=0.001	Mean door to needle, in minutes A: 178.63 B: 26.23 p<0.001 Mean hospital stay ± SD, in days A: 4.96 ± 1.18 B: 4.69 ± 1.19 p=0.056	Cardiogenic shock, n (%) A: 20 (14.92) B: 15 (10.35), p=0.248 Ventricular fibrillation/ventricular tachycardia (%) A: 16 (11.94) B: 12 (8.28), p=0.309 Atrial fibrillation/supra ventricular tachycardia (%) A: 20 (14.92) B: 22 (15.17), p=0.954
Huang, 2008	Increase in percentage of normal first echocardiograms A: 31% B: 37%; p=0.03 Echocardiogram use increased from 27% of admissions prior to telehealth to 40% of admissions after telehealth (p<0.001)	Inappropriate transfers A: 7 B: 2, p=0.06 No difference in overall rate of transfer	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Kahn, 2016	90-day mortality [ratio of odds ratios exponentiated from difference-in-differences (95% CI), p-value; Group A= Reference] All hospitals: 0.96 (0.94 to 0.98), p<0.01 Rural hospitals: 1.06 (0.99 to 1.13), p=0.09 Nonteaching hospitals: 0.97 (0.95 to 1.01), p=0.11 Small hospitals (<100 beds): 0.97 (0.92 to 1.03), p=0.36 Unadjusted mortality Pre period vs. post period A: 23.5% vs. 23.07%, p<0.01 B: 24.0% vs. 24.3%, p=0.07 Characteristics of before/after 90-day mortality in telemedicine hospitals: Hospitals that significantly increased mortality (n=9) vs. Hospitals with no mortality differences (n=107) vs. hospitals that significantly reduced mortality (n=16) Mean # hospital beds (SD): 195 (143) vs. 183 (142) vs. 265 (261), p=0.17 Academic status Nonteaching: 66.7% vs. 63.6% vs. 50.0% Small teaching: 22.2% vs. 22.4% vs. 31.3% Large teaching: 11.1% vs. 14.0% vs. 18.8% p=0.85 Mean number of ICU admissions (SD): 1037 (1027) vs. 738 (640) vs. 1484 (1598), p<0.01	ICU mean LOS (SD), in days A: Pre-telehealth: 4.8 (6.6) Post-telehealth: 4.8 (6.4) B: Pre-telehealth: 4.7 (6.6) Post-telehealth: 5.0 (6.6) Pre-period: TH vs. non TH p=0.04 TH pre-period vs. TH post-period p<0.01 Hospital mean LOS (SD), in days A: Pre-telehealth: 8.2 (9.1) Post-telehealth: 7.8 (8.7) B: Pre-telehealth: 8.6 (9.3) Post-telehealth: 8.3 (8.9) Pre-period: TH vs. non-TH p<0.01 TH pre-period vs. TH post-period p<0.01	NR
Kalb, 2014	ICU mortality ratio (APACHE IV-adjusted) A: 0.34 B: (3 months post implementation): 0.67, p<0.04 vs. A C: 0.65, p<0.03 vs. A	Mean % adherence to low tidal volume-based lung protective ventilation (SD) A: 29.5 (18.2) B: 44.9 (15.7), p<0.002 vs. A C: 51.8 (22.7), p<0.003 vs. A Mean ventilator duration ratio (SD), in days (number of days of mechanical ventilation/APACHE IV predicted days of mechanical ventilation) A: 1.08 (0.34) B: 0.92 (0.28), p=0.09 vs. A C: 0.96 (0.24), p=0.37 vs. A	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Kim, 2013	Very low birthweight deliveries, n (%) A: 50; 13% B: 27; 7% p=0.0099 There were no changes in other hospitals Mortality A: 13% B: 6.7% Statewide infant mortality decreased during study period No change in bronchopulmonary dysplasia or necrotizing enterocolitis	NR	TH-hospitals non-NICU had incidence of IVH slightly increase (p=0.03)
Klein, 2010	Mortality, n (%) A1: 0 (0) A2: 1 (1.4) B: 1 (1.0) p=0.391 Need for neurosurgery, n (%) A1: 17 (11.2) A2: 9 (12.3) B: 9 (9.2) p=0.793	Transferred, n (%) A1: 152 (100) A2: 54 (74) B: 40 (40.9) Delayed transfer, n (%) A1: NA A2: 1 (1.3) B: 2 (2.04) p=0.234 Length of stay, n (SD) A1: 4.19 (6.0) A2: 3.92 (3.5) B: 4.48 (5.1) p=0.787 Need for neurological rehabilitation, n (%) A: 4 (2.6) C: 15 (20.8) B: 8 (8.2) p<0.001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Kohl, 2012	Mean severity adjusted ICU mortality (SEM) A1: 0.54 (0.06) A2: 0.42 (0.04) B1: 0.09 (0.02) B2: 0.01 (0.003) p=0.003 Mean severity adjusted hospital mortality (SEM) A1: 0.74 (0.05) A2: 0.56 (0.04) B1: 0.13 (0.03) B2: 0.04 (0.01) p=0.023	Mean severity adjusted ICU LOS (SEM), in days A1: 5.27 (0.52) A2: 6.09 (0.43) B1: 6.25 (0.50) B2: 3.86 (0.17) p<0.001 Mean severity adjusted hospital LOS (SEM), in days A1: 19.0 (1.0) A2: 12.5 (1.1) B1: 10.9(0.8) B2: 16.7 (0.8) NS	NR
Labarbera, 2013	Mortality A: 3% B: 1.8% C: 3.6%, p=0.38 Mean LOS (SD), in days A: 9.8 (11.9) B: 7.6 (5.8) C: 8.5 (7.8), p=0.47	Transport rate: A: 100% B: 85.7% C: 87.5% p=0.04 Lower for both telemedicine cohorts Transfers to tertiary care A:19.5% B1: 14.5% B2: 6.1% p=0.0003 Cohorts 2 and 3 re-analyzed based on if they received telephone or telemedicine consult - of those with TH consult 72.7% were transferred with 7.5% diverting to tertiary ward and of those with telephone consult 100% were transferred and 12.3% diverting to tertiary ward (p<0.001)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Lilly, 2011	ICU mortality, n (%) A: 164 (10.7%) B: 410 (8.6%) p=0.003 Hospital mortality, n (%) A: 208 (13.6) B: 562 (11.8) p=0.005	Mean ICU LOS (SD), and median (IQR), in days A: 6.4 (11), 2.5 (0.2 to 6.5) B: 4.5 (6.7), 2.4 (0.1 to 4.6) p<0.001 Mean hospital LOS, and median (IQR), in days A: 13.3 (17.1) 7.9 (0.2 to 15.0) B: 9.8 (10) 6.8 (0.2 to 12.0) p<0.001	Complications n/total patients eligible (%) Ventilator associated pneumonia A: 76/584 (13%) B: 32/1949 (1.6%) OR (95% CI): 0.15 (0.09 to 0.23), p<0.001 Catheter-related bloodstream infection A: 19/1529 (1) B: 29/4761 (0.6) OR (95% CI): 0.50 (0.27 to 0.93), p=0.005 Acute kidney injury A: 174/1452 (12) B: 540/4565 (12) OR (95% CI): 1.00 (0.71 to 1.69), p=0.38
Lilly, 2017	Total annual costs, in USD A: $142,766,712 B: $182,719,738 C: $200,934,975 Total annual direct contribution margin A: $7,921,584 B: $37,668,512 C: $60,586,397	Mean hospital LOS (SD), in days A: 10.4 (13.4) B: 9.7 (9.3) C: 8.8 (8.3) A and C p<0.0001 B and C p<0.001	Complications (specifics NR) A: 30.6% B: 55.5% C: 62.8% B vs. A: p<0.0001 C vs. A: p<0.0001 C vs. B: p<0.0001
Marcin, 2004a	Patients receiving telemedicine consult were sicker (higher PRISM score) than those not receiving consult or historic controls Mortality observed/predicted A1: 2.6% / 7.1% A2: 3.5% / 5.1% B1: 2.1% / 8.9% B2: 1.6% / 4.6%	Overall satisfaction with telehealth, mean (SD) 5-point scale, 5=extremely satisfied Referring nurse respiratory therapist: 4.53 (0.15) Referring MD: 4.56 (0.09) Parent or guardian: 4.05 (0.19)	NA

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Marcin, 2004b	Annual cost savings, in USD To patients receiving TH consult: $172,000 To patients not transferred due to TH consults: $300,000 Revenue generated, in USD From patients receiving TH consult: $186,000 From patients not transported after TH consult: $279,000	NA	NA
Marcin, 2004c	Feasibility: Telemedicine is feasible in this setting. Patients who received consults were younger and more severely injured (severity =18.3 vs. 14.7, p=0.07) Mean ICU LOS (SD), p-value A1: 3.5 (6.2) A2: 3.4 (5.8) B: 5.9 (8.1) C: 3.8 (6.3), p=0.31 Observed/expected mortality odds ratio (95% CI) A1: 0.95 (0.26 to 3.48) A2: 0.44 (0.07 to 1.96) B: Reference C: 0.73 (0.06 to 1.44) NS	Parents were satisfied with communication, quality of medical care and overall telemedicine. Providers were satisfied with quality and ease of use of equipment and overall telemedicine. Mean parent satisfaction: 3.8 on a 5-point scale	NA
Martin-Khan, 2016	NR	Total average consultation time (range); SD, in minutes A: 25.91 (4 to 77); 9.38 B: 9.89 (4 to 35); 5.83 p<0.005 Triage decisions not significantly different	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
McCambridge, 2010	Mortality Hospital mortality, n (%) A: 204 (21.4%) B: 141 (14.7%), p<0.001 ICU mortality A: 15.8% B: 11.5%, p=0.006 Standardized mortality ratio A: 1.075 B: 0.758 Mortality logistical regression (controlling for APACHE IV and DNR status): OR 0.605 (SE 0.159, p=0.002)	Ventilator use A: 36.1% B: 31.5%, p=0.04 Hospital LOS, in days A: 9.2 B: 9.2, p=0.83 ICU LOS, in days A: 4.1 B: 3.8, p=0.88	NR
Mielonen, 2000	Significant cost reduction associated with care planning conferences via Videoconference vs. conventional in person consults. Cost per patient were FIM 2,510 videoconferences FIM 4,750 conventional Video is cheaper if there are 30 cases per year With 50 cases the savings would be FIM 117,000	Satisfaction with quality of communication 90% of respondents were satisfied with quality of communication of videoconferencing Staff satisfaction: 47% video as good as conventional meeting 48% video almost as good as conventional Preference for next meeting to be video: 86% of health care staff 84% patients 92% relatives of patients	NR
Migliaretti, 2013	Stratified analysis possible showing modest benefit in mortality risk on those over 70 years old with consultation with a neurosurgeon. Mortality (95% CI) OR 1.32 (1.08 to 1.74) AOR 1.25 (0.83 to 1.91) NS People over 70: AOR 1.14 (1.04 to 1.82)	Duration of consultations: Within 22 mins: 50% More than 60 mins: 10%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Miyamoto, 2014	NR	Mean quality scores out of 5 with 5 being "excellent," for OES child abuse examination forms (95% CI): General information and authorization: A: 4.98 (4.93 to 5.02) B: 4.96 (4.90 to 5.02) Consent: A: 4.46 (4.16 to 4.76) B: 4.94 (4.85 to 5.03), p<0.05 Patient history: A: 4.72 (4.51 to 4.92) B: 4.43 (4.17 to 4.70) General examination: A: 4.38 (4.10 to 4.66) B: 4.76 (4.62 to 4.89), p<0.05 Genital/perianal examination: A: 3.28 (2.95 to 3.61) B: 4.08 (3.85 to 4.32), p<0.05 Examination findings: A: 3.20 (2.87 to 3.52) B: 3.77 (3.50 to 4.04), p<0.05 Overall assessment: A: 3.24 (2.96 to 3.53) B: 3.88 (3.63 to 4.13), p<0.05 Total quality score: A: 29.21 (28.22 to 30.20) B: 31.20 (30.39 to 32.02), p<0.05	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Miyamoto, 2014 (continued)	(continued)	Mean completeness and accuracy scores for the forensic examination, out of 5 with 5 being "excellent" (95% CI) Photo/video quality: A: 2.57 (2.35 to 3.80) B: 3.86 (3.66 to 4.06), p<0.05 Complete/thorough exam: A: 3.83 (3.64 to 4.02) B: 4.49 (4.35 to 4.63), p<0.05 Diagnostic accuracy: A: 3.68 (3.46 to 3.91) B: 4.14 (3.94 to 4.34), p<0.05 Total completeness and accuracy score: A: 11.88 (11.13 to 12.63) B: 14.52 (13.84 to 15.20), p<0.05	(continued)

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Morrison, et al., 2010	A: Baseline B: eICU Wave 1 C: eICU Wave 2 Mortality: Total mortality: A: 9.9% B: 11.1% C: 10.0%; A vs. B, p=0.20; B vs. C, p=0.15 ICU mortality: A: 6.6% B: 7.9% C: 7.4%; A vs. B, p=0.09; B vs. C, p=0.34 Non-ICU mortality: A: 3.5% B: 3.5% C: 2.9%; A vs. B, p=0.82; B vs. C, p=0.25 Total mortality OR (95% CI) A (ref) vs. B 1.14 (0.84 to 1.55) B (ref) vs. C 1.06 (0.72 to 1.57) ICU mortality OR (95% CI) A (ref) vs. B 1.25 (0.889 to 1.759) B (ref) vs. C OR (95% CI) 1.07 (0.755 to 1.524) Non-ICU mortality OR (95% CI) A (ref) vs. B 1.01 (0.643 to 1.575) B (ref) vs. C 0.80 (0.494 to 1.297) Cost (adjusted total hospital costs divided by 1000) [A vs. B vs. C means (SD); p-value] A: 22.43 (24.31) B: 21.41 (25.88) C: 23.21 (29.61), A vs. B p=0.93; B vs. C p=0.03 [*B Linear regression coefficient, estimated, p-value*] -0.064, 0.94, p=0.05 [*C vs. B Linear regression coefficient, SE, p-value*] 0.170, 0.042, p<0.01	Mean hospital LOS (SD) A: 7.72 (7.98) B: 7.98 (7.94) C: 7.89 (8.60) A vs. B p=0.48; B vs. C p=0.56 Mean ICU LOS (SD) A: 2.60 (3.16) B: 2.92 (3.94) C: 3.18 (4.49) A vs. B p=0.15; B vs. C p=0.09 [B Linear regression coefficient, estimated, p-value] Hospital LOS: 0.004, 1.00, p=0.91 ICU LOS: 0.051, 1.05, p=0.11 [C vs. B Linear regression coefficient, SE, p-value] Hospital LOS: 0.115, 0.046, p=0.01 ICU LOS: 0.078, 0.035, p=0.03	NA

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Nagayoshi, 2016	NR	Patient transfer A: 10 (55%) B: 10 (21%) p<0.05 Waiting period, in days A: 17.2 B: 9.2 p=0.23	NR
Nassar, 2014	Mortality risk adjusted odds ratio (95% CI), after telehealth vs. before telehealth ICU A: 0.88 (0.52 to 1.49), p=0.65 B: 1.07 (0.60 to 1.90), p=0.82 Hospital A: 0.82 (0.57 to 1.19), p=0.30 B: 1.33 (0.86 to 2.07), p=0.20 30-day A: 0.79 (0.62 to 1.01), p=0.06 B: 1.10 (0.82 to 1.47), p=0.52 Unadjusted mortality, n ICU A: B Before telehealth=67 After telehealth=65 B: Before telehealth=49 After telehealth=46 Hospital A: Before telehealth=115 After telehealth=111 B: Before telehealth=62 After telehealth=70	Risk adjusted odds ratio relative LOS (95% CI), after telehealth vs. before telehealth ICU A: 1.00 (0.93 to 1.08) p=0.99 B: 1.02 (0.92 to 1.14) p=0.68 Hospital A: 0.93 (0.86 to 1) p=0.05 B: 1.03 (0.96 to 1.11) p=0.43 Mean LOS (SD), in days ICU A: Before telehealth=2.9 (3.7) After telehealth=2.9 (3.4) B: Before telehealth=2.6 (3.6) After telehealth=2.8 (4.7) p-value: Telehealth before vs. after = 0.15 Control before vs. after = 0.72 After period, telehealth vs. control = 0.18 Hospital A: Before telehealth=6.8 (7.9) After telehealth=6.5 (8.2) B: Before telehealth=6.9 (8.5) After telehealth=7.3 (6.9) p-value: Telehealth before vs. after = 0.18 Control before vs. after = 0.35 After period, telehealth vs. control = 0.11	NR

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Panlaqui, 2017	Total mortality A: 6.5% B: 4.3% RR 0.98 (0.94 to 1.02), p=0.28 ICU A: 1.6% B: 1.1% RR 1 (0.98 to 1.03), p=0.67 Hospital A: 5.4% B: 3.2% RR 1.02 (0.99 to 1.06), p=0.25	Hospital transfer, relative risk (95% CI) A: 31.8% B: 22.9% 0.88 (0.80 to 0.98) p=0.03 Mean hospital LOS in days (SD) A: 4.0 (3.9) B: 5.5 (5.2), p<0.0002 Mean ICU LOS in days (SD) A: 2.2 (1.9) B: 2.1 (1.6), p=0.6	NR
Rendina, 1997	Mortality A: 1 B: 1 Net savings in USD: $13,900 per infant	Hospital LOS, in days A: 41.2 B: 35.2 Pooled variance t-test p=0.23 Reporting time A: 24 hours B: 20 minutes	NR
Rendina, 1998	LOS in NICU A vs. B; regression sign, p-value Telemedicine: -, p=0.001 Birth weight x telemedicine: +, p=0.0009 Low birthweight neonates (<960 grams) -, p=0.05 Higher birthweight neonates (960 grams): NS LOS reduction with telemedicine: 12.5 days (17%), p<0.05	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Rincon, 2012	NR	Nurse satisfaction ICU physicians available A: 38% B: 55% p=NS Adequate physician involvement A: 44% B: 65% p=0.007 Opportunity to ask questions A: 41% B: 53% p=NS	NR
Robison, 2016	NR	Face time interface versus arrival at the bedside, in minutes A: 3.7 B: 2.6 p=0.012 Admitted to PICU A: 73% B: 58%, p=0.13 Interventions A: 1.9 B: 1.4, p=not significant	NR

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Romig, 2012	ICU Mortality rate before vs. after telehealth, % (n) A: 4.9% (15/305) vs. 4.6% (14/307) B: 1.5% (6/30) vs. 3.5% (14/403) ICU LOS before vs. after telehealth, % (n), in days A: 3.9 vs. 3.8 B: 5.1 vs. 4.5	Nurse satisfaction and perceptions of quality after telehealth, mean survey score out of 5 (SD) <u>Remote ICU unit</u> Communications Pre-telehealth: 2.99 (1.13) Post-telehealth: 3.27 (1.27), p<0.01 Psychological working conditions and burnout Pre-telehealth: 3.10 (1.10) Post-telehealth: 3.23 (1.11), p=0.02 Education Pre-telehealth: 3.52 (0.84) Post-telehealth: 3.76 (0.78), p<0.03 <u>Control ICU</u> Significant decline in 2 scales Patient care and perceived effectiveness and education	NA

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Rosenfeld, 2000	Mortality ICU: A1: 9.8% A2: 3.5% B: 1.5%, p<0.05 Hospital: A1: 11.6% A2: 6.93% B: 4.48%, p<0.05 Cost reduction, in USD ICU: costs reduced by 25% (from A1) and 31% (from A2), including lower routine, radiology and therapy costs. ICU total cost change B vs. A1: 0.75 (p=0.002) B vs. A2: 0.69 (p=0.031) Hospital total costs B vs. A1: 0.88 (p=0.15) B vs. A2: 0.81 (p=0.12) Hospital: costs were 12% (than A1) and 19% (than A2) lower but not stat significant. ICU-based costs, as percent of total hospital costs, were lower during B, by 62% (A1) and 53% (A2).	Mean LOS (95% CI) ICU A1: 2.71 (2.14 to 3.03) A2: 3.06 (1.95 to 3.89) B: 2.0 (1.66 to 2.3), p<0.01 Hospital A1: 9.18 (8.04 to 10.44) A2 10.11 (8.32 to 11.94) B: 9.28 (7.87 to 10.82) ICU: LOS shorter in B by 26% (A1) and 35% (A2); and 26% lower than predicted, whereas A1 and A2 did not differ from predicted. Hospital: No differences in LOS.	Complications A1: 15.1% A2: 18.8% B: 9.5% p<0.05 Costs related to complications: 64% of difference in cost between baselines and intervention were associated with higher incidence of complications during baseline periods; and regardless of study period, hospital costs of patients with complications was 3x costs of patients without complications.

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Ruesch, 2012	Hospital LOS (actual; predicted), in days A: 11.25; 9.75 B: 9.48; 10.9 (statistical significance NR) ICU LOS (actual; predicted), in days A: 4.1 days actual; 2.87 predicted B: 3.66 actual; 3.89 predicted days (statistical significance NR) Severity-adjusted mortality (actual; predicted) Hospital: A: 22; 25.5 B: 36; 57.7 predicted indicating the saving of 22 lives (statistical significance NR) ICU: A: 17; 17.6 B: 24.0; 39.4 (statistical significance NR) Actual costs not reported. Estimated cost saving based on changes in LOS were over $2.5 million USD, comparing a calendar quarter preimplementation and the last quarter of the evaluation	Ventilator-associated pneumonia compliance: 6% increase from 87.2% vs. 93.3%, p=0.02 Peptic ulcer disease bundle compliance: 0.5%, NS Deep vein thrombosis compliance bundle: 1%, NS Frequency of hypoglycemia: A: 2.8% B: 1.3% Missed SCIP opportunities on postoperative day 2 for cardiac surgery: A: 69% B: 43% Nurse documentation of patient restraint compliance: A: 74% B: 100%	NR
Sadaka, 2013	ICU mortality A: 7.9% B: 3.8 % OR 0.46, 95% CI (0.32 to 0.66) p=0.0001 Hospital mortality A: 8.8% B: 6.9% OR 0.76, 95% CI (0.55 to 1.0) p=0.1	ICU LOS (SD), in days A: 2.7 (4.1) B: 2.2 (3.4) HR 1.16, 95% CI (1.00 to 1.40) p=0.01 Hospital LOS (SD), in days A: 5.2 (6.1) B: 6.2 (7.4) HR 1.30, 95% CI (1.25 to 1.35) p=0.00	NR

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Sharma, 2016	NR	Mean handling time (95% CI), in minutes A: 43.5 (37.9 to 49.0) B: 26.9 (15.4 to 38.4) p=0.004 Time to response A: 405.7 (301.0 to 510.3) B: 344.7 (291.3 to 398.0) p=0.602 Teledermatology alone sufficiently answered consultations in 10 of 25 study consultations.	NR
Shin, 2015	Estimated blood loss m/L, median (range) A: 2.5 (0 to 7) B: 2.5 (0 to 7)	Median (range) Estimated duration, in minutes A: 15.0 (5 to 25) B: 15.0 (5 to 35) Robotic skills assessment p>0.05 Mentors preferred remote to in room p=0.05	There was one intraoperative complication reported. During an in-room mentored robotic partial nephrectomy, a colon serosal injury occurred from bipolar energy of a fenestrated bipolar forceps. This was immediately recognized by the mentor and over-sutured, resulting in no postoperative sequelae. No intraoperative complications were noted in remote mentored cases.

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Steinman, 2015	Mortality by condition AMI A vs. B: 17% vs. 14% C vs. D: 14.4% vs. 7.6% Septic shock A vs. B: 65.7% vs. 67.9% C vs. D: 70.9% vs. 40.4% Ischemic stroke A vs. B: 50% vs. 43.8% C vs. D: 75.6% vs. 32.1% Hemorrhagic stroke A vs. B: 23.4% vs. 27.8% C vs. D: 36.9% vs. 15.6% A vs. B comparisons are all NS C vs. D comparisons trend toward significant but p=NR	Change in treatment plan for 18 (7.1%) patients the telehealth consult influenced making a definite diagnosis, for 239 (92.9%) the telehealth consult contributed to clinical management.	NR
Thomas, 2009 same patients as Franzini, 2011	Mortality ICU mortality (95% CI) A: 9.2% (8.0 to 10.5) B: 7.8% (6.7 to 9.0) A to B decrease: 1.4% (-0.3% to 3.2%) p=0.12 RR 0.88; (0.71 to 1.08) Hospital mortality (95% CI) A: 12.0% (10.6% to 13.5%) B: 9.9% (8.6% to 11.2%) A to B decrease, 2.1%; (0.2% to 4.1%); p=0.03 RR: 0.85; (95% CI 0.71 to 1.03)	ICU LOS (95% CI), in days A: 4.3 (4.0 to 4.5) B: 4.6 (4.3 to 4.9) Hospital LOS A: 9.8 (9.4 to 10.2) B: 10.7 (10.2 to 11.1)	ICU complication rates (95% CI) A: 17.9% (16.3 to 19.6) B: 19.2% (17.5 to 20.9) The CAIC-reduced model revealed that the rate of complications was associated with SAPS II score (p=0.001) but not with tele-ICU implementation (p=0.15).

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Wallace, 2008	No evidence of cost saving for hospital (details not reported) Capital outlay was significant (£70K)	Difference in overall management of referrals p=0.004 Admission (95% CI) A: 28.3% (24.9 to 32) B: 29.6% (25.2 to 34.3) In person review (95% CI) A: 22.1% (19.0 to 25.5) B: 15.4% (12.2 to 19.3) Day surgery (95% CI) A: 17% (14.2 to 20.2) B: 27.5% (23.3 to 32.1) Inappropriate referral (95% CI) A: 0.5% (0.2 to 1.4) 0.3% (0.0 to 1.4)	NR
Webb, 2013	Mortality, morbidity: control patients significantly more likely to receive inotropic support and indomethacin. Adjusted OR (95% CI) Death 0.922 (0.389 to 2.136) Cardiac arrest 0.527 (0.184 to 1.505) Mean LOS, in days Total A: 1.6 (6.4) B: 0.72 (4.1) p=0.027 ICU A: 1.6(6.2) B: 0.65 (4.0) p=0.027 no differences in LOS in pediatric wards and well nursery. Transport to tertiary care: A: 10% B: 4% p<0.01 AOR 0.435 (95% CI 0.229 to 0.827)	Time to diagnosis: Mean (SD), in minutes A: 147 (60) B: 100 (67) p<0.001 *telemedicine patients were located significantly farther from tertiary hospitals.	No significant differences in death, cardiac arrest, and intraventricular hemorrhage or in use of prostaglandin infusion, mechanical ventilation, or extracorporeal membrane oxygenation.

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Willmitch, 2012	Hospital mortality 1 year post RR 0.92 (95% CI 0.82 to 1.03) p=0.142 2 years post RR 0.88 (95% CI 0.78 to 0.98) p=0.025 3 years post: RR 0.77 (0.69-0.87)p<0.001 Severity-adjusted Before/After Mean LOS, in days (95% CI) Hospital A: 11.86 (11.55 to 12.21) D: 10.16 (9.80 to 10.53), p<0.001 ICU A: 4.35 (4.22 to 4.49) D: 3.80 (3.65 to 3.94) p<0.001	NR	NR

AOR = adjusted odds ratio; APACHE IV = Acute Physiology and Chronic Health Evaluation; AUD = Australian dollars; CAIC = consistent Akaike information criterion model; CI = confidence interval; DNR = do not resuscitate; FIM = Finnish markka; HR = hazard ratio; ICU = intensive care unit; IQR = interquartile range; IVH = intraventricular hemorrhage; LOS = length of stay; MICU = medical intensive care unit; NICU = neonatal intensive care unit; NR = not reported; NS = not significant; OES = Office of Emergency Services; PCU = progressive care unit; PICU = pediatric intensive care unit; RR = relative risk; SAPS II = Simplified Acute Physiology Score II; SCIP = Surgical Care Improvement Project; SD = standard deviation; SEM = standard error mean; SICU = surgical intensive care unit; TCH = Tyrone County Hospital; TEMPiS = Telemedic Pilot Project for Integrative Stroke Care; TH = telehealth; USD = United States dollars

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-1

See Appendix C. Included Studies for full citations

Table F-4. Emergency medical services/emergency department evidence table: study characteristics

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Amorim, 2013	Pennsylvania USA	March 2005 to December 2008	Before-After	A: Before telestroke implementation B: After telestroke implementation
Astarcioglu, 2015	Turkey	January 2015 to May 2015	Prospective Cohort	A: Concurrently treated STEMI patients who were not triaged B: Smartphone triaged STEMI patients in the ER
Audebert, 2006	Bavaria Germany	July 2003 to March 2005	Prospective Cohort	A: 5 hospitals without specialized stroke care B: 5 hospitals without specialized stroke care with telehealth stroke support
Bergrath, 2012	Aachen Germany	May 2010 to September 2010	Prospective Cohort	A: Usual care B: Telehealth
Bladin, 2015	Australia	A: January to December 2010 B: October 2011 to October 2012	Before-After	A: Before telestroke protocol initiation B: After telestroke initiation
Brennan, 1998 and 1999	Northwest New Jersey USA	NR	RCT	A: Usual care B: Telehealth
Brokmann, 2016b	Aachen Germany	August 2012 to July 2013	Before-After	A: Before telehealth B: After telehealth
Brokmann, 2016	Aachen Germany	Before: April 2011 to March 2012 After: August 2012 to August 2013	Before-After	A: Before telehealth B: After telehealth
Brunetti, 2014	Apulia Italy	October 2012 to April 2013	Prospective Cohort	A: Usual care B: Telehealth
Chan, 2012	British Columbia Canada	April 2009 to March 2011	Retrospective Cohort	A Usual care B: Telehealth
Cho, 2011	Seoul Korea	March 2008 to February 2009	RCT	A: Usual care B: Tele-airway
Choi, 2006	Texas USA	A: January 2003 to March 2004 B: April 2004 to May 2005	Before-After	A: Patients treated with tPA without telestroke B: Patients treated with tPA with telestroke
Chowdhury, 2012	London United Kingdom	July 2007 to Dec 2009	Retrospective Cohort	A: Usual care B: Telehealth
Darkins, 1996	Ireland	A: September 1993 to September 1994 B: October 1994 to October 1995	Before-After	A: Before telehealth B: After telehealth
Dayal, 2016	Sacramento, California USA	2010 to 2014	Retrospective Cohort	A: Usual care B: Telehealth

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Demaerschalk, 2010	USA	December 2007 to October 2008	RCT	A: Telephone only B: Telehealth
Dharmar, 2013	Rural California USA	4-year period (2 years before tele and 2 years after) Dates not specified	Retrospective Cohort	A: No consultation completed B: Emergency consults completed by teleconsult C: Emergency consults completed by telephone
Dharmar, 2013	California USA	January 2003 to December 2009	Retrospective Cohort	A1: No telehealth, no consult A2: No telehealth, phone consult B: Telehealth
Dharmasaroja, 2010	Thammasat Thailand	A: June 2007 to February 2008 B: March 2008 to March 2009	Before-After	A: Before implementation of telestroke network B: After implementation of telestroke network
Duchesne, 2008	USA	January 2000 to January 2005	Before-After	A: Before trauma telehealth implementation B: After trauma telehealth implementation
Fong, 2015	Hong Kong	January 2009 to December 2012	Prospective Cohort	A: Neurologist on site B: Telestroke, no neurologist on site
Goh, 1997	Hong Kong	March 1995 to May 1996	Prospective Cohort	A: Usual care B: Teleradiology
Handschu, 2008	Bavaria Germany	1 year Dates not specified	Prospective Cohort	A: Usual care (telephone consult) B: Telestroke with video
Hashimoto, 2001	Japan	1994 to 1999	Before-After	A: Before telehealth B: After telehealth
Heffner, 2015	Pennsylvania USA	2006 to 2014	Retrospective Cohort	A: Patients treated at regional stroke center B: Patients treated at hospital served by telehealth and remained at the local hospital C: Patients treated at hospital served by telehealth and transferred to regional stroke center
Hubert, 2016	Helsinki Finland	January 2011 to December 2013	Retrospective Cohort	A: Usual care B: Telehealth
Ickenstein, 2005	Germany	December 2001 to December 2003	Before-After	A: Before telehealth B: After telehealth
Ionita, 2009	New York USA	January 2006 to December 2008	Retrospective Cohort	A: Patients treated with thrombolysis at a regional medical center B: Patients treated with thrombolysis at community hospitals via telemedicine
Itrat, 2016	USA	July 2014 to November 2014	Prospective Cohort	A: Usual care B:Telehealth
Johansson, 2011	Salzburg Austria	2006 to 2009	Retrospective Cohort	A: Usual care B: Telehealth

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Kim, 2011	Wonju South Korea	June 2007 to March 2008	Retrospective Cohort	A: Patients without telemetry system B: Patients with telemetry system
Langabeer, 2016 and 2017	Houston, Texas USA	January to December 2015	Retrospective Cohort; Economic Evaluation	A: Usual care B: Teleconsult
Macedo, 2016	San Paulo Brazil	2011 to 2014	Before-After	A: Before telehealth B: After telehealth
Machado, 2018	Columbus, Ohio USA	July 2010 and February 2013	Retrospective Cohort	A: Usual care B: Telehealth
Marcolino, 2013	Belo Horizonte Brazil	2009 to 2011	Before-After	A: Before telehealth B: After telehealth
Martinez-Sanchez, 2014	Madrid Spain	Pre: March 2008 to February 2010 Post: March 2010 to February 2013	Before-After	A: Before telestroke B: After telestroke
Martinoni, 2011	Italy	18 month period	Retrospective Cohort	A: Usual care B: Telehealth
Mathews, 2008	Australia	September 2006 to March 2007	Before-After	A: All patients referral for rural transfer for 6-month period before tele-link B: All patients referral for rural transfer for 6-month period after tele-link who received a teleconsult. C: All patients referral for rural transfer for 6-month period after tele-link who did not receive a teleconsult
Mazighi, 2017	Paris France	April 2006 to March 2010	RCT	A: Usual care B: Telethrombolysis
Meyer, 2008	NR	January 2004 to August 2007	RCT	A: Telephone only consultation B: Telemedicine
Mohr, 2018 (same patients as Mohr 2017)	North Dakota USA	2008 to 2014	Retrospective Cohort	A: Usual care B: Telehealth
Mohr, 2017(same patients as Mohr 2018)	North Dakota USA	2008 to 2014	Retrospective Cohort	A: Usual care B: Telehealth
Nagao, 2012	Melbourne, Victoria Australia	Telestroke: October 2009 to September 2010 and control group: October 2008 to September 2009	Before-After	A: Before telestroke B: After telestroke
Narasimhan, 2015	USA, South Carolina	March 2009 to June 2013	Prospective Cohort	A: Patients with the same mental health conditions and demographic characteristics but were treated in hospitals that did not have telepsychiatry. B: Telepsychiatry recipients

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Natafgi, 2017	7 states 85 rural hospitals Hub located in South Dakota USA	October 2009 to February 2014	Economic Evaluation	A: Tele-ED not activated B: Tele-ED activated
Nguyen-Huynh, 2018	Northern CA USA	2015 to 2016	Before-After	A: Before telehealth B: After telehealth
Noble, 2005	Single hospital ED United Kingdom	NR	Economic Evaluation	A: Hospitals without teleconsultations B: Hospitals with teleconsultations
Ortolani 2006	Bologna Italy	January 2003 to December 2004	Retrospective Cohort	A: ED B: Local hospital C: Telehealth
Ortolani, 2007	Italy	January 2003 to December 2005	Retrospective Cohort	A: Conventional hospital-based triage B: Pre-hospital telemedicine ambulance triage
Paik, 2017	Newark, New Jersey USA	May 1, 2013 to May 31, 2013	Retrospective Cohort	A: Usual care B: Telehealth
Patel, 2015	Wilmington, Delaware USA	July 2012 to September 2012	RCT	A: Cell phone B: Telehealth
Pedersen, 2009	Denmark	January 2005 to July 2008	Prospective Cohort	A: Usual care B: Telehealth
Pedragosa, 2009	Spain	January 2006 to December 2007	Before-After	A: Before telemedicine B: After telemedicine
Pervez, 2010	Boston, Massachusetts USA	January 2003 to March 2008	Retrospective Cohort	A: Telephone B: Telehealth (for treatment in place)
Poon, 2001	Hong Kong	October 1998 to July 1999	RCT	A: Telephone consultation B: Teleradiology and telephone consultation C. Video-consultation
Saffle, 2009	USA	2003 to August 2007	Before-After	A: Before telemedicine for acute burn implementation B: After telemedicine for acute burn implementation
Sairanen, 2011	Helsinki Finland	2007 to 2009	Prospective Cohort	A: Usual care B: Telehealth
Sanchez-Ross, 2011	New Jersey USA	June 2006 to February 2009	Prospective Cohort	A: Usual care B: STAT-MI Network
Schwab, 2007	Regensburg and Munich Germany	February 2003 to November 2004	Prospective Cohort	A: Usual care B: Telehealth
Sejersten, 2008	Denmark	October 2003 to October 2005	Prospective Cohort	A: Usual care B: Telehealth
Southard, 2014	Indiana USA	January 2009 to January 2010	Before-After	A: Before telemedicine B: After telemedicine

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Switzer, 2009	Augusta, Georgia USA	February 2003 to March 2006	Prospective Cohort	A: Emergency department B: Telehealth
Taqui, 2017	Cleveland, Ohio USA	July 2014 to November 2014	Prospective Cohort	A: Traditional ambulance B: Mobile stroke unit
Theiss, 2013	Erfurt Germany	2006 to 2009	Before-After	A: Control hospitals without telemedicine B: Comprehensive stroke centers C: Neuro Net hospitals with stroke telemedicine
Traub, 2013	Unclear USA	April to June 2012	Retrospective Cohort	A: Usual care B: Telehealth
Tsai, 2007	Taiwan	November 1999 to August 2003	Prospective Cohort	A: Emergency air medical transport system before implementing preflight screening and teleconsultation B: Emergency air medical transport system after implementing preflight screening and teleconsultation
Wong, 2006	Hong Kong	October 1998 to September 2001	RCT	A: Telephone only consultation (standard of care) B: Telephone + teleradiology (sharing of images) C: Videoconference
Yang, 2015	Northern, California USA	January 2003 and May 2012	Retrospective Cohort	A: Telephone B: Telehealth
Zaidi, 2011	Pittsburgh, Pennsylvania USA	July 2008 to July 2009	Prospective Cohort	A: Stroke center B: Telestroke
Zanini, 2008	Mantova Italy	June 2003 to June 2005	Retrospective Cohort	A: Usual care B: Telehealth
Zennaro, 2014	Italy	September 2013 to October 2013	Pre/Post	A: Pediatric patients with fractures receiving telephone consultation from orthopedic surgeon on call B: Same pediatric patients with fractures receiving telephone consultation from orthopedic surgeon on call this time including an image of the x-ray sent to the consulting orthopedic surgeon via an iPad

ED = emergency department; RCT = randomized controlled trial; STAT-MI = ST-Segment Analysis Using Wireless Technology in Acute Myocardial Infarction; STEMI = ST-elevation myocardial infarction

See Appendix C. Included Studies for full citations

Table F-5. Emergency medical services/emergency department evidence table: patient characteristics

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Amorim, 2013	2,588 A: 919 B: 1,669	Rural patients	ED physician	Neurologists	Yes	ED/EMS	Videoconference	Real-time
Astarcioglu, 2015	108 A: 55 B: 53	Adults, average age 62.2 in Group A and 64.6 in Group B, majority male, with expected comorbidities for STEMI patients	ED	Interventional cardiology	No	ED/EMS	WhatsApp	Real-time
Audebert, 2006	3,122 A: 1,151 B: 1,971	Adults	Multiple (non-neurology)	Neurology	Yes	ED/EMS	Videoconference, radiological data transfer	Real-time
Bergrath, 2012	64 A: 46 B: 18	NR	EMS physician	Hospital-based EMS physician	Yes	ED/EMS	Videoconference	Real-time
Bladin, 2015	282 A: 144 B: 138	Adult	ED physicians (with medical registrars and nursing staff)	Neurologists/stroke specialist	Unclear - patient was present in the ED, but did not seem like the consulting specialist saw the patient directly	ED/EMS	Telephone and radiology images; video camera unclear	Real-time
Brennan, 1998 and 1999	100 A: 50 B: 50	NR	Nurse	Emergency physician	Yes	ED/EMS	Videoconference	Real-time
Brokmann, 2016b	160 A: 80 B: 80 Complete Numerical Rating Scale A: 32/80 B: 65/80	Pediatric and adults	Paramedic	EMS physician	Yes	ED/EMS	Video	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Brokmann, 2016	78 A: 39 B: 39	Adults	Paramedic	EMS physician	Yes	ED/EMS	Video	Real-time
Brunetti, 2014	297 A: 174 B: 123	Adults	EMS	Cardiologist	Yes	ED/EMS	Smart phone and electronic EKG	Real-time
Chan, 2012	594 A: 427 B: 167	Adults	Paramedic	ED physician	Yes	ED/EMS	ECG transmitted electronically	Real-time
Cho, 2011	25 A: 13 B: 12	Adults	Emergency residents	Emergency physician	Yes	ED/EMS	Videoconference	Real-time
Choi, 2006	655 A: 327 B: 328	Stroke	Academic medical center	Neurology	Yes	ED/EMS	Videoconference	Real-time
Chowdhury, 2012	97 A: 52 B: 45	Adults	ED doctors and senior stroke nurse	Stroke specialist	Yes	ED/EMS	Videoconference plus S&F scans	Real-time
Darkins, 1996	16,700 A: 6,729 B: 9,972, 51 seen using TH	Emergency	Academic medical center	Emergency-orthopedic	Yes	ED/EMS	Videoconference	Real-time
Dayal, 2016	1,106 A: 524 B: 582	Pediatric	ED physician	Pediatric critical care physician	Yes	ED/EMS	Videoconference	Real-time
Demaerschalk, 2010	54 A: 27 B: 27	Adults	ED physician	Stroke neurologist	Yes	ED/EMS	Videoconference	Real-time
Dharmar, 2013	320 A: 199 B: 58 C: 63	Pediatric emergencies	Academic medical center	Pediatric critical care	Yes	ED/EMS	Videoconference or telephone	Real-time
Dharmar, 2013	234 A1: 85 A2: 76 B: 73	Children	ED physician	Pediatric Critical Care	Yes	ED/EMS	Videoconference	Real-time
Dharmasaroja, 2010	576 A: 170 B: 406	Adults	Neurology residents	Neurology	Yes	ED/EMS	Telephone, transfer of radiological data	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Duchesne, 2008	814 A: 351 B: 463 (51 sent to trauma center)	Rural patients	Nurse practitioner	Physician	Yes	ED/EMS	Videoconference	Real-time
Fong, 2015	152 A: 102 B: 50	Not specified	Internist	Neurologist	Yes	ED/EMS	Telephone, teleradiology	Real-time
Goh, 1997	63 A: 28 B: 35	Not specified	Not specified	Neurologist	Unclear	ED/EMS	Telephone, teleradiology	Real-time
Handschu, 2008	151 A: 74 B: 77	Not specified	Not specified	Neurologist	Yes	ED/EMS	Videoconference, data transfer	Real-time
Hashimoto, 2001	29 A: 17 B: 12	Not specified	Not specified	Radiation-oncology	Yes	ED/EMS	Digital images of any scans	Unclear
Heffner, 2015	479 A: 272 B: 134 C: 73	Not specified	Neurologist	Neurologist	Yes	ED/EMS	Not specified	Real-time
Hubert, 2016	2,691 A: 912 B: 1,779	Adult	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Ickenstein, 2005	319 A: 155 B: 164	Adults	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Ionita, 2009	155 A: 128 B: 27	Not specified	Not specified	Neurology	Yes	ED/EMS	Not specified	Real-time
Itrat, 2016	156 A: 56 B: 100	Adult	EMS	Vascular neurologist	Yes	ED/EMS	Videoconference	Real-time
Johansson, 2011	351 A: 304 B: 47	Adults	ED physician	Stroke neurologist	Yes	ED/EMS	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Kim, 2011	938 A: 750 B: 188	Suburban and urban emergency patients seen by EMS system	EMT	Public health doctors	Yes	ED/EMS	Code division multiple access for real-time information exchange, patient data monitoring via online method, and cellular phone	Real-time
Langabeer, 2016 and 2017	11,140 A: 5,570 B: 5,570	Adults	Paramedic	EMS physician	Yes	ED/EMS	Video	Real-time
Macedo, 2016	376 A: 113 B: 263	Adult	ED physician	Cardiologist	Yes	ED/EMS	Videoconference	Real-time
Machado, 2018	314 A: 219 B: 95	Adults	ED clinicians	Intensivist	Yes	ED/EMS	NR	Real-time
Marcolino, 2013	2,600 A: 1,242 B: 1,358	Adults	Hospitalist	Cardiac specialist	Yes	ED/EMS	Telephone and electronic EKG	Real-time
Martinez-Sanchez, 2014	484 A: 259 B: 225	Adults	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Mixed
Martinoni, 2011	3,901 A: 2,298 B: 1,603	Adults	EMS	Cardiologist	Yes	ED/EMS	ECG transmission	Real-time
Mathews, 2008	191 A: 78 B: 113	Rural emergency	Urban hospital	Multiple	Unclear	ED/EMS	Videoconference	Real-time
Mazighi, 2017	47 A: 22 B: 25	Adults	ER physician	Stroke neurologist	Yes	ED/EMS	Video	Real-time
Meyer, 2008	222 A: 111 B: 111	Adults at least 18 years old	Emergency nurse practitioners	NR	Unclear	ED/EMS	Videoconference	Real-time
Mohr, 2018 (same patients as Mohr 2017)	2,662 A: 2,371 B: 291	Adults	Rural ER physician	ED physician	Yes	ED/EMS	Video	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Mohr, 2017 (same patients as Mohr 2018)	2,662 A: 2,371 B: 291	Adults	Rural ER physician	ER physician and ED nurse	Yes	ED/EMS	Video	Real-time
Nagao, 2012	54 A: 30 B: 24	Adults	Emergency physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Narasimhan, 2015	14,522 A: 7,261 B: 7,261	All patients seen in ED for psychiatry issues	ED doctors	Psychiatrists with at least one year experience in emergency psychiatry	Yes	ED/EMS	Videoconference	Real-time
Natafgi, 2017	173,339 A: 164,291 B: 9,048	Not specified	Rural ER physician	Emergency medicine physician	Yes	ED/EMS	Videoconference	Real-time
Nguyen-Huynh, 2018	A: 310 B: 557	Adult	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Noble, 2005	253 A: 191 B: 62	Not specified	Nurse	ED	Yes	ED/EMS	Unclear; pictures or video	Unclear
Ortolani, 2006	658 A: 316 B: 176 C: 166	Adults	EMS physician	Cardiologist	Yes	ED/EMS	ECG transmission	Real-time
Ortolani, 2007	121 A: 79 B: 42	Patients with STEMI with cardiogenic shock	Ambulance personnel (1 physician, 2 paramedics)	Cardiologists	No	ED/EMS	Records (EKG trace sent)	Asynchronous
Paik, 2017	84 A: 42 B: 42	NR	ED clinicians	Plastic surgeon and orthopedics	Yes	ED/EMS	IPad app	Real-time
Patel, 2015	50 A: 25 B: 25	Pediatric	Pediatric transport team	Medical command officer	Yes	ED/EMS	Videoconference	Real-time
Pedersen, 2009	1,437 A: 821 B: 616	Adults	EMS	Cardiologist	Yes	ED/EMS	ECG transmissionmobile phone with fax	Real-time
Pedragosa, 2009	399 A: 201 B: 198	Rural patients	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Pervez, 2010	296 A: 181 B: 115	Adults	Emergency physician	Neurologist	Yes	ED/EMS	Video	Real-time
Poon, 2001	327 A: NR B: NR	Neurosurgical patients	Physician	Neurosurgeon	Yes for videoconference, unclear for others	ED/EMS	Videoconference	Mixed
Saffle, 2009	98 A: 28 B: 70	General	Physician	Physician	Yes	ED/EMS	Videoconference	Real-time
Sairanen, 2011	1,091 A: 985 B: 106, 61 received thrombolysis	Adults	Emergency physician	Neurologist	Yes	ED/EMS	Videoconference and review of images, if provided	Real-time
Sanchez-Ross, 2011	142 A: 50 B: 92	Patients confirmed to have STEMI	ED physician	Cardiology	Yes	ED/EMS	Telephone, test results	Mixed
Schwab, 2007	302 A: 132 B: 170	Adult	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Sejersten, 2008	257 A: 89 B: 168	Adults	EMT	Cardiologist	Yes	ED/EMS	ECG to mobile phone	Real-time
Southard, 2014	62 A: 24 B: 38	Rural patients	ED physician	Mental health specialists: social workers, licensed mental health counselors, and counseling psychologists	Unclear	ED/EMS	Videoconference	Real-time
Switzer, 2009	75 A: 26 B: 49	Adult	ED physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Taqui, 2017	153 A: 53 B: 100	Adults	EMT mobile stroke unit	Vascular neurologist	Yes	ED/EMS	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Theiss, 2013	1,324 A: 168 B: 845 C: 311	Adults	Emergency physician	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Traub, 2013	302 A: 196 B: 106, 36 used telehealth		Nurse	Emergency physician	Yes	ED/EMS	Videoconference	Real-time
Tsai, 2007	822 A: 685 B: 137	General	Physician	Physician	Unclear	ED/EMS	Videoconference, medical record review	Real-time
Wong, 2006	710 A: 235 B: 239 C: 236	Consecutive patients from the district general hospital requiring emergency neurosurgical consultation (mean age 58, 60% male)	Not specified	Neurosurgeon	Yes	ED/EMS	Telephone + teleradiology or videoconference	Real-time
Yang, 2015	138 A: 64 B: 74	Pediatric	ED physician	Pediatric critical care physician	Yes	ED/EMS	Videoconference	Real-time
Zaidi, 2011	142 A: 59 B: 83	Adult	NR	Neurologist	Yes	ED/EMS	Videoconference	Real-time
Zanini, 2008	399 A: 263 B: 136	Adults	Ambulance staff	Cardiologist	Yes	ED/EMS	ECG transmission Phone	Real-time
Zennaro, 2014	42 A: 42 B: 42 (same patients as A)	Pediatric patients presenting with fractures	Pediatrician	Orthopedic surgeon	No	ED/EMS	Telephone +/- sending images via iPad	Asynchronous

ECG = electrocardiogram; ED = emergency department; EKG = electrocardiogram; EMS = emergency medical services; EMT = emergency medical technician; NR = not reported; S&F = store and forward; STEMI = ST-elevation myocardial infarction; TH = telehealth

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-4

See Appendix C. Included Studies for full citations

Table F-6. Emergency medical services/emergency department evidence table: results

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Amorim, 2013	Overall IV tPA use A: 2.8% B: 6.8%, p<0.001 For patients receiving IV tPA (n=27 vs. 113) [mean (SD), p-value] Onset to treatment minutes: A: 129.8 (34) B: 124.4 (34), p=0.49 Door to treatment minutes: A: 74.2 (32.1) B: 74.0 (29.1), p=0.98 Symptomatic intracerebral hemorrhage: A: 3.7% B: 0.9%, p=0.34 In-hospital mortality: A: 7.4% B: 10.9%, p=0.59 Discharge outcomes: Home: A: 33.3% B: 26.5%, p=0.48 Rehabilitation: A: 33.3% B: 32%, p=0.95	NR	NR
Astarcioglu, 2015	Door to balloon time reduction of 21 minutes (95% CI 9.1 to 32.3) Door to door time reduction of 18 minutes (95% CI 11.45 to 32.95), the majority of the door to balloon estimate. Cath lab to balloon time was not different, 2 minutes (95% CI -2.97 to 8.17) False STEMI did not occur in Group B, but did in 8.3% of Group A (NS)	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Audebert, 2006	Mean LOS (SD), in days A: 11.9 (6) B: 10.7 (6) p<0.0001 Hospital discharge destination p=0.001 Home: A: 38% B: 39% Rehab unit: A: 34% B: 38% NH: A: 5% B: 3% Other hospital: A: 13% B: 13% Dead: A:10% B: 8% 3-month outcomes p<0.0001 Dead: A: 19% B: 17% Institution: A: 14% B: 13% Home, severe disability: A: 21% B: 14% Home without severe disability: A: 46% B: 56%	Diagnostic procedures All p<0.001 Rapid brain imaging: A: 32% B: 74% Carotid artery sonography: A: 62% B: 83% Standardized test for dysphagia A: 48% B: 73% Treatments all p<0.0001 Thrombolytic treatment: A: 0% B: 5% Physiotherapy: A: 49% B: 85% Speech therapy: A: 10% B: 82% OT: A: 7% B: 74%	NR
Bergrath, 2012	NR	Median EMS alarm to physician arrival (IQR), in minutes A: 7 (4) B: 5 (2), p=0.0182 Median door to brain imaging (IQR), in minutes A: n=42; 57 (80) B: n=16; 59.5 (67.5), p=0.6447	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Bladin, 2015	Mortality A: 7% B: 10%, p=0.58 Median LOS, in days (IQR) A: 3 (1 to 6) B: 4 (2 to 6), p=0.34 Discharged from hospital A: 93% B: 90% tPA use (within 4.5 hours of onset window) All strokes: A: 10 (17%) B: 16 (26%), p=0.26 Ischemic strokes: A: 10 (19%) B: 16 (28%), p=0.28	Median door to medical contact, in minutes A: 13 B: 13, (p=0.94) Median door to CT scan, in minutes A: 63 B: 34 (p=0.006) Median door to VST consult, in minutes A: no data B: 68 Median minutes for patients receiving tPA: Door to CT scan: A: 15 B: 20 (p=0.63) Door to needle time: A: 101 B: 85 (p=0.32) Stroke onset to needle: A: 218 B: 173 (p=0.11) Door to VST consultation: A: No data B: 50 Discharge destination Home: A: 14 (24%) B: 21 (34%) Nursing home: A: 2 (3%) B: 3 (5%) Rehab: A: 22 (38%) B: 19 (31%)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**[a]	**Results: KQ3: Adverse Effects or Unintended Consequences**[a]
Brennan, 1998 and 1999	NR	Average throughput time, in minutes A: 117 B: 10672 Hour return visit A: 0% B: 0% Need for additional care A: 2.4% B: 2.3%, p=0.99 Positive patient-physician interaction A: 100% B: 98%, p=0.32 Positive patient-nurse interaction A: 98% B: 98%, p=0.97 Overall patient satisfaction A: 95% B: 98%, p=0.54	NR
Brokmann, 2016b	NR	Adequate initial pain reduction Numerical Rating Scale (NRS) A: A: 31/32 B: 61/65 NRS reduction during mission A: 4.38 ± 2.2 points B: 3.78 ± 2.0 p=0.0159	Complications A: 0 B: 0 Nausea and vomiting A: 11% B: 11%

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Brokmann, 2016	NR	Correct handling12-lead ECG A: 39 B: 38, p>0.99 Acetylsalicylic acid A: 33 B: 31, p=0.73 Heparin A: 33 B: 34, p>0.99 Morphine A: 27 B: 29, p=0.50 Oxygen A: 18 B: 29, p=0.007	None detected
Brunetti, 2014	NR	Mean time to balloon ± SD, in minutes A: 94 ± 61 B: 41 ± 17, p<0.001	NR
Chan, 2012	30-day mortality A: 13.3% B: 5.4% p=0.006	90-minute door to balloon A: 8.7% B: 80.4%, p<0.001 Post-procedural thrombolysis in myocardial infarction flow grade 3 after the emergency procedure A: 91.4% B: 97.6%, p=0.02	NR
Cho, 2011	NR	Mean intubation times (SD), in seconds A: 56 (2) B: 62 (12) p=0.30 Complication rate p=0.36 Success rate p>0.05	Complication rate was not significantly different p=0.36
Choi, 2006	0 Received tPA A: 0.81% B: 4.3% p<0.001 No intracerebral hemorrhages	Median door to needle: 85 minutes (range 27 to 165) Received tPA n=14 (24 hours posttreatment) 7 improved by 4 points on NIHSS; 3 worsened	1 patient required phone call consultation due to equipment failure. No patients developed hemorrhages occurred.

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Chowdhury, 2012	3-month mortality A: 15.5% B: 11%, p=0.6 Favorable outcome A: 36.5% B: 42%, p=0.9	Median onset to treatment (IQR), in minutes A: 100 (78 to 120) B: 125 (55 to 105), p=0.001 Median admission to treatment, in minutes A: 33 (23 to 47) B: 61 (43 to 106), p<0.001	Symptomatic intracranial hemorrhage A: 7.7% B: 4.4% p=0.7
Darkins, 1996	Difference in cost, in GBP A: £50,000 for onsite staff B: £7,250 for equipment	ED referrals: A: 2.3% B: 1.5% Primary care referrals: A: 11.9% B: 3.8%	NR
Dayal, 2016	Mortality n (%) A: 23 (4.4) B: 14(2.4) p=0.07	Mean PICU LOS (SD), in days A: 3.8 (9.4) B: 3.1 (5.5) p=0.11	NR
Demaerschalk, 2010	Mortality A:11% B: 4%	Mean onset to decision time ± SD, in minutes A:164 ± 28.6 B: 188.2 ± 138.2 p=0.07	Intracerebral hemorrhage A: 0% B: 4% p>0.99
Dharmar, 2013	NR	Assessment of quality of care (7 point rating) Unadjusted, overall Mean (95% CI) A: 5.20 (5.07 to 5.34) B: 5.60 (5.42 to 5.79) C: 5.37 (5.16 to 5.59) A to B: p<0.05 Adjusted meandifference (95% CI) B to A: 0.50 (0.17 to 0.84), p=0.05 Linear regression of overall quality: A: NA (reference) B: n=58; β=0.50 (95% CI 0.17 to 0.84] C: n=63; β=0.12 (95% CI −0.14 to 0.39) Referring ED physicians changed diagnosis: B: 47.8% C: 13.3%; p<0.01 Changed in therapeutic interventions: B: 55.2% C: 7.1%; p<0.01	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes[a]	Results: KQ2: Intermediate Outcomes[a]	Results: KQ3: Adverse Effects or Unintended Consequences[a]
Dharmar, 2013	Mortality n (%) A1: 2 (2.6) A2: 1 (1.2) B: 3 (4.1)	Physician-related ED medication errors, n (%) A1: 16 (12.5) A2: 18 (10.8) B: 5 (3.4) B vs. A2: p<0.05 B vs. A1: p<0.05	NR
Dharmasaroja, 2010	Unclear	Receipt of tPA A: 8% B: 27%	Protocol violations 5 of 124 patients after telehealth, no data provided from before period
Duchesne, 2008	Mortality, n (%): A: 17 (4.8) B: 4 (7.8) Hospital costs: A: $7,632,624 B: $1,126,683 p<0.001 LOS at local community hospital, in hours A: 47 B: 1.5, p<0.001	Discharge outcomes Home: A: NRB: 61.3% Admitted to local community hospital: A: NRB: 13.6% Transfer to trauma center: A: 100% B: 11% Mode of transfer A: 74.9% ground B: 70.5% ground	NA
Fong, 2015	Excellent outcome mRS 0-1 (at 3 months) A: 43% B: 52% p=0.30 In multivariate analyses, the absence of onsite neurologists was not associated with negative outcomes. Mortality A: 11.9% B: 8.3%, p=0.58	Median minutes (IQR) Onset to door A: 54 (43 to 70) B: 54 (43 to 70), p=0.15 Door to CT A: 26 (20 to 38) B: 30 (25 to 43), p=0.29 CT to needle A: 41 (32 to 57) B: 67 (50 to 82), p<0.001 Door to needle A: 71 (60 to 89) B: 97 (85 to 19), p<0.001 Onset to needle A: 133 (109 to 154) B: 148 (134 to 170), p=0.012	Symptomatic intracranial hemorrhage rate A: 4.9% B: 4.0%, p=1.0

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Goh, 1997	Glasgow Outcome Scale Death: A: 14.3% B: 14.3% Vegetative: A: 7.1% B: 8.6% Severe disability: A: 10.7% B: 2.9% Moderate disability: A: 14.3% B: 14.3% Good: A: 53.6% B: 60%	Treatments Overall therapeutic interventions prior to transfer: A: 10.7% B: 32.1%, p=0.062 Individual interventions: Endotracheal tube: A: 7.1% B: 9.6% Mannitol: A: 3.6% B: 12.9% Other: A: 0 B: 9.6%	Overall adverse events: A: 32.1% B: 6.4%, p=0.017 Individual adverse events Hypoxia: A: 3.6% B: 0.0% Hypotension: A: 3.6% B: 3.2% Neurologic deterioration: A: 17.7% B: 0.0% Convulsions: A: 3.6% B: 0.0% Missed injuries: A: 3.6% B: 3.2%
Handschu, 2008	Mortality 10 days post-stroke A: 6.8% B: 1.3%, p<0.05 Institutional care 10 days post-stroke A: 5.4% B: 2.6%, NS Diagnosis corrected at discharge: A: 17.6% B: 7.1%, p<0.05 Length of stay, in days: A: 12.3 B: 11.4, NS Admission to stroke ward: A: 45.9% B: 59.7%, NS Transfer to stroke center: A: 14.9% B: 9.1%, p<0.05 Total time for consultation, in minutes: A: 27.1 B: 49.8, p<0.01	NR	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes[a]	Results: KQ2: Intermediate Outcomes[a]	Results: KQ3: Adverse Effects or Unintended Consequences[a]
Hashimoto, 2001	1-year survival: A: NR B: 72% 2-year survival: A: NR B: 42% Mean hospitalization time (range), in months: A: NR B: 2.3 (1 to 3)	Treatment within 24 hours A: 17.6% B: 92% Successful ambulation for patients who were nonambulant A: n=8, 25% B: n=6, 83% (p<0.05) Mean onset to radiotherapy time (SD), in days A: 7.1 (7.9) B: 0.8 (0.4), p<0.05	NR
Heffner, 2015	Multivariate analysis OR (95% CI) In-hospital mortality B vs. A: 11.046 (2.785 to 43.810) B+C vs. A: 6.835 (2.157 to 21.659) LOS, in days >6 days OR (95% CI) B vs. A: 4.696 (2.428 to 9.083) B+ C vs. A: 4.280 (2.356 to 7.774) B vs. A, OR (95% CI) Modified Rankin Scale score of 6: 1.542 (0.635 to 3.746) Pneumonia 0.560 (0.163 to 1.929) UTI 1.486 (0.652 to 3.390) MI/A fib 0.741 (0.259 to 2.123) GI bleed 0.702 (0.132 to 3.720) Falls 0.982 (0.116 to 8.301) Intubated 0.043 (0.007 to 0.256) Seizure 0.821 (0.142 to 4.752)	Door to needle, in minutes (SD) A: 71.98 (30.2) B: 76.57 (23.5) A to B p=0.151 C: 74.89 (28.3) B to C p=0.683 Onset to needle, in minutes (SD) A: 155.6 (43.3) B: 147.57 (40.1) A to B p=0.072 C: 133.8 (42.5) B to C p=0.028	NR
Hubert, 2016	NR	Median (IQR); mean ± SD, in minutes Onset to door time A: 88 (60 to 135); 105.3 ± 55.9 B: 65 (48 to 101); 80.1 ± 45.3 p<0.001 Door to needle time A: 18 (13 to 30); 25.1 ± 20.0 B: 39 (26 to 56); 44.7 ± 26.7 p<0.001 Onset-to-treatment time A: 117 (81 to 168); 130.4 ± 59.1 B: 115 (87 to 155); 124.8 ± 49.4 p=0.452	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Ickenstein, 2005	NR	Patients presenting with 3 hours and receiving tPA A: 10 (6%) B: 45 (27%)	NR
Ionita, 2009	Discharge Modified Rankin scale >3 A: 61 (48%) B: 13 (48%) p<0.96 Post-thrombolytic intracranial hemorrhage A: 26 (20%) B: 9 (33%) p<0.15 Inpatient mortality A: 14(11%) B: 3 (11%) p<0.98 Analysis of variables predictive of mortality or intracranial hemorrhage A vs. B =NS	Mean time from onset to needle (SD), in minutes A: 143.9 (29.5) B: 130.7 (42.1), p<0.13	NR
Itrat, 2016	NR	Median door to CT read (IQR), in minutes A: 25 (19 to 35) B: 25 (20 to 29) p=0.59 Median door to IV-tPA (IQR), in minutes A: 58 (53 to 68) B: 32 (24 to 47) p<0.001	NR
Johansson, 2011	Good functional outcome at 3 months (mRS, dichotomized analysis 0 to 1) A: 43% B: 47% p=0.694 Overall mortality at 3 months A: 13% B: 19% p=0.248	Mean onset to needle, in minutes A: 122 (n=277) B: 113 (n=42) p=0.263	Hemorrhagic bleeding A: 7.6% B: 6.4%

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Kim, 2011	NR	Mean time to the scene, in minutes (SD) A: 6.6 (4.7) B: 6.6 (5.3), p=0.944 Mean treatment time at the scene, in minutes (SD) A: 6.3 (5.9) B: 4.4 (3.5), p<0.001 Mean transport time, in minutes (SD) A: 15.8 (9.4) B: 19.4 (9.9), p<0.001 % receiving medical direction for treatment A: 0.3 B: 8.0, p<0.001 % receiving medical direction for ambulance diversion A: 0.1% B: 14.4%, p<0.001	NR
Langabeer, 2016 and 2017	Mortality A: 0% B: 0% Average unit cost per patient (SD), in USD A: $270 (77.7) B: $167(42.7), p<0.0001	Ambulance utilization disposition to ED by ambulance A: 74% B: 18%, p<0.001 Patient satisfaction A: 87% B: 88%, p=0.250 Unit productivity Median total back in service time, in minutes (IQR) A:83 (20 to 140) B:39 (27 to 90), p<0.001	NR
Macedo, 2016	Mortality (%) A: 8 B: 3 p=0.06	Use of pharmacoinvasive strategy A: 38% B: 55.8% p=0.002	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Machado, 2018	Mortality % (n) A: 22.4% (49) B: 26.3% (25) p=0.471 Total hospital costs, in USD A: $24,364 ± 25,068 B: $19,713 ± 16,550 p=0.274	Mean time to antibiotics ± SD, in minutes A: 163.4 ± 204.4 B: 122.3 ± 83.3 p=0.043 Antibiotics administered within 3 hours A: 71.2% B: 82.1% p=0.097 LOS ± SD, in days A: 10. ± 8.5 B: 8.6 ± 5.7 p=0.088 Readmission in 30 days, % (n) A: 11.4 (25) B: 16.8 (16) p=0.204	NR
Marcolino, 2013	In-hospital mortality A: 12.3% B: 7.1% p<0.001 The mean cost of admission, in Brazilian reals A: $2,480.00 B: $3,501.00 p<0.001	Admissions including ICU stay A: 32.4% B: 66.1% p<0.001 Patients admitted to tertiary hospitals A: 47.0% B: 69.6%; p<0.001	NR
Martinez-Sanchez, 2014	In-hospital mortality A: 1 (16.7%) B: 1 (10%) p=1.0 Patients treated with tPA, Favorable outcome, n (%) A: 4 (33.3) B: 10 (55.6), p=0.145	Received IV rtPA A: 4.7% B: 8%, p=0.125 Median door to needle (IQR), in minutes A: 143.5 (48) B: 66 (54), p<0.0001	Stroke recurrence, n (%) A: 0 B: 1 (5.6%) Intracranial hemorrhage, n (%) A: 2 (16.7) B: 0, p=0.152
Martinoni 2011	30-day mortality of patients admitted by EMS A: 7.9% B: 5.3%, p=0.06	First medical contact to balloon, median minutes (IQR) A: 75 (49 to 112) B: 50 (30 to 78.5), p<0.001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Mathews, 2008	Median LOS (range), in days A: 3.0 (0.1 to 98.8) B: 2.0 (0.1 to 144.8), p=0.31	Referring doctors felt better able to manage 59% of cases. 98% felt the equipment was easy to use. Aeromedical retrievals A: 92% B: 78%, p=0.009 Not transferred A: 5% B: 16%, p=0.022 Helicopter flights A: 73% B: 52%, p=0.004	9% of cases were felt to not be better managed
Mazighi, 2017	NR	Received IV rtPA A: 4 B: 21 Median onset to IV rtPA (range), in minutes A: 184 (178 to 258) B: 145 (110 to 200)	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes[a]	Results: KQ2: Intermediate Outcomes[a]	Results: KQ3: Adverse Effects or Unintended Consequences[a]
Meyer, 2008	Barthel Index score or 95 to100 at 90 days: A: 54% B: 43% OR: 0.6 (95% CI 0.4 to 1.1), p=0.13 Modified Rankin scale score of 0 to 1 at 90 days: A: 47% B: 34% OR: 0.6 (95% CI 0.3 to 1.1), p=0.09 Overall mortality: 13% vs. 19%; 1.6 (0.8-3.4), p=0.27 tPA use: A: 23% B: 28%, p=0.42	Mean times (SD), in minutes Onset to decision: A: 230.6 (222.4) B: 258.0 (229.9), p=0.07 Onset to thrombolysis (n=30 vs. 55): A: 143.0 (33.1) B: 157.2 (37.7), p=0.14 Times from door/call: Door to decision (n=69 vs. 77): A: 95.5 (64.1) B: 99.8 (43.5), p=0.20 Call to decision: A: 55.2 (33.9) B: 64.7 (29.1), p=0.03 Times from consent: Consent to decision: A: 22.9 (23.6) B: 32.0 (17.3), p=0.0001 Consent to thrombolysis (n=24 vs. 30): A: 44.8 (21.4) B: 51.2 (17.8), p=0.16 Decision to thrombolysis (n=24 vs. 30): A: 15.6 (8.5) B: 10.0 (9.8), p=0.02 % correct decision; OR (95% CI) Level 2b (SDAC): A: 82% B: 98%; 10.9 (2.7 to 44.6); p=0.0009	NR
Mohr, 2018 (same patients as Mohr 2017)	Mortality, adjusted OR (95% CI) Telehealth used: 0.9 (0.5 to 1.4) Telehealth available: 1.2 (0.9 to 1.7)	ED LOS, mean adjusted difference (95% CI) Telehealth used: -12.2 (-27.6 to 3.2) Telehealth available: 15.4 (9.8 to 21.0) Interhospital transfer, adjusted OR (95% CI) Telehealth used: 1.2 (0.8 to 1.8) Telehealth available: 1.2 (1.1 to 1.4) CT scans, adjusted OR (95% CI) Telehealth used: 0.9 (0.7 to 1.2) Telehealth available: 1.6 (1.3 to 1.9) X-Rays, adjusted OR (95% CI) Telehealth used: 1.1 (0.8 to 1.4) Telehealth available: 1.3 (1.1 to 1.5)	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes[a]	Results: KQ2: Intermediate Outcomes[a]	Results: KQ3: Adverse Effects or Unintended Consequences[a]
Mohr, 2017 (same patients as Mohr 2018)	Mortality, n (%) A: 16 (0.6%) B: 8 (2.7%)	Discharged home, n (%) A: 923 (36.8%) B: 66 (22.2%) Admitted, n (%) A: 395 (15.7%) B: 43 (14.5%) Inter-hospital transfer, n (%) A: 1127 (44.9%) B: 170 (57.2%) Univariate analysis, inter-hospital transfer A: 8.5% B: 13.1%, (95% CI 2.3% to 6.9%) Multivariable analysis, inter-hospital transfer AOR: 1.28, (95% CI 0.94 to 1.75)	NR
Nagao, 2012	Mortality, n (%) A: 3 (13%) B: 3 (10%), p=0.6 (DF3) Discharged home, n (%) A: 14 (47%) B: 12 (50%) Other hospital, n (%) A: 13 (43%) B: 8 (33%)	Thrombolysed, n (%) A: 0 B: 8 (33%) Intracerebral hemorrhage A: 0 B: 0	Complications Further stroke, n (%) A: 0 B: 2 (8.3%)
Narasimhan, 2015	Adjusted utilization outcomes OR (95% CI), p-value Inpatient admission 0.41 (0.19 to -0.88), p=0.022 LOS, in days -0.43 (-0.17 to -0.14), p=0.002 Change in inpatient charges, 30 days post ED visit: -2,338 (-4,582 to -94), p=0.041 Change in total health care charges, 30 days post ED visit: -649 (-3,221 to 1,902), p=0.614	Adjusted utilization outcomes OR (95% CI), p-value 30-day outpatient followup 5.44 (4.40 to 6.72), p<0.001 90 day outpatient followup 5.65 (4.60 to 6.93), p<0.001	NR
Natafgi, 2017	Mortality, n (%) A: 791 (0.5%) B: 358 (4.0%) Transferred, n (%) A: 1059 (0.7%) B: 4224 (47.6%) Estimated savings per avoided transfer, in USD: $3,823	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Nguyen-Huynh, 2018	NR	Alteplase administration per month, mean ± SD A: 34.4 ± 12.4 B: 61.8 ± 12.4, p<0.001 Door to needle time, mean minutes ± SD A: 63.2 ± 31.2 B: 41.8 ± 30.6, p<0.001	Symptomatic intracranial hemorrhage rates A: 2.2% B: 3.8%, p=0.29
Noble, 2005	Returned to normal activity in 7 days, (95% CI) A: 47.6% (34.9 to 60.6) B: 47.0% (41.0 to 53.2) Mean 7-day cost difference per patient in GPB (95% CI), [95% bias corrected CI] NHS cost: £39.47 (-1.28 to 80.21), [28.31 to 73.67] Patient/family cost: £14.28 (-26.59 to 55.15), [-11.18 to 25.85] Total cost: £53.75 (-6.97 to 114.46), [24.10 to 101.81]	Required a change in treatment (95% CI) A: 6.3% (1.8 to 15.5) B: 9.6% (6.4 to 13.8)	NR
Ortolani, 2006	Overall mortality, n (%) A: 23 (7.3) B: 13 (7.4) C: 8 (4.8) p=0.537 In-hospital mortality among cardiogenic shock subgroup (n=80) A: 48.1% (13/27) B: 37.5% (9/24) C: 13.8% (4/29) p=0.019	Median treatment delay (IQR), in minutes A: 191 (135 to 318.7) B: 236 (163.7 to 363.2) C: 146 (108.2 to 214.5), p=0.001	Nothing designated specifically as complications, however not sure if some of the results reported in the table are considered complications.

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Ortolani, 2007	Mortality In-hospital cardiac mortality: A: 44% B: 21% OR: 0.34 (95% CI 0.14 to 0.81), p=0.02 In-hospital all-cause mortality: A: 46% B: 21% OR: 0.32 (95% CI 0.14 to 0.77), p=0.01 1-year survival rate: A: 52% B: 74% OR: NR, p=0.019 Median total ischemic time, in minutes A: 212 (150 to 366) B: 142 (106 to 187)	NR	NR
Paik, 2017	NR	Response time, in minutes A: 48.3 B: 8.9 p<0.001 Overall agreement, n (%): 38 (90.5%)	NR
Patel, 2015	NR	Average call duration, in seconds A: 186 B: 139, p=0.055 Medical Command Officer Survey, n=12 100% found video intuitive 92% disposition based on phone report was difficult 80% video provided better understanding of patient condition 70% video assisted disposition 80% believed video should be used for transport	NR
Pedersen 2009	All-cause mortality or nonfatal MI hazard ratio (95% CI) 0.67; (0.46 to 0.97), p=0.035	Median door to balloon time (IQR), in minutes A: 103 (80 to 135) B: 83 (67 to 100) p<0.001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Pedragosa, 2009	Urgent ambulance transfer: A: 17% B: 10%, p=0.04 Specialized neurologist evaluation: A: 17% B: 38%, p<0.001 Unnecessary transfers to the stroke center: A: 51% B: 20%, p=0.02 Stroke unit admissions: A: 11% B: 8%, p=0.34 tPA use: A: 4.5% B: 9.6%, p=0.07 tPA in 0 to 3 hour window A: 30% in 2006 B: 68% in 2007, p=0.04	Onset to needle, in minutes A: 210 B:162, p=0.05	NR
Pervez 2010	In-hospital mortality A: 17.4% B: 14.9%, p=0.57 Discharge outcomes Home A: 30.5% B: 28.6% p=0.74 Inpatient rehabilitation A: 55.3% B: 53.3% p=0.67 Ambulatory at discharge A: 77.7% B: 73.8% p=0.5	Mean LOS ± SD, in days A: 7.6 ± 6.5 B: 5.9 ± 3.7 p<0.001 Median onset to tPA time (IQR), in minutes A: 130 (102.5, 162.8) B: 140 (117.3, 165.3) p=0.06	Symptomatic ICH <36 hours A: 5.2% B: 3.9% p=0.58 Systemic hemorrhage <36 hours A: 2.6% B: 0.6% p=0.14

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Poon, 2001	Favorable outcome A: 38.2% B: 30.8% C: 43.5% (no statistical test reported)	Time between referral and decision to transfer, in minutes A: 1.8 B: 49.2 C: 65.4 Actual time spent in consultation, in minutes A: 1.8 B: 13.2 C: 10.2 Time between referral and image received, in minutes A: NA B: 36 C: 55	NR
Saffle, 2009	Patients requiring air transportation A: 100% B: 44.3% p<0.05 Mortality, n (%) A: 1 (3.6%) B: 0	Received emergency air transport A: 100% B: 44.3% p<0.05 Larger burn size A: 6.5% B: 9.0% p=NS Median LOS (IQR), in days A: 8 (24) B: 13 (23) p=NS Referring physicians felt that telemedicine changed their decision to transport (“strongly agree” or “agree”), in almost half of cases Satisfied with telemedicine visit (% strongly agree) Burn center physicians: 76.9% Referring physicians: 86.4% Patients transferred: 75.9% Patients non transferred: 69.2% All respondents: 78.2%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Sairanen, 2011	Mortality 3 months, n (%) A: 93/985 (10.2%) B: 7/61 (11.5%) mRS 0-2 (3 months), n (%) A: 556/985 (58.1%) B: 28/57 (49.1%) mRS 0-1 (3 months), n (%) A: 352/957 (36.8%) B: 17/57 (29.4%)	NR	Intracranial bleeding, n (%) A: 93/985 (9.4%) B: 4/60 (6.7%)
Sanchez-Ross, 2011	A: n=43 B: n=72 Median length of stay (IQR), in days A: 5.5 (3 to 10.5) B: 3 (2 to 4), U=378, p<0.001 Mortality A: 6% B: 1.1%, p=0.125 Peak troponin, ng/ml A: 87.6 (38.4 to 227) B: 39.5 (11 to 120.5), U=889.5, p=0.005 CPK-MB, ng/ml A: 290.3 (102.4 to 484) B: 126.1 (37.2 to 280.5), U=883, p=0.001 Post-Infarction LVEF A: 35% (25% to 52%) B: 50% (35% to 55%), U=1075, p=0.004	Median door to balloon time (IQR), in minutes A: n=43; 119 (96 to 178) B: n=72; 63 (42 to 87), U=779.5, p<0.00004	NR
Schwab , 2007	3 month mortality A: 11.5% B: 11.2% 6 month mortality A: 13% B: 14.2%, p=0.45 Good functional outcome at 6 months A: 30.9% B: 39.5%, p=0.10	Mean onset to treatment time, in minutes ± SD (95% CI) A: 145.88 ± 46.99 (126.9 to 164.87) B: 127.57 ± 36.33 (117.14 to 138.01) p=0.45	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**[a]	**Results: KQ3: Adverse Effects or Unintended Consequences**[a]
Sejersten, 2008	Mortality A: 6.9% B: 6.0% p=0.67	Time to percutaneous coronary intervention (PCI), in minutes A: 127 B: 74 p<0.001 Door to PCI, in minutes A: 97 B: 34 p<0.001	Arrhythmia A: 6 (7%) B: 17 (10%)
Southard, 2014	Mean LOS, in hours (range), (SD), median A: 31.7, (12.6 to 65.9), (14.1), 26.3 B: 17.0, (3.0 to 69.5), (18.0), 8.2 p<0.001	Mean order to consult time, in hours (range), (SD), median A: 16.2, (0.5 to 52.9), (13.2), 14.2 B: 5.4, (0.02 to 25.1), (6.4), 2.6 p<0.001 Mean door to consult time, in hours (range), (SD), median A: 22.7, (6.3 to 56.6), (12.6), 19.6 B: 10.5, (1.7 to 50.9), (10.2), 5.9; p<0.001	NR
Switzer, 2009	NR	Onset to treatment time (SD), (95% CI), in minutes A: 145.88 (46.99), (126.9 to 164.87) B: 127.57 (36.33), (117.14 to 138.01)	NR
Taqui, 2017	NR	Median alarm to CT scan completion times, in minutes A: 56 B: 33 p<0.0001 Median alarm to thrombolysis times, in minutes A: 94 B: 55.5 p<0.0001 Median door to thrombolysis times, in minutes A: 58 B: 31.5 p=0.0012 Symptom onset to thrombolysis times, in minutes A: 122.5 B: 97 p=0.0485	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**[a]	**Results: KQ2: Intermediate Outcomes**[a]	**Results: KQ3: Adverse Effects or Unintended Consequences**[a]
Theiss, 2013	Mortality all stroke patients Before A: 12.4% B: 9.6% C: 10.4% After A: 9.6% B: 8.8% C: 8.7%	Likelihood of receiving tPA C vs A, before: OR 5.7, p=0.07 C vs A, after: OR 4.5, p<0.0001 B vs C, before: OR 3.7, p<0.0001 B vs C, after: OR 1.3, p=0.06	NR
Traub, 2013	NR	Admitted, mean (SD) A: 64 (32.65) B: 12 (33.33) p=0.9363 Mean LOS (SD), (95% CI), in minutes A: 258.08 (171.71), (233.89 to 282.27) B: 273.58 (125.35), (231.17 to 316.00) p=0.5246 Mean time to physician evaluation (SD), (95% CI), in minutes A: 42.14 (30.59), (37.80 to 46.48) B: 15.94 (15.22), (10.80 to 21.09) p<0.0001	NR
Tsai, 2007	Total annual savings on emergency air medical transports, in USD $448,986	Average flights per month A: 19.6 B: 12.5 Reduction of 36.3% (no statistical test reported)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes[a]**	**Results: KQ2: Intermediate Outcomes[a]**	**Results: KQ3: Adverse Effects or Unintended Consequences[a]**
Wong, 2006	Favorable outcome at 6 months A: 130, n=232 B: 146, n=311 C: 124, n=167 Total mortality at 6 months, n (%) A: 81 (35%) B: 59 (25%) C: 79 (34%) B vs. A: p=0.025 C vs. A: p=0.923 C vs. B: p=0.043 Average cost per patient, in Hong Kong dollars A: 14,075 B: 14,455 C: 16,370	Diagnostic accuracy: A: 63.8% B: 89.1% C: 87.7% B vs. A: p<0.0005 C vs. A: p<0.0005 Time from referral to decision, in hours (SD) A: 0.70 (1.9) B: 1.0 (1.8) C: 1.30 (2.5) C vs. A p=0.003	30% of failure rate in the videoconferencing arm due to lack of a dedicated team of medical escort staff and the fixed site VC at the Accident and Emergency Department
Yang, 2015	NR	Hospital admissions A: 87.5% B: 59.5%, p<0.05 Observed/expected admission ratio (95% CI) Pediatric Risk of Admission II, overall A: 2.58 (2.00 to 3.32) B: 2.36 (1.80 to 3.10) Revised Pediatric Emergency Assessment Tool, overall A: 2.57 (1.99 to 3.31) B: 2.34 (1.78 to 3.07)	NR
Zaidi, 2011	90 day mortality A: 30.4% B: 31.6% p=0.6 mRS ≤1 at 90 days A: 22.0% B: 34.9% mRS ≤2 at 90 days A: 37.5% B: 42.1% p=0.7	Mean onset to treatment time (SD), in minutes A:156.7 (31.6) B: 145.5 (42.8), p=0.09 Mean arrival to treatment time (SD), in minutes A: 67.8 (26.1) B: 89.9 (36.3), p=0.01 Favorable outcome A: 37.5% B: 42.1% p=0.7	Asymptomatic intracranial hemorrhage A: 18.6% B: 16.2% p=0.7 Symptomatic intracranial hemorrhage A: 5.1% B: 1.2% p=0.1

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes[a]	Results: KQ2: Intermediate Outcomes[a]	Results: KQ3: Adverse Effects or Unintended Consequences[a]
Zanini, 2008	Total in-hospital mortality A: 23/263 (8.7%) B: 4/136 (3%) p=0.039	Onset to balloon (SD), in minutes A: 262 (112) B: 148 (81) p<0.001	NR
Zennaro, 2014	In-hospital consultation required A: 76.1% B: 38% Immediate activation of services A: 0% B: 33.3%	Mean time for decisionmaking (SD), in minutes A: 56.2 (16.1) B: 23.4 (21.8), p<0.001 Diagnostic confidence A: 9.92 (0.31) B: 9.91 (0.32), p=0.88	NR

CI = confidence interval; CPK-MB = creatine kinase-muscle/brain; CT = computed tomography; ECG = electrocardiogram; ED = emergency department; EMS = emergency medical services; GBP = Great British Pound; GI = gastrointestinal; ICH = intracranial hemorrhage; ICU = intensive care unit; IQR = interquartile range; IV = intravenous; LOS = length of stay; LVEF = left ventricular ejection fraction; MI/A fib = myocardial infarction/ atrial fibrillation; mRS = modified Rankin Scale; NA = not applicable; NR = not reported; NRS = numerical rating scale; NS = not significant; NHS = National Health Service; OR = odds ratio; OT = occupational therapy; PCI = percutaneous coronary intervention; PICU = pediatric intensive care unit; SD = standard deviation; SDAC = STRokE DOC adjudicating committee; STEMI = ST-elevation myocardial infarction; tPA = tissue plasminogen activator; USD = United States dollars; UTI = urinary tract infection; VC = video consultation; VST = Virtual Studio Technology

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-4

See Appendix C. Included Studies for full citations

Table F-7. Outpatient evidence table: study characteristics

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Angstman, 2009	Minnesota USA	November 2005 to April 2008	Retrospective Cohort	A: Usual care, seen by specialist in face-to-face consult B: Virtual consult
Arora, 2011	New Mexico USA	NR	Prospective Cohort	A: University HCV clinic (control) B: ECHO site
Bagayoko, 2014	Mali	March 2012 to March 2013	Prospective Cohort for patient costs; Before-After for health center costs	A: Control sites B: Telehealth sites
Baig, 2016	Milwaukee, Wisconsin USA	2008 to 2012	Retrospective Cohort	A: Usual care B: Telehealth
Basudev, 2016	London England	12-month period	RCT	A: Usual care B: Virtual clinic

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Bernstein, 2010	Manitoba Canada	January 1990 to October 2005	Retrospective Cohort	A: No telehealth B1: Local community care (telehealth) near urban center B2: Local community care (telehealth) far from urban center
Beswick, 2016	California USA	August 2013 to March 2015	Retrospective Cohort	A: Usual care B: Telehealth
Bezalel, 2015	Tampa, Florida USA	A: January to May 2012 B: January to May 2013	Before-After	A: Store and forward teledermatology not heavily used B: Store and forward teledermatology fully implemented
Blackwell, 1997	Queensland Australia	December 1995 to February 1997	Before-After	A: Before telehealth B: After telehealth
Boman, 2014	Sweden	2010 to 2013	RCT	A: Standard of care consultation B: Remote consulting and imaging
Britt, 2006	Little Rock, Arkansas USA	A: December 2002 to May 2003 B: December 2003 to May 2004	Before-After	A: Before ANGELS program (some limited telehealth available) B: After ANGELS program (more comprehensive telehealth services)
Brown-Connolly, 2002	California USA	September 1999 to April 2001	Prospective Cohort	A: Face-to-face B: Telehealth Comparison is same patients submitting travel information
Burns, 2017	Queensland Australia	July 2013 to October 2015	RCT	A: Usual care B: Telehealth
Byamba, 2015	Mongolia	September 2013 to January 2014	RCT	A: GPs with access to tele-consultations; B: GPs without tele-consultations (patients were Referred to dermatologists).
Carallo, 2015	Calabria Italy	18 months beginning in 2011	Prospective Cohort	A: Usual care B: Quarterly visits to primary care doctor, phone support by diabetes specialist

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Carter, 2017	Dallas, Texas USA	Before May to December 2013 After May to December 2014	Retrospective Cohort	A: In-person B: Remote assessment
Chan, 2015	Queensland Australia	May 2007 and April 2012	Retrospective Cohort	A: Usual care B: Teleoncology
Chu, 2015	Los Angeles, California USA	September 2013 to March 2014	Retrospective Cohort	A: No telehealth B: Telehealth
Chua, 2001	Northern Ireland	NR	RCT	A: Usual care B: Telehealth
Collins, 2004; Bowns, 2006	United Kingdom	NR	RCT	A: Traditional outpatient consultation B: Asynchronous teleconsultation
Crossland, 2016	Rural, regional, urban Australia	February 2011 to February 2014	Prospective Cohort	A: Usual care B: Telehealth
Datta, 2015	Durham, North Carolina USA	December 2008 to March 2011	Economic Evaluation	A: Usual care B: Telehealth
Davis, 2011	USA	12 months	RCT	A: Usual care B: Collaborative care via telehealth
Davison, 2004	London United Kingdom	November 2000 to November 2001	Before-After	A: Before telehealth B: After telehealth
De Luca, 2005	Italy	June 1999 to December 1999	Prospective Cohort	A: Face-to-face B: Telehealth
Doolittle, 1997	Kansas City, Missouri USA	May 1995 to April 1996	Economic Evaluation	A: Fly in outreach clinic B: Traditional Clinic C: Telehealth
Dowie, 2007	London England	15 month period Specific dates NR	Economic Evaluation	A: Conventional referrals B: Telehealth
Eminovic, 2009, 2010	Netherlands	February 2004 to January 2006	RCT; Economic Evaluation	A: Usual practice B: Teleconsultation
Endean, 2001	Kentucky USA	NR	Pre/Post	A: Onsite vascular evaluation B: Telehealth vascular evaluation
Ferrandiz, 2007	Seville Spain	March 2005 to February 2006	Prospective Cohort (pre/post for clinical accuracy)	A: Conventional system B: Teleconsultation
Fortney, 2013	Arkansas USA	18 months between 2007 and 2009	RCT	A: Practice based collaborative care B: Telehealth based collaborative care

Author, Year (See Appendix C for full citation)	Geographic Location of Studies	Study Period	Study Design	Comparison and Intervention
Fortney, 2007	South-Central USA	12 months	RCT	A: Usual care B: Collaborative care via telehealth
Fortney, 2011	USA	April 2003 to September 2004	RCT	A: Usual care B: Telehealth
Fortney, 2015	USA	November 2009 to September 2011	RCT	Telehealth outreach including medications and CPT
Fox, 2007	Tennessee USA	3 years Dates not specified	Before-After	A: Year before telehealth program implemented B: One year after telehealth program implemented C: Two years after telehealth program implemented
Frank, 2015	USA	July 2011 to December 2013	Before-After	A: Patient panels of primary care providers with pain that never presented at SCAN-ECHO B: Patient panels of primary care providers with pain that have presented at the SCAN-ECHO meetings
Gattas, 2001	Queensland Australia	NR	RCT	A: Face-to-face B: Teleconsultations
Gilmour, 1998	United Kingdom	1995 to 1996	Prospective Cohort	A: Face-to-face B: Telehealth
Harno, 2000	Finland	1998	Economic Evaluation	A: Hyvinkaa Hospital (no telehealth) B: Peijas Hospital (telehealth)
Harno, 2001	Finland	1998	Economic Evaluation	A: Outpatient clinic B: Videoconference
Haukipuro same patients as Ohinmaa and Vuolio, 2000	Finland	1998	RCT; Economic Evaluation	A: Conventional hospital outpatient clinic B: Videoconferencing
Herce, 2011	Seville Spain	January and December 2009	Prospective Cohort	A: Usual care B: Telehealth
Hsiao, 2008	San Francisco, California USA	January 2003 to July 2007	Retrospective Cohort	A: Face-to-face dermatology consultation B: Teledermatology consultation

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Izquierdo, 2009	Onondaga County, New York USA	NR	RCT	A: Usual care: in-person visits to diabetes center every three months B: Telehealth: monthly visit
Jaatinen, 2002	Satakunta Finland	5 months (from December 1999)	RCT	A: Control group (conventional referral letter sent to hospital outpatient clinic or telephone call) B: Telehealth group (teleconsultation form or telereferral form and web-based telehealth system)
Jacklin, 2003 Same study as Wallace 2002, 2004	England	1999 to NR	RCT	A: Face-to-face consultation B: Teleconsult (joint with referring general practitioner also participating with patient)
Jacobs, 2015	Ameland Netherlands	2006 and 2009	Before-After	A: Before teleradiology B: After teleradiology
Jong, 2004	Canada	NR	Prospective Cohort	A: Physicians visiting clinic B: Physicians using email C: Physicians videoconferencing
Jue, 2017	Florida USA	July 2012 and June 2014	Prospective Cohort	A: Usual care, travel to Miami facility B: Telehealth
Kobza, 2000	NR	December 1998 to February 2000	Before-After	A: Usual care B: Telehealth
Krier, 2011	Palo Alto, California USA	NR	RCT	A: Usual care B: Telehealth
Krupinski, 2004	Tucson, Arizona USA	1999 to 2002	Retrospective Cohort	A: Cases that were referred to dermatology and seen in person B: Teledermatology referrals
Kunkler, 2007	Edinburgh, Scotland United Kindom	March 2004 to April 2005	RCT	A: In-person meetings B: Telehealth linkage to breast specialists in a cancer center

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Lamminen, 2001	Finland	September 1996 to May 1997	Economic Evaluation	A 1: Conventional consultations - Ophthalmology A 2: Conventional - Dermatology B 1: Teleophthalmology B 2: Teledermatology
Lee, 2014	USA	April 2011 to 2013	Prospective Cohort	A: 6 months before E-consult program started B: 6 months beginning one year after E-consult program started
Lim, 2012	Waikato New Zealand	8 month period	Prospective Cohort	A: Face-to-face B: Telehealth
Loane, 2000	Northern Ireland	12 month period Dates NR	RCT	A: Usual care B: Telehealth video C: Telehealth store and forward
Loane, 1999	Northern Ireland United Kingdom	9 months Dates not specified	RCT	A: Traditional hospital consultation B: Teledermatology consultation
Loane, 2001	New Zealand	10 months Dates not specified	Economic Evaluation	A: Traditional hospital appointment B: Teledermatology appointment
Long, 2014	Arkansas USA	2001 to 2007	Retrospective Cohort	A: Before telehealth service available B. After telehealth service available (numbers not reported for which ultrasounds were via telehealth vs conventional)
Mahendran, 2005	England	18-month period, dates not specified	Pre/Post	A: Face-to-face consultation with dermatologist B: Store and forward, image consultation with dermatologist

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
McCrossan, 2012	Northern Ireland United Kingdom	20 months Dates not specified	Prospective Cohort	A: Hospital without remote fetal echocardiograms B: Hospital with tele fetal echocardiograms
Moreno-Ramirez, 2009	Spain	2004 to 2005	Economic Evaluation	A: Conventional care B: Teledermatology
Mulgrew, 2011	California USA	October 2008 to December 2009	Prospective Cohort	A. Face-to-face B: Telehealth
Nickenig, 2008	Germany	July 2003 to July 2005	Prospective Cohort	A: Conventional care B: Telehealth
Nikkanen, 2008	Oulu Arc Sub region Finland	10 to 14 months, 2005	Pre/Post	A: First visit to telehealth supported system B: Follow-up visit to telehealth supported system
Nordal, 2001	Norway	1994-1995	Retrospective Cohort	A1: Patients with a GP were seen by one dermatologist over the video-link. A2: Patients with a GP were seen by one dermatologist face-to-face.
Ohinmaa Same patients as Vuolio and Haukipuro, 2002	Finland	NR	RCT; Economic Evaluation	A: Conventional outpatient visits B: Video-conferencing
Pak, 2009; Pak, 2007	Texas USA	NR	RCT; Economic Evaluation	A: Usual care B: Teledermatology consultation
Piette, 2017	Paris France	February and June 2014	RCT	A: Usual care B: Telehealth
Rossaro, 2013	California USA	2006 to 2010	Retrospective Cohort	A: HCV treatment at the University of California Davis Hepatology Clinic B: HCV treatment at different telehealth sites
Salami, 2015	USA	2009 to 2013	Retrospective Cohort	A: Patients evaluated through standard interfacility consultation. B: Patients evaluated through the Virtual Tumor Board
Salazar-Fernandez, 2012	Seville Spain	January 2008 to February 2010	Prospective Cohort	A: Conventional systems B: Store and Forward

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Santamaria, 2004	Kimberly Australia	October 2002 to October 2003	RCT	A: Standard wound care B: Telehealth
Scuffham, 2002	United Kingdom	June 2000 to May 2001	Economic Evaluation	A: Outreach visits B: Face-to-face at hospital C: Telehealth
Sharma, 2003	New York USA	May 1998 to August 1998	Retrospective Cohort	A: Pregnant women undergoing in-person fetal echocardiograms who were referred from outlying primary care center. B. Pregnant women undergoing fetal echocardiograms via telehealth at their local hospital.
Smith, 2002	Queensland Australia	November 2000 to January 2002	Before-After	A: Before pediatric telehealth B: After pediatric telehealth
Smith-Strom, 2018	Norway	2012 to 2016	RCT	A: Usual care B: Telehealth
Specht, 2001	Iowa USA	NR	Economic Evaluation	A: In-person visit at an acute care facility for a wound care specialist visit B: Telehealth consultation with a wound care specialist at an acute care facility.
Stalfors, 2003	Sweden	September 1998 to September 1999	Prospective Cohort	A: Face-to-face patient presentation at tumor meeting B: Telehealth patient presentation at tumor meeting
Stalfors, 2005	Sweden	September 1998 to September 1999	Economic Evaluation	A: Face-to-face consultation B: Telehealth
Stern, 2014	Ontario Canada	17 months	Before-After (stepped wedge)	A: Not telehealth B: Enhanced multidisciplinary team supported by telehealth
Strymish, 2017	Boston, Massachusetts USA	2014	Before-After	A: Face-to-face B: Telehealth
Taylor, 2007	Nashville, Tennessee USA	September 2003to August 2004	Before-After	A: Referral for exam B: Digital screen

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Thaker, 2013	Queensland Australia	March 1 2007 to November 30 2011	Economic Evaluation	A: Model generated usual care costs B: Cost of patients managed by telehealth system
Tsitlakidis, 2005	Lemnos and Skyros Greece	October 2002 to October 2003	Economic Evaluation	A: Hospital referrals (to Athens) B: Telehealth
Tuulonen, 1999	Oulu Finland	February 1998 to May 1998	Before-After	A: Conventional outpatient visit B: Telehealth
van der Pol, 2010	Scotland, Shetland Islands and Aberdeen United Kingdom	2007	Economic Evaluation	A: Mainland endoscopy clinic B: Tele-endoscopy clinic
Van Gelder, 2017	Netherlands	March 2001 to June 2012	RCT	A: Usual care B: Telehealth
Vuolio Same patients as Ohinmaa and Hakipuro, 2003	Finland	February 1997 to June 1998	RCT; Economic Evaluation	A: Outpatient clinic B: Videoconference
Wallace, 2002	United Kingdom	1999 to NR	RCT	A: Standard outpatient specialist visit B: Virtual visit between patient, general practitioner, and specialist
Wallace, 2004	United Kingdom	NR	RCT	A: Usual care B: Virtual outreach group
Whited, 2002	Durham, North Carolina USA	NR	RCT; Economic Evaluation	A: Usual care (text-based electronic consult request) B: Teledermatology consultation (digital images and a standardized history, in addition to the text-based electronic consult)
Whited, 2003	Durham, North Carolina USA	2001	RCT; Economic Evaluation	A: Usual care B: Telehealth

Author, Year (See Appendix C for full citation)	**Geographic Location of Studies**	**Study Period**	**Study Design**	**Comparison and Intervention**
Whited, 2004	Durham, North Carolina USA	NR	RCT; Economic Evaluation	A: Usual care (text-based electronic consult) B: Teledermatology consultation (digital images and a standardized history, in addition to the text-based electronic consult)
Whited, 2013a, 2013b	USA	2008 to 2011	RCT	A: Conventional care B: Teledermatology
Wilson, 2005	Phoenix, Arizona USA	1999 to 2003	Retrospective Cohort	A: Before telehealth B: After telehealth
Xu, 2008	Queensland Australia	November 2000 to January 2002	Economic Evaluation	A: Conventional outpatient ENT consultation B: Tele-ENT service
Young, 2014	Chicago, Illinois USA	July 2009 to June 2012	Before-After	A: Before telehealth B: After telehealth
Zahlmann, 2002	Germany	NR	Prospective and Retrospective Cohort	A: Normal treatment B: Teleconsultation
Zarchi, 2015	Denmark	February 2011 to September 2012	Prospective Cohort	A: Wound care without telehealth B: Wound care with telehealth
Zilliacus, 2011	New South Wales and Australia	December 2007 to December 2009	Prospective Cohort	A: Face-to-face B: Telehealth

ANGELS = Antenatal and Neonatal Guidelines, Education and Learning System; CPT = cognitive processing therapy; ECHO = Extension for Community Healthcare Outcomes; ENT = ear, nose, throat specialist (otorhinolaryngologist); GP = general practitioner; HCV = hepatitis C virus; NR = not reported; RCT = randomized control trial; SCAN-ECHO = Specialty Care Access Network-Extension for Community Healthcare Outcomes

See Appendix C. Included Studies for full citations

Table F-8. Outpatient evidence table: patient characteristics

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Angstman, 2009	728 A: 500 B: 228	Adults	General practitioners	Not specified	A: Yes B: No	Outpatient	Electronic health documentation, test results	Mixed
Arora, 2011	407 A: 146 B: 261	Adults between 18-65 with HCV	Primary care	Hepatology, infectious diseases, psychiatry, and pharmacology	No	Outpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Bagayoko, 2014	211 A: NR B: NR	Rural	NR	Obstetrics and cardiology	Yes	Outpatient	EKG and obstetric ultrasounds transmitted via laptops with low bandwidth internet connection	Asynchronous
Baig, 2016	Unclear A: Unclear B: Unclear	Adults	Primary care physician	Sleep specialist	No	Outpatient	E-Consult	Asynchronous
Basudev, 2016	167 A: 88 B: 79	Adult	Primary care	Diabetes specialist	No	Outpatient	NR	Real-time
Bernstein, 2010	2,663 A: 2,196 B: 285 C: 182	People age 17 to 70+, mean age 59.1 years. 56% male. 65% Caucasian, 28% aboriginal. 50% diabetic nephropathy, though higher rates of DN in local communities. 5-year mortality 56%	Primary care	Nephrology team	No	Outpatient	Record/flowsheet review	Real-time
Beswick, 2016	41 A: 26 B: 15	Adults	Nurse and speech pathologist	Head and neck surgeon	Yes	Outpatient	Audiovisual teleconference	Real-time
Bezalel, 2015	3,065 A: 1,557 new patients B: 1,508 new patients n for established patients NR	Adults (VA patients)	NR	Dermatologist	No	Outpatient	Unclear/NR	Asynchronous
Blackwell, 1997	579 A:315 B: 264; 24 received telehealth	NR	Emergency department director	Ophthalmology specialist	Yes	ED	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Boman, 2014	38 A: 19 B: 19	Adults	General practitioner	Cardiologist	Yes	Outpatient	Store and forward (history, ECG) and "bidirectional communication" (likely videoconference)	Mixed
Britt, 2006	NR	Rural; Women with high-risk pregnancies	NR	Maternal-fetal medicine specialists and associated residents	Unclear	Inpatient for transports and hospital days Outpatient for consultations	NR - videoconference, presumably	Real-time
Brown-Connolly, 2002	741 A: NR B: NR	Adults and Pediatrics	Primary care	Various	Yes	Outpatient	NR	Real-time
Burns, 2017	82 A: 39 B: 43	Adult	Regional speech pathologist	Hospital speech pathologist	Yes	Outpatient	Videoconference	Real-time
Byamba, 2015	450 A: 229 B: 221	Rural patients	General practitioner	Dermatologist	No	Outpatient	Clinical notes and pictures	Asynchronous
Carallo, 2015	312 A: 208 B: 104	Adults with type II diabetes, without major cardiovascular disease	Primary care	Diabetes	Unclear	Outpatient	Electronic health record	Asynchronous
Carter, 2017	252 A: 173 B: 79	Adults	Primary care physician	Dermatology	Yes	Outpatient	Electronic health record	Asynchronous
Chan, 2015	206 A: 117 B: 89	rural	General physician	Oncologist	Yes	Outpatient	Videoconference	Real-time
Chu, 2015	97 A: NR B: NR	Veterans	Primary care	Urology	Yes	Outpatient	Videoconference	Real-time
Chua, 2001	141 A: 65 B: 76	Adult	Primary care physician	Neurologist	Yes	Outpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Collins, 2004; Bowns, 2006	208 A: 97 B: 111	Adults 16 or older, with no diagnoses of dermatological or mental health problems	General practitioner	Dermatology	No	Outpatient	Not specified	Asynchronous
Crossland, 2016	1,024 A: 577 B: 447	Adults	General practitioners	Ophthalmologists	Unclear	Outpatient	Teleconferences and/or email	Unclear
Datta, 2015	391 A: 196 B: 195	Adults	Primary care physician	Dermatologist		Outpatient	Records and images	Asynchronous
Davis, 2011	360 A: 200 B:160	Veterans (adults) 75% white; >80% male	Not specified	Nurse, pharmacist, psychiatrist	No	Outpatient	Videoconference	Real-time
Davison, 2004	112 A: 50 B: 62	Adults	Chest medicine lung cancer clinical nurse	Thoracic surgeon and radiologist	No	Outpatient	Video	Real-time
De Luca, 2005	3,934 A: 1,985 B: 1,949	Adults	Primary care	Cardiologist	Yes	Outpatient	Internet based digital network	Asynchronous
Doolittle, 1997	NR A: 81 B: NR C: 103	NR	NR	Oncologist	Yes	Outpatient	Videoconference	Real-time
Dowie, 2007	504 A: 387 B: 117	Pregnant women and pediatric	Unclear	Cardiologist	Yes and no	Outpatient	Videoconference	Mixed
Eminovic, 2009, 2010	605 A: 304 B: 301	Pediatric and adult patients	General practitioner	Dermatology	Yes	Outpatient	Digital camera and website	Asynchronous
Endean, 2001	32 A: 32 B: 32	Adults	NR	Vascular specialist	Yes	Outpatient	Videoconference	Real-time
Ferrandiz, 2007	134 A: NR B: NR	Adults	Primary care	Dermatologist	Unclear	Outpatient	Digital pictures inserted into Word document containing other clinical information. Document sent via intranet to email account of skin cancer clinic.	Asynchronous

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Fortney, 2013	364 A: 185 B: 179	Adults, majority low income, rural	Primary care	Pharmacy, psychology, psychiatry, care management	Sometimes	Outpatient	Telephone, videoconference	Real-time
Fortney, 2007	395 A: 218 B: 177	Adults, majority older white men	Primary care	Psychiatry	Yes	Outpatient	Phone, medical records, video	Real-time
Fortney, 2011	395 A: 218 B: 177	Adults	Primary care provider	Psychiatrists	Yes	Outpatient	Mixed (interactive video, telephone)	Real-time
Fortney, 2015	265 A: 132 B: 133	Veterans, mostly male	PTSD providers in CBOCs were recruited as were patients with PTSD diagnoses	Telepsychiatrists, telephone nurse care manager	Yes	Outpatient	Telephone for care managers and pharmacist. Psychotherapy and psychiatric consultation via videoconference. Care managers also used web based decision support system.	Real-time
Fox, 2007	706 A: 173 B: 257 C: 276	Adolescents in state correctional facilities	General nurse	Multiple	Yes	Other (correctional facility)	Videoconference	Real-time
Frank, 2015	322,059 A: 299,981 B: 22,454	Adult VA patients with pain that have an established primary care provider at the VA	Primary care provider	Pain specialist	No	Outpatient	Videoconference	Real-time
Gattas, 2001	62 A: 23 (8 providers, 8 counselors, 5 patients) B: 44 (16 providers, 16 counselors, 12 patients)	NR	Genetic counselor	Genetics	Yes	Outpatient	Videoconference	Real-time
Gilmour, 1998	126 A: NR B: NR	Pediatrics and adults	General practitioner	Dermatologist	Yes	Outpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Harno, 2000	292 A: 85 B: 207	Adults	Primary care	Various hospital outpatient specialties	No	Outpatient	Electronic referral system; referrals transferred by intranet to electronic mail boxes in the hospital information system; video-networking in separate study.	Asynchronous
Harno, 2001	225 A: 168 B: 57	Adults	Unclear	Orthopedics	Yes	Outpatient	Email Videoconference	Real-time
Haukipuro same pts as Ohinmaa and Vuolio, 2000	145 A: 69 B: 76	Adult	General practitioner	Orthopedics	Yes	Outpatient	Videoconference	Real-time
Herce, 2011	2,647 A: 2,550 B: 97	Adult	Primary care dentist	Oral surgeon	No	Outpatient	Digital images	Asynchronous
Hsiao, 2008	169 A: 77 B: 92	Veterans seen in the San Francisco VA or outlying VA clinics	Primary care provider	Dermatology	No	Outpatient	Electronic consult through a shared medical record system.	Asynchronous
Izquierdo, 2009	41 A: 18 B: 23	Kindergarten through eighth grade	School nurse	Diabetes nurse practitioner	Yes	Outpatient (School)	Videoconference	Real-time
Jaatinen, 2002	78 A: 24 B: 54	Adults	General practitioners	Internists, surgeons, geriatricians	Unclear	Outpatient	Web-based system	Asynchronous
Jacklin, 2003 Same study as Wallace 2002, 2004	1,939 A: 971 B: 968	Not clearly defined in this paper, refer to another previous paper, essentially any patient that met inclusion criteria not defined in this paper, that needed a consultation	General practitioner	Not specified, seems like any consultation	Yes	Outpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	Number Analyzed[a]	Population	Referring Providers Specialty/Type	Consulting Provider Specialty/Type	Patient Present?	Patient Setting	Modalities of Telehealth Consultation Intervention	Timing
Jacobs, 2015	794 A: 312 B: 482	All patients who visited GP with trauma related to the musculoskeletal system	General practitioner	Radiologist and surgeon	No	ED/EMS: Urgent visit to GP office acting as ED	Data transfer: digital x-rays	Asynchronous
Jong, 2004	12 A: 2 B: 4 C: 6 For cost outcomes, patient sample size NR	NR	Primary care	Rheumatology	Not always	Outpatient	Videoconference	Real-time
Jue, 2017	296 A: Same patients B: 296	Adults	Nurse practitioner	Surgical oncologist	Yes	Outpatient	Videoconference	Real-time
Kobza, 2000	196 A: 120 B: 76	Adults	Home health nurse	Wound care specialist	Yes	Home	Videoconference	Real-time
Krier, 2011	34 A: 19 B: 15	Adults	Gastroenterology fellows	Gastroenterology and endoscopy specialist	Yes	Outpatient	Videoconference	Real-time
Krupinski, 2004	100 A: 50 B: 50	Rural patients referred for dermatology consult	Primary care provider	Dermatology	No	Outpatient	Records and images	Asynchronous
Kunkler, 2007	473 A: 195 B: 278	Predominantly rural	NR	Consultant breast surgeons, medical and clinical oncologists, radiologists, pathologists, and breast care nurses	No	Outpatient	Viewing of mammograms, CT scans and pathology as well as videoconferencing	Real-time
Lamminen, 2001	191 A: 85 B: 64 C: 24 D:18	NR	General practitioner	Ophthalmology and dermatology	Yes	Outpatient	Videoconference	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Lee, 2014	3,081 A: NR B: NR	Adults	Primary care	Osteology	No	Outpatient	Laboratory data, clinical risk factors, prior treatment, electronic notes	Asynchronous
Lim, 2012	300 A: 100 B: 200	Pediatric/adults	General practitioner	Dermatologist	No	Outpatient	Secure server	Asynchronous
Loane, 2000	204 A: 102 B: 102 Video C: 96 (96 of the 102 were also store and forward)	Pediatric and adults	Primary care physician	Dermatologist	Yes	Outpatient	Video	Mixed
Loane, 1999	164 A: 103 B: 61	Adults and children (range: 3 months to 84 years; mean age 42 years)	General practitioners	Dermatologist	Yes	Outpatient	Low-cost videoconferencing units (VC7000, British Telecom)	Real-time
Loane, 2001	203 A: 94 B: 109	Adults and children (range: 3 months to 84 years; mean age 42 years)	General practitioners	Dermatologist	Yes	Outpatient	Low-cost personal computers with videoconferencing; video cameras to transmit close-up images of skin lesions.	Real-time
Long, 2014	NR A: NR B: NR	Maternal Medicaid population	Community providers	Maternal fetal medicine specialists (maternal fetal medicine nurses staff 24/7 call center)	Yes for some ultrasounds, but not clear on how many.	Outpatient	Six-fold telehealth model - includes education and training for providers, 24/7 call center for support, telehealth network, clinical research, case management and evidence based guidelines and protocols.	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Mahendran, 2005	163 A: 163 B: 163; same as group A	Any patient with suspicious skin lesion presenting to their GP during a specified 18 months period.	General practitioner	Dermatology	No	Outpatient	Store and forward: records	Asynchronous
McCrossan, 2012	66 A: NR B: NR	Pregnant women, 31.3 years (range = 17.1 to 40.8 years) Neonates, 23 weeks (range = 21 to 26 weeks)	NR	Fetal cardiologist	Yes	Outpatient	Mixed	Real-time
Moreno-Ramirez, 2009	4,018 A: 2,009 B: 2,009	NR	General practitioner	Dermatologist	Yes	Outpatient	Digital Camera and Intranet	Asynchronous
Mulgrew, 2011	25 A: 15 B: 10	Pediatric	Primary care physician	Pediatrician specializing in weight management	Yes	Outpatient	Videoconference	Real-time
Nickenig, 2008	857 A: 772 B: 85	NR	Dentist	Implant Specialist	No	Outpatient	Videoconference	Real-time
Nikkanen, 2008	101 A: 101 B: 101 (same as A)	Adults	Diabetes	Diabetes		Outpatient	Videoconference, electronic records, electronic stethoscope	Real-time
Nordal, 2001	121 A1: NR A2: NR	Adult men and women (aged 17-82 years)	University Hospital of Tromsø	Dermatologist	Yes	Outpatient	Videoconference	Real-time
Ohinmaa Same patients as Vuolio and Haukipuro, 2002	145 A: 69 B: 76	Adults	General practitioner	Orthopedics	Yes	Outpatient	Videoconference	Real-time
Pak, 2009; Pak, 2007	508 A: 236 B: 272	Adult (≥18 years old) who were referred from the Department of Defense	Clinician	Dermatologist	No	Outpatient	Store and forward: records	Asynchronous
Piette, 2017	103 A: 50 B: 53	Adults	General practitioner	Dermatology	No	Outpatient	Email	Asynchronous

Author, Year (See Appendix C for full citation)	Number Analyzed[a]	Population	Referring Providers Specialty/Type	Consulting Provider Specialty/Type	Patient Present?	Patient Setting	Modalities of Telehealth Consultation Intervention	Timing
Rossaro, 2013	80 A: 40 B: 40	Adults	Primary care	Hepatologist	No	Outpatient	Videoconference	Real-time
Salami, 2015	116 A: 68 B: 48	Adult men	Oncology, gastroenterology, hepatology, surgery, other	Radiology, gastroenterology, hepatology, transplantation, surgical oncology, medical oncology, radiology	Not specified	Outpatient	VA electronic medical record, audiovisual teleconferencing	Real-time
Salazar-Fernandez, 2012	1,052 A: 710 B: 342	Adults	Dentist	Oral and maxillofacial	Yes	Outpatient	Store and forward	Asynchronous
Santamaria, 2004	93 A: 43 B: 50	Adults	Wound care nurses	Wound care consultant	No	Outpatient	Imaging system	Asynchronous
Scuffham, 2002	25 A: NR B: NR C: NR	Adults	General dentist	Specialist dentist	Yes	Outpatient	Videoconference	Real-time
Sharma, 2003	229 A: 195 B: 34	Adults aged 25-89	NR	Staff echocardiographer, pediatric cardiology fellow	Yes	Primary care center	Live screening of echocardiogram transmitted via data transmission	Real-time
Smith, 2002	387 A: NR B: NR	Children	Pediatricians	Physicians in subspecialty fields including burns, cardiology, dermatology, diabetes, endocrinology, neurology, nephrology, oncology, orthopedics and respiratory medicine	Unclear	Outpatient	Videoconference, email, fax, telephone	Real-time
Smith-Strom, 2018	182 A: 88 B: 94	Adult	Community nurses	Specialist nurse	Yes	Outpatient	Web-based record and mobile phone	Asynchronous
Specht, 2001	NR A: NR B: NR	Adults in a long term care facility.	Primary nurse and/or skin care nurse at the LTC	Chronic wound nurse expert	Yes	Long term care facility	Video using Teledoc 5000	Asynchronous

Author, Year (See Appendix C for full citation)	**Number Analyzed[a]**	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Stalfors, 2003	104 (completed patient satisfaction survey) A: 46 (39) B: 58 (45)	Not specified	Ear nose and throat surgeon	Multiple specialties	Yes	Outpatient	Videoconference, still images	Real-time
Stalfors, 2005	118 A: 50 B: 68	Patients with head and neck cancers that are discussed in the multidisciplinary team meeting	NR	Multidisciplinary team	Yes	Outpatient	Videoconference	Real-time
Stern, 2014	Total wounds analyzed: 259 among 137 LTC residents	Long term care facilities with >100 beds in Toronto Central and Central LHINs with pressure ulcer prevalence >5.5%	Unclear	Skin and wound care, plastic surgeon, occupational therapist, chiropodist	Unclear	Long term care facility	Email, telephone, data	Asynchronous
Strymish, 2017	480 A: 195 B: 285	Adults	NR	Specialist	No	Unclear	e-consult	Asynchronous
Taylor, 2007	495 A: 294 B: 201	Adults	Primary care physician	Expert technical graders	No	Outpatient	Digital images	Asynchronous
Thaker, 2013	NR A: NR B: 147	Not specified	Not specified	Oncologist	Yes, local physician not always present	Outpatient	Videoconference	Real-time
Tsitlakidis, 2005	38 A: NR B: NR	Children and adults (majority of patients were between 20 and 30 years of age)	Officers with medical background, conscripts with medical background (not yet specialized), flight surgeons, general medical staff	NR	Yes	Outpatient	PC-based ISDN videoconferencing	Real-time

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Tuulonen, 1999	70 A: 41 B: 29	Adults	General practitioner	Ophthalmology	Yes	Outpatient	Videoconference	Real-time
van der Pol, 2010	90 A: NR B: NR	Adults	Anesthesiologist or surgeon	Endoscopy specialist	Yes	Outpatient	Videoconference	Real-time
Van Gelder, 2017	3,004 A: 1,727 B: 1,277	Adult	General practitioner	Nephrologist	No	Outpatient	Electronic health record	Asynchronous
Vuolio Same patients as Ohinmaa and Hakipuro, 2003	145 A: 69 B: 76	Adults	General practitioner	Orthopedics	Yes	Outpatient	Videoconference	Real-time
Wallace, 2002	1,939 A: 971 B: 968 155 post-randomization exclusions	Adults & Pediatrics in London (urban) and Shrewsbury (rural)	General practitioner	Multiple: orthopedics, urology, ENT, gastroenterology and other medical specialists	Present	Outpatient (Primary Care)	PC-based video	Real-time
Wallace, 2004	1,939 A: 971 B: 968	Not specified	General practice	Multiple specialties	Yes	Outpatient	Videoconference	Real-time
Whited, 2002	275 A: 140 B: 135	Adults	General medicine, internal medicine, women's health	Dermatology	Unclear	Outpatient	Mixed (images, standardized history, standardized consult)	Asynchronous
Whited, 2003	275 A: 140 B: 135	Adults	Primary care physician	Dermatologist	No	Outpatient	Digital records	Asynchronous
Whited, 2004	Clinicians: 91 A: 53 B: 38 Patients: 275 A: 140 B: 135	Adults	Primary care	Dermatology	Yes	Outpatient	Mixed (images, standardized history, standardized consult)	Asynchronous

Author, Year (See Appendix C for full citation)	**Number Analyzed**[a]	**Population**	**Referring Providers Specialty/Type**	**Consulting Provider Specialty/Type**	**Patient Present?**	**Patient Setting**	**Modalities of Telehealth Consultation Intervention**	**Timing**
Whited, 2013a, 2013b	Randomized: 391 A: 196 B: 195 Analyzed: 261 A: 136 B: 125	Adults, 97.5% men	Primary care	Dermatology	No	Outpatient	Store and forward electronic medical record, digital images, text	Asynchronous
Wilson, 2005	6,978 A: 2,910 B: 4,068	Adults	Primary care physician	Image reading Center	No	Outpatient	Digital images	Asynchronous
Xu, 2008	265 A: 177 B: 88	Pediatric	Pediatricians and other physicians	ENT specialists	No	Outpatient	Videoconference	Real-time
Young, 2014	1,201 A: 514 B: 687	Adult inmates	Correctional nurse	Infectious disease physician	Yes	Prison	Videoconference	Real-time
Zahlmann, 2002	62 A: 20 B: 42	Adults	General practitioner	Ophthalmology	Yes	Outpatient	Videoconference	Mixed
Zarchi, 2015	90 A: 40 B: 50	Chronic wound patients in home care	Home-care nurses	Hospital-based wound-expert teams	NR	Outpatient	Store and forward	Asynchronous
Zilliacus, 2011	195 A: 89 B: 106 Completed questionnaires	Adult women	Genetic counselor	Genetic specialist	Yes	Outpatient	Videoconference	Real-time

CBOC = community-based outpatient clinics; CT = computed tomography; DN = diabetic nephropathy; E-consult = electronic consultations; ECG = electrocardiogram; ED = emergency department; EKG = electrocardiogram; EMS = emergency medical services; ENT = ear, nose, throat specialist (otorhinolaryngologist); GP = general practitioner; HCV = hepatitis C virus; LHIN = Local Health Integration Networks; LTC = long-term care; NR = not reported; PTSD = post-traumatic stress disorder; VA = Veteran's Affairs

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-7

See Appendix C. Included Studies for full citations

Table F-9. Outpatient evidence table: results

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Angstman, 2009	Unscheduled return visit to primary care within 2 weeks, any reason n (percent), p-value A: 138 (27.6) B: 87 (38.2), p<0.01 OR (95% CI) 1.88 (1.33 to 2.66), p≤0.01 No return visit within 2 weeks, any reason: A: 362 (72.4) B: 141 (61.8), p<0.01 Unscheduled return visit to primary care within 2 weeks, same reason A: 98 (19.6) B: 46 (20.2), p=0.86 OR (95%CI) 1.18 (0.79 to 1.76), p=0.43 No return visit within 2 weeks for the same reason: A: 402 (80.4) B: 182 (79.8), p=0.86	NR	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Arora, 2011	Sustained virologic response according to genotype and site of treatment Number of patients with response/total number (%) All genotypes A: 84/146 (57.5) B: 152/261 (58.2) Genotype 1 A: 38/83 (45.8) B: 73/147 (49.7) Genotype 2 or 3 A: 42/59 (71.2) B: 78/112 (69.6) Difference between ECHO sites and UNM HCV clinic Percentage points (95% CI) All genotypes: 0.7 (-9.2 to 10.7), p=0.89 Genotype 1: 3.9 (-9.5 to 17.0), p=0.57 Genotype 2 or 3: -1.5 (-15.2 to 13.3), p=0.83 OR for sustained virologic response in univariate models (95% CI) B vs. A: 1.03 (0.68 to 1.55), p=0.89 AOR for sustained virologic response in multivariate models (95% CI) B vs. A: 1.10 (0.71 to 1.70), p=0.68 ALT (alanine aminotransferase), per 10-unit-per-liter increase: 1.05 (1.01 to 19), p=0.01 White-cell-count, per 1000-cell-per-microliter decrease: 0.86 (0.76 to 0.97), p=0.02 APRI score, per 1-unit increase: 0.43 (0.30 to 0.62), p<0.001 Genotype 1, vs. genotype 2 or 3: 0.40 (0.26 to 0.62), p<0.001	NR	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Bagayoko, 2014	Patient savings, in USD Mean: $25 Maximum: $70 (in a country with a per capita GDP of $1,300 USD per year) Volume: General trend toward more consultations at both project and related sites but greater rate of attendance at telehealth sites. Rate of attendance A: 44.9% B: 79.8% Telehealth tools accounted for an increase in attendance at the following project centers: 35% in Dioila District Hospital, 10% in Bankass, and 8% in Kolokani and Djenne.	Diagnostic concordance, whether the initial diagnosis made by the physician changed after tests or answer from expert; out of 103 total cases: Little changed=6 cases Not changed at all=26 cases Changed completely, a lot, or moderately=73 cases Whether tests or input from remote expert had modified treatment (of 211 total cases): No change=3 cases Little change=5 cases Moderate or complete change=203 cases	NR
Baig, 2016	NR	Sleep consults per year A: 150 B: 1,851 Number of sleep studies A: 282 B: 833 Wait time for positive airway pressure prescription, in days A: ≧ 60 B: ≦ 7	NR
Basudev, 2016	NR	Glycemic control HbA1c, in mmol/mol (difference ± SD) A: 10 (0.8 ±1.9%) B: 8 (0.6 ±1.7%), p=0.4 Mean reduction in systolic blood pressure ± SD, in mmHg A: 2 ±18 B: 6 ±16, p=0.008	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Bernstein, 2010	2- to 5-year survival, HR B1 vs A: 0.67, p<0.001 B2 vs. A: 0.72, p<0.05 Diabetic nephropathy, HR B1 vs A: 0.63, p<0.001 B2 vs. A: 0.63, p<0.01 Other diagnoses not or marginally significant	NR	NR
Beswick, 2016	NR	Mean time from initial referral to evaluation (range), in days A: 21 (6 to 61) B: 18 (6 to 53) Mean time from evaluation to surgery (range), in days A: 28 (0 to 55) B 48 (11 to 101) Mean time from referral to surgery (range), in days A: 49 (22 to 83) B: 54 (17 to 108)	NR
Bezalel, 2015	NR	New patient wait times, in days A: 32.9 B: 9.75, p<0.001 Established patient wait times, in days A: 4.14 B: 1.49, p=0.37 Correlation between quantity of telehealth consultations completed and percentage of new patients seen at main dermatology clinic within 30 days: R^2=0.88, p<0.05 Correlation between quantity of telehealth consultations completed and new patient wait times: R^2=0.95, p<0.001 Correlation between quantity of telehealth consultations completed and established patient wait times: R^2=0.10, p=0.36	NR
Blackwell, 1997	Savings due to transfer, over 3 months: $6,500	Patients transferred for urgent care A: 17 B: 4	No adverse outcomes were identified

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Boman, 2014	NR	Median total process time, in days A: 114 B: 27, p<0.001 Median time from randomization to attaining a specialist consultation, in days A: 86 B: 12, p<0.001 Clinical examination to GP signs off the results, in days A: 6 B: 5, p=0.35 Favorable response to telehealth and found comparable to standard care: 89% (17/19) of patients Satisfied with information provided in remote consultation: 100% of patients Felt they had received faster care compared to standard care and felt that telehealth was superior: 95%	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Britt, 2006	Mean number of maternal transports to UAMS A: 278 B: 237 Mean LOS per maternal transport (SD), in days A: 8.02 (10.38) B: 6.06 (7.32), p=0.003	Mean number of remote consultations (phone and fax system existed prior to program) A: 108 B: 269, p=0.01 Mean number of phone consultations: A: 55 B:107, p=0.03 Mean number of phone consults between doctors: A: 55 B: 107, p=0.03 Total doctors involved in weekly case discussions: A: 33 B: 98, p=NR Mean number of doctors involved in weekly case discussions (SD) A: 4.33 (1.5) B: 8.58 (4.17) Different doctors participating in teleconsultations: A: 22 B: 36, NS Different counties participating in teleconsultations: A: 12 B: 28, p=0.04	
Brown-Connolly, 2002	NR	Distance to specialist, in km A: 195 B: 27 Difference: -168 km, p<0.05 Travel time, in minutes A: 156 B: 26 Difference: -130 minutes, NS 90% would use telehealth again 91% telehealth made it easier to get services 39% would get better care in person	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Burns, 2017	NR	Mean response to management (SD, range), in days A: 3.20 (3.74, 0 to 11) B: 3.12 (3.44, 0 to 14) p=0.928 Clinician satisfaction reached statistical significance for all parameters assessed in favor of telehealth	NR
Byamba, 2015	Patient travel expense, in USD (n) A: $3,174 (28) B: $320 (7) Reduction in costs $76.36 per patient Variety of diagnosis: A: 4 diagnoses B: 12 diagnoses, p=0.03 Hospital referrals, n (%) A: 28 (12.2%) B: 7 (3.1%) p<0.01	Time to receive care, in hours A: 322 B: 53	NR
Carallo, 2015	Changes in diabetic profile: HbA1c mmol/mol from baseline to followup ± SD A: No change B: 58 ± 6 decreased to 54 ± 8 p=0.01 LDL cholesterol mg/dL from baseline to followup ± SD A: 107.5 ± 40.6 to 98.3 ± 37.7, p=0.01 B: 101.7 ± 36.9 to 90.3 ± 34.4, p=0.001 BMI kg/m^2 from baseline to followup ± SD A: No change B: 31.0 ± 4.8 to 30.5 ± 4.6, p=0.03 No difference between groups: Blood pressures Triglycerides Waist size	Access to specialist Mean number of visits ± SD A: 1.3 ± 1.5 B: 0.6 ± 0.9, p<0.0001 Mean duration of visit ± SD, in minutes A: 24 ± 11 B: 7 ± 3	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Carter, 2017	NR	Median time to evaluation, in days A: 70.0 B: 0.5 Median time to treatment, in days A: 73.5 B: 3.0	NR
Chan, 2015	No toxicity related deaths in either group. Inpatient hospital admissions A: 35.3% B: 28%	NR	Rate of serious side effects A: 9.5% B: 4.4% Side effects include: Neutropenia A: 18% B: 29% Nausea and vomiting A; 1.7% B: 0 Diarrhea A: 6.9% B: 1.1% Neuropathy A: 1.7% B: 3.3% Fatigue A: 4.3% B: 0 Other A: 26% B: 16% Hospital admissions A: 43% B: 36%
Chu, 2015	Estimated savings, in USD Expenses: $67 Lost opportunity cost: $126 Total patient savings 5 hours $193 per visit	Estimated savings Mean distance: 277 miles Mean time: 290 minutes	NR
Chua, 2001	Cost of consultation A: £49 B: £72	Reviews after first consultation A: 14 (22%) B: 22 (29%)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Collins, 2004; Bowns, 2006	NR	Response rate (n) A: 70% (68) B: 72% (80) Satisfaction Overall high and no significant difference Satisfaction with care you received: A: 90% B: 81%, p=0.16 Satisfaction with way skin problem was managed: A: 87% B: 84%, p=0.59	NR
Crossland, 2016	NR	Screening rates: A: 22 to 53% B: 100% Diagnosed with mild-moderate diabetic retinopathy A: 5% B: 9% Appropriate followup recorded A: 29% B: 95%	NR
Datta, 2015	Total mean cost, in USD Societal perspective A: $106,194 B: $89,523 VA perspective A: $66,145 B: $59,917 Mean cost per participant (SD) Societal perspective A: 541 (403) B: 460 (428) Difference (95% CI): -82 (-152 to -12), statistically significant VA perspective A: 338 (291) B: 308 (298) Difference (95% CI): -30 (-79 to 20), NS	Dermatology clinic visits A: 303 B: 214 Mean change in utility score, baseline to month 9 (SD) A: 0.02 (0.18) B: 0.03 (0.19) p=0.50	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Davis, 2011	Regression analysis of variables predicting response to treatment among veterans (N=360) enrolled in a collaborative care program for depression OR (95% CI) Age model 1: 1.03 (0.99 to 1.05) Age model 2: 1.03 (0.99 to 1.05) Male model 1: 1.59 (0.38 to 6.69) Male model 2: 1.57 (0.38 to 6.60) Income category model 1: 1.00 (0.85 to 1.18) Income category model 2: 1.01 (0.86 to 1.20) Intervention model 1: 1.30 (0.68 to 2.50) Intervention model 2: 2.35 (0.25 to 22.31) Racial group status model 1: 0.49 (0.16 to 1.45) Racial group status model 2: 0.48 (0.16 to 1.43) Minority group status by intervention model 1: 6.18 (1.56 to 24.5) p<0.01 Minority group status by intervention model 2: 6.02 (1.48 to 24.30) p<0.01 Prior depression treatment model 1: 0.75 (0.36 to 1.55) Prior depression treatment model 2: 1.32 (0.42 to 4.12) Current depression treatment model 1: 0.80 (0.39 to 1.66) Current depression treatment model 2: 0.59 (0.20 to 1.73) Perceived barriers model 1: 0.96 (0.85 to 1.10) Perceived barriers model 2: 0.97 (0.81 to 1.17) Antidepressants acceptable model 1: 0.76 (0.51 to 1.13) Antidepressants acceptable model 2: 0.78 (0.42 to 1.43) Prior depression treatment by intervention: 0.39 (0.09 to 1.74) Current depression treatment by intervention: 1.64 (0.38 to 6.98) Perceived barriers by intervention: 0.98 (0.76 to 1.27) Antidepressants acceptable by intervention: 0.97 (0.43 to 2.79)	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Davison, 2004	NR	Mean time from first seen in clinic to surgery (SD), in days A: 69 (38) B: 54 (26) p>0.05 Thoracotomy resections, per year A: 14.7 B: 19 Telehealth meetings associated with a 30% increase in resection rate	NR
De Luca, 2005	Reduction in blood pressure (SBP/DBP) A: 4.1 ± 0.4/3.1 B: 7.3 ± 0.4/5.4 ± 0.26 mmHg, p<0.001 Percentage of patients with BP< 140/90 mmHg A: 47% B: 51% , p<0.001 Major cardiovascular events (MACE) A: 4.3% B: 2.9%, p<0.02 Adjusted OR 0.838, (95% CI 0.73 to 0.964, p<0.05) TVCR score A: (baseline) 3.5 ± 0.03 A: (followup) 3.4 ± 0.03, NS B: (baseline) 3.5 ± 0.02 B: (followup) 3.2 ± 0 p<0.01	NR	NR
Doolittle, 1997	Average cost per visit, in USD A: $897 B: $149 C: $812	NR	NR
Dowie, 2007	Mean cost of the initial consult A:£277 B: £411 After 6 month followup A: £2,172 B: £3,350 Nonsignificant	EuroQOL EQ-5D Mean (SD), n A: 0.72 (0.22), 11 B: 0.86 (0.14), 26	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Eminovic, 2009, 2010	Patient recovery at 1 month A: 4.1% B: 20% Preventable consultation A: 18.3% B: 39.0% Difference (95% CI): 20.7% (8.5% to 32.9%)	No significant differences in patient satisfaction were found between groups.	NR
Endean, 2001	NR	Mean evaluation time, in minutes A: 19.0 B: 20.6 Overall concordance, n (%) 29 of 32 (91%) Mean physician satisfaction score with TH consult (7 point scale, 7= highest) 5.71 Mean patient satisfaction score comparing TH to conventional from -1 to 1 (1=better) 0.27	NR
Ferrandiz, 2007	NR	Mean consultation to operation wait time (95% CI), in days A: 60.57 (56.20 to 64.93) B: 26.10 (24.51 to 27.70), p<0.001 Accuracy of telediagnoses: k=0.86 (95% CI 0.83 to 0.89) Agreement rate between surgical technique planned through teleconsultation and technique performed: k=0.75 (95% CI 0.04 to 0.79)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Fortney, 2013	AOR (95% CI), p-value 7.74 (3.94 to 15.20), p<0.0001 Remission 12.69 (4.81 to 33.46), p<0.0001 Adherence 1.22 (0.38 to 3.89), p=0.737 Any specialty mental health visits 0.56 (0.24 to 1.82), p=0.4253 Adjusted incidence rate ratio (95% CI), p-value Primary care visits 1.16 (0.98 to 1.36), p=0.0807 Depression-related primary care visits 0.99 (0.72 to 1.37) p=0.9579	AOR (95% CI), p-value Satisfaction Baseline 1.08 (0.64 to 1.83), p=0.7654 6 months 2.76 (1.50 to 5.01), p=0.0012 12 months 1.99 (1.06 to 3,71), p=0.0313 18 months 1.67 (0.89 to 3.13), p=0.107 Depression severity Adjusted group difference (95% CI) Baseline: -0.04 (-0.18 to 0.10), p=0.5935 6 months: -0.50 (-0.65 to -0.35), p<0.0001 12 months: -0.49 (-0.65 to -0,33), p<0.0001 18 months: -0.33 (-0.49 to -0.18), p<0.0001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Fortney, 2007	OR (95% CI), p-value Depression treatment response: 6 months: 1.94 (1.09 to 3.45), p=0.02 12 months: 1.42 (0.85 to 2.37), p=0.18 Remission: 6 months: 1.79 (0.82 to 3.88), p=0.14 12 months: 2.39 (1.13 to 5.02), p=0.02 Health status indicators: Adjusted group difference (95% CI), p-value Change in PCS: 6 month: 0.31 (-1.61 to 2.24), p=0.75 12 month: 1.09 (-0.94 to 3.12), p=0.29 Change in MCS: 6 month: 2.46 (-0.20 to 5.12), p=0.07 12 month: 3.90 (0.97 to 6.83), p<0.01 Change in quality of wellbeing: 6 months: 0.037 (0.01 to 0.06), p<0.01 12 months: 0.005 (-0.02 to 0.03), p=0.70 Mean depression related total cost (SE), in USD A: 741.20 (85.32) B: 951.83 (99.20), p=0.190 Mean depression related outpatient cost (SE) A: 445.91 (39.73) B: 611.73 (49.55), p=0.046 Mean depression related primary care cost (SE) A: 188.72 (14.76) B: 286.14 (34.20), p=0.013 Depression specialty physical health costs A: 5.05% with nonzero cost B: 1.70% with nonzero cost, p=0.077 Depression mental health costs A: 232.95 (31.10) B: 309.80 (34.23), p=0.034 Depression hospital costs A: 1.83% with nonzero cost B: 2.82% with nonzero cost, p=0.617	OR (95% CI), p-value Medication adherence: 6 months: 2.11 (1.02 to 4.36), p=0.04 12 months: 2.72 (1.36 to 5.44), p<0.01 Treatment satisfaction: 6 months: 1.83 (1.14 to 2.93), p=0.01 12 months: 1.71 (1.06 to 2.77), p=0.03	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Fortney, 2011	Mean total outpatient and inpatient costs (SE), in USD A: 5384.76 (540.79) B: 7469.42 (1366.66) p=0.141	Mean outpatient encounters (SE) A: 18.84 (1.08) B: 22.21 (1.26) p=0.008	NR
Fortney, 2015	Mean point decrease in PTSD symptom severity (measured by Posttraumatic Diagnostic Scale): 6-month followup: A: 1.07 B: 5.32, p< 0.001 12-month followup: A: 1.32 B: 4.17, p=0.02 Controlling for group differences changes in symptoms severity were also significant, B (95% CI), p-value 6 months: -3.81 (-6.19 to -1.43), p=0.002 12 months: -2.49 (-4.9 to -0.08), p=0.04 Mean reduction in depression severity (measured by Hopkins Symptom Checklist), B (95% CI), p-value: 6 months:-0.25 (-0.4 to -0.10), p=0.001 12 months: -0.23 (-0.4 to -0.05), p=0.01 Physical concerns (measured by Physical Component Summary), B (95% CI), p-value: 6 months: 2.67 (0.45 to 4.91) p=0.02 12 Months: 0.97 (-1.09 to 3.03) p=0.35 Attendance at 8 CPT sessions or more predicted improvement in PTSD symptom severity, B (95% CI), p-value: -3.86 (-7.19 to -0.54), p=0.02	AOR (95% CI), p-value Medication PTSD medication prescriptions in first 6 months: Telehealth: 2.98 (1.03 to 8.68), p=0.45 Prazosin prescriptions: 6 months: 2.43 (1.14 to 5.20), p=0.2 12 months: 3.58 (1.71 to 7.48), p<0.001 Adherence to medication: OR (95% CI), p-value 6 months: 0.86 (0.46 to 1.62), p=0.64 12 months: 0.91 (0.47 to 1.78), p=0.79 Cognitive processing therapy (CPT) Percent receiving some cognitive processing therapy: A: 12.1% B: 54.9% Percent attending at least 8 psychotherapy sessions: A: 5.3% B: 27.1% Mean number of CPT sessions attended: A: 0.8 B: 4.2 Risk ratio: 9.51 (95% CI 4.58 to 19.77), p<0.001	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Fox, 2007	Health care utilization: [Estimate, p-value, incidence density ratio (IDR): A vs aggregate 2 years after telehealth] Outpatient visits per center per month (n=144; 4 facilities) Facility 1: 0.86, p<0.001, 2.37 Facility 2: -0.05, p=0.6998, 0.95 Facility 3: 0.33, p=0.0004, 1.39 Facility 4: 1.08, p<0.0001, 2.93 ED visits per center per month (n=144; 4 facilities) Facility 1: 0.26, p=0.2977, 1.30 Facility 2: -0.14, p=0.4203, 0.87 Facility 3: 0.79, p=0.0044, 2.21 Facility 4: 0.90, p=0.1543, 2.45 Inpatient visits per center per month (n=144; 4 facilities) Facility 1: -1.71, p=0.0233, 0.18 Facility 2: 0.17, p=0.8689, 1.19 No visits in baseline year at facilities 3 or 4 Effect of telehealth volume usage on access (n=144) [Estimate, p-value, incidence density ratio (IDR)] Outpatient visits per center per month: 0.02, p<0.0001, 1.0204 ED visits per center per month: -0.05, p<0.0001, 0.9524 Inpatient visits per center per month: -0.04, p=0.1954, 0.9615	Timeliness of care rates: Mean time from referral to psychiatric treatment, in days A: 50.1 B: 24.86 C: 21.59 Time from referral to treatment by facility (n=4 facilities): [hazard ratio, % change in time to referral, p-value: A vs Aggregate 2 years after telehealth] Facility 1: 4.40, 77.27% reduction, p<0.001 Facility 2: 1.09, 8.26% reduction, p=0.622 Facility 3: 2.29, 56.33% reduction, p=0.0006 Facility 4: 0.74, 35.14% increase, p=0.1326	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Frank, 2015	NR	HR (95% CI) Delivery of out-patient care: Physical medicine 1.10 (1.05 to 1.14) Mental health 0.99 (0.93 to 1.05) Substance use disorder 0.93 (0.84 to 1.03) Specialty pain clinics 1.01 (0.94 to 1.08) Medication initiation Anti-depressant 1.09 (1.02 to 1.15) Anticonvulsant 1.13 (1.06 to 1.19) Opioid analgesics 1.05 (0.99 to 1.10)	NR
Gattas, 2001	NR	Patient satisfaction: Communication Ability to maintain eye contact Comfort level of room Satisfaction with clinic format NS No numerical data available Provider satisfaction: Communication: no difference Ability to maintain eye contact: slightly lower Room comfortability: higher Satisfaction with clinic format: no difference Counselor satisfaction: Counselors reported higher satisfaction with face-to-face consultations	NA

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Gilmour, 1998	Diagnosis Agreement 59% Telehealth unable 11% Telehealth missed 6% Telehealth wrong 4% Diagnosis made A: 97% B: 60%, p=0.002 81% management plan correct	NR	NR
Harno, 2000	Variable cost for outpatient visits, in euros: A: € 210.81 B: € 32.06	Volume of referrals, referrals/inhabitants A: 3.8/1000 B: 7.5/1000 Proportion of patients receiving appointments at outpatient clinic: A: 79% B: 43% Proportion of referrals from GP for on-line medical advice responded to by teleconsultation: A: NR B: 78% Patients referred by GP for outpatient visit receiving teleconsultation: A: NR B: 32% Proportion of referrals to Peijas resulting in teleconsultation (by GPs' estimates of urgency of referral) Most urgent (needing treatment within one week): A: NR B: 10% Least urgent (needing treatment > 30 days): A: NR B: 50%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Harno, 2000 (continued)	(continued)	Feasibility of telehealth system rated by specialists at Peijas Hospital (used telehealth): Excellent or good: 67% of the cases studied Bad or very bad: 10% of cases studied Feasibility of telehealth system rated by specialists in Hyvinkaa Hospital (did not use telehealth): Excellent or good:19% of cases studied Bad or very bad: 72% of cases studied Diagnostic effectiveness- proportion of consultations with revisions to diagnoses A: 25% B: 29% Patient satisfaction- wanted next appointed via telehealth: A: 60% B: 80%	(continued)
Harno, 2001	Total cost per patient, in euros A: €154.44 B: €41.22 Outpatient 45% higher Marginal cost decreased €48 for each visit	Mean time, in minutes A: 12 B: 13 Diagnosis revised A: 16% B: 12% Decision to perform surgery A: 38% B: 53%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Haukipuro same pts as Ohinmaa and Vuolio, 2000	NR	Average total time of visit, including travel, in hours A: 8 B: 1.5 Average distance travelled, in km A: 170 B: 8 Success of exam, rated at least good by practitioner A: 99% of cases B: 80% of cases	NR
Herce, 2011	NR	Mean time to surgical wait list (95% CI), in days A: 28 (24.51 to 29.6) B: 3.33 (2 to 4.65), p<0.001 On the day surgery cancellation rate A: 8.85% (5.62 to 11.81%), p<0.005 B: 7.8% (3.8% to 10.5%), p=0.76	NR
Hsiao, 2008	Mean days (SD, 95% CI) To initial evaluation: A: 48 (38, 40 to 57) B: 4 (5, 3 to 5), p<0.0001 To biopsy: A: 57 (52, 45 to 68) B: 38 (41, 30 to 47), p=0.034 To surgery: A: 125 (63, 111 to 140) B: 104 (67, 90 to 118), p=0.006 13 encounters with teledermatology, that may have created a bias in the initial bias, were removed from analysis: Teledermatology still associated with shorter intervals to initial evaluation (p=0.0001) Teledermatology no longer statistically significant for the time intervals to biopsy (p=0.054) or to surgery (p=0.053)	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Izquierdo, 2009	HbA1c values at 6 months A: Increase (not significant) B: Decrease (p<0.02) Outcomes at 3 months Urgent encounters A: 59 B: 63 Urgent calls A: 20 B: 14 Treatment needed A: 52 B: 50 Outcomes at 6 months Urgent encounters A: 49 B: 25 Urgent calls A: 14 B: 2 Treatment needed A: 48 B: 20 Outcomes at 9 months Urgent encounters A: 47 B: 27 Urgent calls A: 27 B: 6 Treatment needed A: 43 B: 23	Effect of telehealth on Pediatric Quality of Life Modules Diabetes dimension: no difference between groups Treatment 1 dimension, after 6 months A: NS B: p≤0.04 Treatment 2 dimension, before summer break: A: NS B: p<0.02 Treatment 2 dimension, after 6 months: A: Significant improvement B: Stayed at 6 month levels Worry dimension: unaffected Effect of telehealth on Pediatric Quality of Life Generic Score Scales Improved physical functioning: A: NS B: NS Improved emotional functioning, baseline to 6 months: A: NS B: p<0.01 Improved emotional functioning, baseline to 6 to 12 months A: p<0.04 B: NS School functioning A: NS B: NS Social functioning A: NS B: NS	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Izquierdo, 2009 (Cont.)	Outcomes at 12 months Urgent encounters A: 35 B: 10 Urgent calls A: 23 B: 2 Treatment needed A: 30 B: 9 Hospitalizations for diabetic ketoacidosis A: 4 B: 1	Students and parents TH satisfaction survey results (0=not comfortable at all, 5=very comfortable), mean score ± SD Felt comfortable with form of communication: 4.68 ± 0.89 Encounter was convenient: 4.41 ± 0.91 Lack of physical contact is acceptable: 4.54 ± 0.86 Concerns about privacy of personal medical information: 0.73 ± 1.39 Overall, satisfied with TH services: 4.59 0.96 Willing to use TH services again: 91%	(Cont.)
Jaatinen, 2002	NR	Success of telehealth in relating patient history: good vs moderate vs bad A: 85% vs 10% vs 5% B: 62% vs 31% vs 8% p=0.23 Success of telehealth in relating physical status: good vs moderate vs bad A: 90% vs 10% vs 0% B: 46% vs 33% vs 21% p=0.01 Success of telehealth in relating overall patient case: good vs moderate vs bad A: 85% vs 15% vs 0% B: 48% vs 39% vs 13% p=0.02 Median total time for visit, in hours A: 3.5 B (teleconsultation): 1.0 B (telereferral): 1.0	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Jacklin, 2003 Same study as Wallace 2002, 2004	Estimated mean cost of index consultation, in pounds A: £32 B: £164 Mean difference: £132 Total patient costs, in pounds A: £11.38 (33.85) B: £3.69 (16.89) Difference: £-7.70 (95% CI -10.35 to -5.05), p<0.0001 Mean total NHS costs (SD), in pounds A: £625.26 (1199.77) B: £723.98 (832.07) Difference: £98.72 (95% CI 9.98 to 187.46), p=0.03 NHS adjusted difference, in pounds £93.80 (7.34 to 180.40) Mean cost per patient among specialties: Urology: mean cost were lower in B but NS all other specialties, mean cost per patient was significantly higher in B Cost of prescriptions: Not significantly different No differences between the two groups in terms of tests, investigations and other health services in two arms of the trial. Cost Less travel time, less time off work and slightly lower cost in patients on the virtual consultation arm.	Followup: A significantly greater proportion of patients in the virtual outreach group were offered a followup appointment	NR
Jacobs, 2015	Referral to hospital A: 26.6% B: 8.1% Unnecessary trips to the hospital A: 13.1% B: 0.4%	NR	Missed fractures A: 13.6% B: 1.7%

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Jong, 2004	Physician satisfaction Accessibility to rheumatologist: A: All rated satisfactory B: All rated satisfactory C: All rated very satisfactory Usefulness of method of consultation: A: No rating provided B: No rating provided C: No rating provided Impact on management: A: No rating provided; did not improve management B: No rating provided; improved management C: No rating provided; improved management	Costs, in dollars A: $975 for flight to on-site B: $87.50 for 1/2 hour of teleconsultation	NR
Jue, 2017	Total cost savings for travel and hotel based on distance from patient home to the Miami VA Facility $155,627.20	Reduction in travel distance B: 80.7%	NR
Kobza, 2000	Stage II pressure ulcer healing rate A: 34% B: 83% Stage IV pressure ulcer healing rate A: 10% B: 38% Healing rate for all wounds improved with telehealth, except for stage III pressure ulcers Healing time decreased in all categories with telehealth Discharge with healed wounds A: 37% B: 58%	Mean number of home visits A: 60 B: 33 Hospitalizations A: 18% B: 6%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Krier, 2011	NR	Mean duration, in minutes (SD, range) A: 59 (10, 26 to 73) B: 60 (14, 35 to 80) p=0.81 Mean wait time, in minutes (SD, range) A: 18 (14.5, 5 to 60) B: 25 (25, 5 to 90) p=0.31 The two groups similarly rated as excellent their clinic experience and the major clinical satisfaction indices of attention to patient concerns, bedside manner, and perceived skill level of the doctor.	NR
Krupinski, 2004	In-person group had less evidence in the records about actions taken as a result of the consultation. Recorded notes on action taken: A: 12% B: 43% Z=3.14, p<0.01 Patients seen again: A: 10% B: 8% Z=0.40, p>0.05	NR	NR
Kunkler, 2007	Compliance of decisions with guidelines on best practice at meeting A: 116/116 (100%) B: 136/137 (99%) Telehealth meetings cheaper than standard meetings: approximately 40 meetings per year.	Mean (SE) response of MDT members on a 5 point scale with 5 being strongly agree, to the following 3 statements: Consensus was reached by all parties involved A: 4.20 (0.067) B: 4.06 (0.058), p=0.048 Confident decision was in the best interests of the patient A: 4.16 (0.064) B: 4.07 (0.056), p=0.12 Discussion of patient was appropriately shared by participants A: 4.17 (0.079) B: 4.04 (0.066), p=0.12	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Lamminen, 2001	Cost of consultation per patient, in Euros A1: €126 A2: €143 There were cost savings in relation to teleconsultations when the annual numbers of patients were more than 110 in ophthalmology and 92 in dermatology.	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Lee, 2014	Intervention facilities All fractures Patients prescribed bisphosphonate, n (%), p-value A: 43 (4.8) B: 78 (7.3), p=0.02 Patients prescribed Ca and/or vitamin D, n (%), p-value A: 192 (21.3) B: 374 (35.2), p<0.01 Control facilities All fractures Patients prescribed bisphosphonate, n (%), p-value A: 37 (6.2) B: 23 (4.4), p=0.23 Patients prescribed Ca and/or vitamin D, n (%) A: 213 (35.6) B: 179 (34.4) Intervention facilities Major osteoporotic fractures Patients prescribed bisphosphonate, n (%), p-value A: 19 (7.6) B: 35 (11.3), p=0.15 Patients prescribed Ca and/or vitamin D, n (%), p-value A: 69 (27.7) B: 132 (42.7), p<0.01 Control facilities Major osteoporotic fractures Patients prescribed bisphosphonate, n (%), p-value A: 14 (8.6) B: 11 (6.8), p=0.68 Patients prescribed Ca and/or vitamin D, n (%), p-value A: 64 (39.3) B: 64 (39.5), p=1.00	NR	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Lim, 2012	NR	Mean waiting time, in days A: 114 B: 39 Patient satisfaction survey: 1 (poor) to 5 (excellent) Overall experience A: 3.8 B: 4.5 Financial cost per patient, in NZ$ A: $306.48 B: $264.48	NR
Loane, 2000	NR	Required at least one subsequent hospital appointment A: 45% B: 46% C: 69%	NR
Loane, 1999	NR	Mean wait time to see doctor, in minutes A: 20 B: 5.4 Mean consultation time with doctor, in minutes A: 16.8 B: 22.0 Mean total travel time, in minutes A: 48.0 B: 31.6 Mean total time involved in attending appointment, including waiting, consultation and travel, in minutes A: 84.4 B: 59.3 Mean total distance involved in attending appointments, in km A: 25.4 B: 10.4	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Loane, 2001	Total cost of dermatologist's time spent in performing consultations, in NZ$ A: $5724.00 B: $6162.80 Cost of patient time to attend consultations, in NZ$ A: $7838.17 B: $1845.54 Total travel costs for patients to attend consultations, in NZ$ A: $16,519.15 B: $876.64 Total societal costs of consultations, in NZ$ A: $30,081.33 B: $34,345.55	Mean consultation time, in minutes A: 21.60 B: 20.04	NR
Long, 2014	% of pregnancies receiving comprehensive ultrasound: A: 9.6% B: 11.3%, p<0.0001 % of high-risk pregnancies receiving comprehensive ultrasound: A: 16.9% B: 19.9%, p<0.001	% of high-risk pregnancies with prenatal care starting each trimester: First trimester A: 74.3% B: 75.0% Second trimester A: 21.5% B: 21.1% Third trimester A: 4.2% B: 4.0% Statistical significance NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Mahendran, 2005	NR	Telehealth diagnosis (face-to-face is gold standard): 48% agree 15% uncertain but actual diagnosis mentioned 20% incorrect or could not be made 15% image not adequate Agreement on management plan for same patients evaluated 55% Managed appropriately 13% required reassurance only 9% recommended further review 33% minor operation Not adequately managed by telehealth 15% poor image quality 20% complex and required in-person exam and consent 10% telehealth recommended surgery not needed or wrong surgery	Diagnostic and referral issues: In 20% of cases the diagnosis was either incorrect or could not be made. 45% of teledermatology referrals were not adequately managed by the consultants. 10% of all cases would have been inappropriately booked directly for surgery if teledermatology was used.
McCrossan, 2012	Mean difference in days taken off work (95% CI), p-value: 0.61 (0.39 to 0.82), p<0.01	Mean aggregate patient satisfaction (SD) A: 23.2/25 (2.2) B: 23.2/25 (2.0) p=0.92	NR
Moreno-Ramirez, 2009	Unit cost per patient, in Euros A: €129.37 B: €79.78 p=0.005 For benign lesions conventional care was 3.29 times more expensive	NR	NR
Mulgrew, 2011	NR	Mean overall patient satisfaction defined as a score of 5 or 6 (almost always, or always) (SD) A: 44.5 (3.85) B: 43.8 (4.83) p=0.42 Satisfaction with consulting health care provider A: 9.3 (0.91) B: 9.4 (1.01)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Nickenig, 2008	NR	Concept changes in diagnosis, n (%) A: 36 (4%) B: 0 (0%) Prosthodontic protocol, n (%) A: 67 (7%) B: 3 (3%) Number and position of implants, n (%) A: 148 (19%) B: 13 (15%)	NR
Nikkanen, 2008	Mean HbA1c (SD) A: 8.0% (1.9) B: 7.6% (1.5) Difference: -0.4; p=0.007 LDL cholesterol (mmol/L) A: 3.3 (0.9) B: 2.7 (0.8) Difference: -0.6; p=0.001 Systolic blood pressure (in mmHg) A: 146 (22) B: 140 (16) Difference: -6; p=0.004 Body mass index, in kg/m2 A: 30. 6 (6.3) B: 30.4 6 (6.7) Difference: -0.2; p=0.58 Subgroup analyses indicate largest change in HbA1c results in patients with DM >10 years and with higher HbA1c at baseline.	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Nordal, 2001	NR	Diagnostic agreement: 72% complete concordance 14% had partial concordance 13% were discordant Provider mean score of confidence in diagnoses: Face-to-face: 2.7 Telecommunication: 2.4 p>0.05 Provider preferences: 22% favored face-to-face 14% of ratings favored telehealth Time spent for a consultation: Face-to-face: 10.1 minutes Telecommunication: 9.5 minutes Patient reports: 61% no disadvantage to video 18% reduced contact with specialist 7% discomfort being recorded. 86% favored having GP present for teledermatology patient satisfaction: Face-to-face: 8% Telecommunications: 26% p=0.0006	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Ohinmaa Same patients as Vuolio and Haukipuro, 2002	Mean time spent by patient, in hours A: 8 B: 1.5 Mean distance travelled, in km A: 170 B: 8 Cost: Total cost, including travel and indirect costs based on 100 patients, per patient in euros A: €114.0 B: €87.8 Difference dependent on patient travel: Breakeven point: 80 cases if 160km 200 case if 80 km Total cost savings from use of teleconsultation €2,620	NR	NR
Pak, 2009; Pak, 2007	Changes in clinical course Improved A: 65% B: 64% No change A: 32% B: 33% Worse A: 3% B: 4%, NS Total average cost per patient, in USD A: $129,133 ($372) B: $119,402 ($340) Direct costs, in USD A: $98,365 B: $103,043 Lost productivity, in USD A: $30,768 B: $16,359	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Piette, 2017	NR	Median delay between the initial GP's consultation and the reply allowing for treatment to begin, in days A: 40 B: 4 Adjusted hazard ratio=2.55; p<0.011 Patients' global satisfaction Very satisfied or satisfied A: 47 (94%) B: 45 (84.9%) p=0.99 Unsatisfied or very unsatisfied A: 3 (6%) B: 8 (15.1%) Patients' satisfaction about the delay before care Very satisfied or satisfied A: 13 (26%) B: 38 (71.7%) p=0.20 Unsatisfied or very unsatisfied A: 37 (74%) B: 15 (28.3%)	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Rossaro, 2013	Sustained virological response A: 16 (43%) B: 21 (55%), p=0.36	Completion of therapy, n (%) A: 21 (53%) B: 31 (78%), p=0.03 Mean number of weeks of therapy A: 30.2 B: 36.7, p=0.07 Mean number of visits A: 2.2 B: 19.6 <0.0001 Mean number of visits per week of therapy A: 0.07 B: 0.61, p<0.001 Stopped therapy due to depression A: 1 B: 4 Anti-depressant medication A: 7 B: 14 Reasons for early termination of therapy: A: Severe anemia, skin rash, and weight loss B: Severe depression, NS	Side effects were similar for both groups - not significant Neutropenia GI side effects Fatigue Depression Weight loss Insomnia Skin rash Anemia A: 53% B: 25% p=0.02 Patients discontinued therapy due to depression A: 1 B: 4 On anti-depressant medication A: 7 B: 14

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Salami, 2015	NR	Comprehensive clinical evaluation prior to initiation of treatment n (%) A: 44 (64.7%) B: 44 (91.7%), p=0.001 Guideline-driven clinical evaluation prior to initiation of treatment n (%) A: 51 (75.0%) B: 48 (100.0%), p<0.001 Assessment of tumor stage n (%) A: 50 (73.5%) B: 44 (91.7%), p=0.002 Assessment of transplant eligibility n (%) A: 58 (85.3) B: 46 (95.8), p=0.006 Median time from referral to evaluation (range), in days A: 39 (11 to 387) B: 23 (8 to 97), p<0.001 Median time from referral to treatment initiation (range), in days median A: 63 (27 to 231) B: 55 (27 to 180), p=0.152 Median miles travelled by patient to receive evaluation (range) A: 683 (0 to 3327) B: 0 (0 to 0), p<0.001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Salazar-Fernandez, 2012	Mean cost of lost working hours per patient (95% CI) A: 32.24 (31.6 to 32.8) B: 16.8 (16.2 to 17.3), p=0.01	Patients referred to maxillofacial surgery A: 83 (11.6%) B: 35 (10.2%), p=0.28 Resolved consultation A: 529 (74.5%) B: 304 (88%), p=0.07 Second consultations A: 29 (4.6%) B: 3 (0.8%), p=0.07 Mean lost working hours A: 32.24 B: 16.8, p=0.01 Mean time until treatment (95% CI), in days A: 78.6 (77.0 to 80) B: 2.3 (2.2 to 2.4), p=0 Number of complaints A: 6 (0.8%) B: 1 (0.3%), p =0.1 Mean lost working hours (95% CI) A: 32.24 (31.6 to 32.8) B: 16.8 (16.2 to 17.3), p=0.01	NR
Santamaria, 2004	Average healing rate, per week A: -4.9% B: 6.8%, p=0.012 Amputations A: 6 B: 1 Mortality A: NR B: 2 Total cost, in AUD A: $862,161 B: $670,226; n=43	NR	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Scuffham, 2002	Total variable costs per patient, in pounds A: £233.86 B: £1181.52 C: £404.10 Total societal costs, in pounds A: £403.11 B: £1181.51 C: £582.69 Outreach visits are least expensive	NR	NR
Sharma, 2003	Mean inadequately identified cardiovascular items (out of 31 during pilot) A: 2.3 B: 2.1 p=0.2	Mean patient satisfaction score, (5-point scale, 5=very satisfied), p-value Comfort during exam: A: 4.6 B: 4.3, NS Amount of information received during exam: A: 4.6 B: 4.3, p=0.05 Willingness of doctor to answer questions: A: 4.6 B: 4.5, NS Explanation of results of exam: A: 4.6 B: 4.4, NS Care and concern of doctor: A: 4.6 B: 4.4, NS Translator's ability to speak language: A: 4.5 B: 4.6, NS Overall quality of care and services: A: 4.6 B: 4.5, NS	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Smith, 2002	NR	Change in pediatric admissions from Mackay region to Royal Children's Hospital, in patients per month A: 9.7 B: 6.0 Change in pediatric admissions From Hervey Bay region to Royal Children's Hospital, in patients per month A: 10.0 B: 12.5 Patient referrals for outpatient appointments to Brisbane from Mackay, in patients per month A: 7.9 B: 5.7 Patient referrals for outpatient appointments to Brisbane from Hervey Bay, in patients per month A: 15.8 B: 15.4 Pediatric outpatient department visits in Mackay A: 78 B: 134 No change in outpatient department visits in Hervey Bay	NR
Smith-Strom, 2018	Mortality, n (%) A: 5 (5.7%) B: 5 (5.3%) Mean difference (95% CI): -0.4% (-6.5 to 5.7) Amputation, n (%) A: 13 (14.8% B: 6 (6.4%) Mean difference (95% CI): -8.3% (-16.3 to –0.5)	Wounds healed, n (%) A: 67 (76.1%) B: 75 (79.8%) Mean healing time, in months A: 3.8 B: 3.4 Mean difference (95% CI): -0.43 (-1.50 to 0.65)	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Specht, 2001	Average cost of chronic wound consultation, in USD A: $246.28 B: $136.16 Cost avoidance Consultant: $36.66/consultation Patient transportation cost avoided: $191.28 Average time spent on appointment A: 8.5 hours, including travel time B: 20 minutes	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Stalfors, 2003	NR	Mean time spent including travel and waiting time ± 95% CI, in hours A: 8.9 ± 0.8 B: 3.4 ± 0.5 Mean presentation time ± 95% CI, in minutes A: 14.2 ± 1.4 B: 13.3 ±2.03 Information received during conference rated as very good A: 69% B: 44%, p<0.05 Information received during conference rated as good A: 26% B: 44%, p<0.05 Information received during conference rated as insufficient A: 0% B: 4% Information received during conference rated as bad A: 0% B: 0% Satisfaction with information about future treatment rated as very good A: 67% B: 56% Satisfaction with information about future treatment rated as good A: 21% B: 38% Satisfaction with information about future treatment rated as insufficient A: 0% B: 2%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Stalfors, 2003 Continued	(see above)	Satisfaction with information about future treatment rated as bad: A: 0% B: 0% No answer: A: 13% B: 4% Answering "totally agree" to statement (n) I felt calm and secure during the presentation: A: 31 B: 36 I did not feel worse than at any other investigation: A: 19 B: 25 It felt good to know my doctor had this kind of support from specialists: A: 31 B: 38 It is as though they listened to me and that I was a participant: A: 20 B: 30 It felt as though everybody received all the important information: A: 18 B: 31 It felt good to have my doctor by my side: A: 9 B: 38, $p<0.05$ Answering "not at all" to statement (n) It felt as if everybody was talking about me, but not to me: A: 15 B: 31, $p<0.001$	(see above)

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Stalfors, 2005	Combined cost, in SEK A: 2,267 B: 2,036, p>0.2 Direct medical cost, in SEK A: 576; 429/patient for district general hospital physician B: 1,550; 1,288/patient is the equipment cost Direct nonmedical cost, in SEK A: 886 B: 176 Indirect nonmedical cost, in SEK A: 805 B: 310	NR	NR
Stern, 2014	Average rate of healing 1.0058 times slower in intervention period (95% CI 0.985 to 1.027, p=0.60) Time to healing, HR (95% CI) Intervention: 1.48 (0.79 to 2.78), p=0.22 Estimated probability of healing (95% CI): A: 35.0% (22.4 to 45.6) B: 53.4% (41.4 to 62.9) Estimated incidence rate of intervention: 1.12 times larger in intervention (95% CI 0.74 to 1.68, p=0.59) Estimated mean hospitalization rate: 1.2 times larger during intervention (95% CI 0.62 to 2.36, p=0.59) Estimated mean ED visit rate: 1.3 times larger during intervention (95% CI 0.58 to 2.90, p=0.52) Direct care costs: Intervention estimated to reduce direct care costs by $649 per resident	Estimated mean VAS wound-specific pain scores: 0.39 units higher during intervention period (95% CI -0.55 to 1.34, p=1.34)	NR
Strymish, 2017	NR	Time to completion for e-consults averaged (SD), in days A: 16.5 (12.4) B: 0.6 (3.6), p<0.05	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Taylor, 2007	NR	Screen completion A: 31% B: 100%	NR
Thaker, 2013	Net savings, in AUD: $320,118 Total cost of teleconsults, in AUD: $442,276 Estimated travel expense avoided, in AUD: $762,394 Travel costs for patients and escorts, in AUD: $658,760 Aeromedical retrievals, in AUD: $52,400 Travel for specialists, in AUD: $47,634 Accommodation costs for a proportion of patients, in AUD: $3600	NR	NR
Tsitlakidis, 2005	Total cost per patient, in euros A: 270.061€ B: 203.578€ Savings dependent on distance travelled and number of cases	Average consultation time, in minutes A: 30.0 B: 5.3 Post-consultation time requirements, in minutes A: 10.0 B: 2.6	NR
Tuulonen, 1999	Cost of visits per case, in USD No difference A: $111 B: $110 Decreased travel saved $55 per visit for telehealth patients, not included in overall cost.	Total mean (SD) time spent for visit including travel, in hours A: 8.5 (2.4) B: 2.0 (1.0), p=0.0001 Mean time absent from work, in hours A: 6.6 B: 3.3 % Very satisfied with overall care A: 69% B: 86% % Selected telehealth for next visit A: 81% B: 96% Reduction in travel as reason for wanting telehealth for next visit A: 97% B: 86%	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
van der Pol, 2010	Total cost per patient, in pounds A: £380.52 B: £353.43 Average cost per clinic, in pounds Staff: A: £350.52 B: £360.54 Equipment: A: £247.34 B: £1390.42 Disposables: A: £32.40 B: £16.20 Average cost per patient, in pounds Staff: A: £17.73 B: £72.11 Equipment: A: £12.37 B: £278.08 Disposables: A: £1.62 B: £3.24 Travel A: £349 B: 0	NR	NR
Van Gelder, 2017	NR	Referral rate A: 3.0% B: 2.3% OR 0.61 (95% CI 0.31 to 1.23) Consultation rate A: 5.0% B: 6.3% OR 2.00 (95% CI 0.75 to 5.33)	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Vuolio Same patients as Ohinmaa and Hakipuro, 2003	NR	Management plan Operation A: 54% B: 64% Follow-up A: 18% B: 18% Problem solved at first visit A: 28% B: 18%	NR
Wallace, 2002	Patients offered followup appointments Difference in %; OR (95% CI) Unadjusted: 11%; 1.52 (1.27 to 1.82) Adjusted including baseline severity: 11%; 1.53 (1.27 to 1.83) Unadjusted by site: London: 5%; 1.25 (0.99 to 1.57) Shrewsbury: 17%; 2.02 (1.53 to 2.68) Unadjusted by Specialty: Orthopedics: 20%; 2.24 (1.45 to 3.48) Urology: 11%; 1.59 (0.97 to 2.60) ENT: 27%; 3.13 (2.20 to 4.43) Gastroenterology: -5%; 0.80 (0.54 to 1.18) Other specialties: -7%; 0.76 (0.51 to 1.14) Resource utilization (n varies based on available data) Difference in means (95% CI) Quantity of tests and investigations: -0.79 (-1.21 to -0.37) Quantity of outpatient visits: 0.04 (-0.10 to 0.18) Total number of contacts with general practice: 0.20 (-0.11 to 0.50) Quantity of emergency visits: 0.002 (-0.02 to 0.03) Quantity inpatient stays: -0.02 (-0.06 to 0.01) Number of day surgery and inpatient procedures: -0.01 (-0.04 to 0.02) Number of prescriptions: 0.57 (-0.64 to 1.78)	Mean patient satisfaction (5 point scale; 1=poor) A: 3.64 (1.06) B: 3.97 (0.99) Difference: 0.33 (0.23 to 0.43) Mean patient enablement (higher scores indicate improved enablement) (SD) A: 2.4 (3.1) B: 2.5 (3.2) Difference: 0.07 (-0.24 to 0.43)	NR

Author, Year (See Appendix C for full citation)	Results: KQ1: Clinical and Economic Outcomes	Results: KQ2: Intermediate Outcomes	Results: KQ3: Adverse Effects or Unintended Consequences
Wallace, 2004	SF-12 Physical score A: 42.7 (12.2) B: 43.1 (12.0); p=0.61 Mental score A: 48.1 (11.9) B: 47.5 (11.8); p=0.43 Costs, GBP NHS (health system) Difference (B-A) 90.80 (2.07-179.54) Patient -7.70 (-10.35 to -5.05)	Offer of followup appointment A: 41% B: 52% AOR (95% CI) 1.53 (1.27 to 1.83), p<0.001 Mean patient satisfaction (1=poor; 5=excellent) (SD) A: 3.64 (1.06) B: 3.97 (0.99)	NR
Whited, 2002	NR	Time to initial definitive intervention, in days ITT analysis mean (SD), median: A: 114.3 (72.3), 127.0 B: 73.8, (71.6), 41.0; p=0.0001 Actual clinic visit analysis mean (SD), median: A: 135.6 (94.3), 137.5 B: 93.4 (96.1), 50.0; p=0.0027	NR
Whited, 2003	Extrapolated cost data from 275 patients to the total population of patients serviced by dermatology clinic in 2001, n=5440 Total annual cost, in USD A: $116,416 B: $198,016 Per patient A: $21.40 B: $36.40 Incremental cost per patient of teledermatology: +$15.00	Median time to initial definitive intervention, in days A: 137.5 B: 50 p=0.0027	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Whited, 2004	NR	Clinicians survey Satisfaction with consult process: Agree: A: 23% B: 92% Neutral: A: 42% B: 5% Disagree: A: 35% B: 3% Patients survey - Patients largely satisfied - Largest source of dissatisfaction, Usual care: Wait time for appointment - Teledermatology: some dissatisfied with time it took to learn their results - Teledermatology patients were generally satisfied with the outcome of consultations and were confident that dermatologists could help them by viewing digital images	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Whited, 2013a, 2013b	Clinical course ratings baseline to 1st visit, n (%) Resolved: A: 3 (2) B: 2 (2) Improved: A: 29 (21) B: 22 (23) Unchanged - not clinically relevant: A: 20 (15) B: 10 (12) Unchanged - clinically relevant: A: 70 (51) B: 54 (57) Worse: A: 15 (11) B: 6 (6), p=0.65 Clinical course ratings baseline to 9 months, n (%) Resolved: A: 35 (26) B: 31 (25) Improved: A: 63 (46) B: 59 (47) Unchanged - not clinically relevant: A: 15 (11) B: 13 (10) Unchanged - clinically relevant: A: 17 (13) B: 13 (10) Worse: A: 6 (4) B: 9 (8), p=0.88	Quality of life change in skindex-16 baseline to 3 months mean Symptoms A: -8.0 (22.9) B: -8.7 (29.8), p=0.81 Emotions A: - 8.9 (25.3) B: -11.6 (27.2) Functioning A: -0.05 (20.9) B: -3.2 (20.2), p=0.22 Composite A: -5.8 (19.1) B: -7.8 (21.9), p=0.39 Baseline to 9 months Symptoms A: -14.4 (28.2) B: -10.3 (30.6), p=0.22 Emotions A: -18.1 (25.1) B: -19.7 (30.7), p=0.61 Functioning A: -6.9 (22.3) B: -6.0, p=0.73 Composite A: -13.2 (21.6) B: -12.0 (24.5), p=0.66	NR
Wilson, 2005	NR	Retinal exams rate (95% CI) for diabetic patients A: 50% (44% to 56%) B: 75% (70% to 80%), p<0.0001 Rate of laser therapy for diabetic retinopathy A: 19.6 per 1,000 patients with diabetes B: 29.5 per 1,000 patients with diabetes 51% increase in laser treatment rate	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Xu, 2008	Mean number of consultations per person: A: 1.5 B: 1.3 Total cost per consultation, in dollars A: $155 B: $161 Variable cost per consultation, in dollars A: $155 B: $108 Total annual variable cost, in dollars A: $27,364 B: $14,160 Difference between conducting 265 consultations A vs. B cost-savings: $7,621	NR	NR
Young, 2014	NR	Complete virologic suppression during the first 6 visits was significantly greater in the telehealth group A: 59.3% B: 91.1% OR 7.0 (95% CI 5.1 to 9.8); p<0.001	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Zahlmann, 2002	NR	Mean (SD) number of visits to practice Referring ophthalmologists: A: 1.85 (0.37) B: 2.02 (0.95), p=0.55 Surgical ophthalmologists: A: 2.05 (0.22) B: 1.07 (0.26), p=0.0001 Mean travel time (SD), in hours A: 2.53 (0.98) B: 2.17 (0.93), p=0.15 Mean referring time (SD), in hours A: 1.64 (0.69) B: 1.37 (0.49), p=0.16 Mean ophthalmologist time (SD), in hours A: 3.03 (0.73) B: 2.08 (0.61), p=0.0001 [mean score (SD); 0=very positive, 10=very negative] Ophthalmic surgeon satisfied with: Communication among patient, referring ophthalmologist and surgeon A: 0.55 (1.39) B: 0.02 (0.15), p=0.017 Inclusion in decision process: A: 0.80 (1.50) B: 0.14 (0.78), p=0.007 Overall treatment A: 0.95 (1.79) B: 0.14 (0.78), p=0.019	NR
Zarchi, 2015	Complete wound healing at 1-year followup A: 45% B: 70% Complete wound healing, adjusted hazard ratio (95% CI), p-value A: Reference B: 2.19 (1.15 to 4.17), p=0.017	NR	NR

Author, Year (See Appendix C for full citation)	**Results: KQ1: Clinical and Economic Outcomes**	**Results: KQ2: Intermediate Outcomes**	**Results: KQ3: Adverse Effects or Unintended Consequences**
Zilliacus, 2011	NR	Generalized satisfaction with genetic counseling; n, mean (SD) A: 84, 40.8 (9.9) B: 87, 45.6 (8.4); p=0.76 No significant differences were found between telegenetics and face-to-face genetic counseling in terms of knowledge gained p=0.55 Cancer-specific anxiety p=0.13 Generalized anxiety p=0.42 Depression p=0.96 Perceived empathy of the genetic clinician p=0.13 Perceived empathy of the genetic counselor p=0.12 Telegenetics performed significantly better than face-to-face counseling in meeting patients' expectations p=0.009 Promoting perceived personal control p=0.031	NR

AOR = adjusted odds ratio; APRI = aspartate aminotransferase:platelet ratio index; AUD = Australian dollar; BMI = body mass index; BP = blood pressure; CI = confidence interval; CPT = cognitive processing therapy; DBP = diastolic blood pressure; DM = diabetes mellitus; ECHO = Extension for Community Healthcare Outcomes; ED = emergency department; EuroQOL EQ- 5D = standardized instrument that measures health-related quality of life; GBP = Great British Pound; GDP = gross domestic product; GP = general practitioner; GI = gastrointestinal ; HbA1c = hemoglobin A1c; HCV = hepatitis C virus; HR = hazard ratio; IDR = incident density ratio; ITT = intention-to-treat; LDL = low-density lipoproteins; LOS = length of stay; MACE = major cardiovascular events; MCS = mental component score; MDT = multidisciplinary team; NHS = National Health Service; NR = not reported; NS = not significant; NZ$ = New Zealand dollars; OR = odds ratio; PCS = physical component score; PTSD = post-traumatic stress disorder; SBP = systolic blood pressure; SD = standard deviation; SE = standard error; SEK = Swedish krona; SF-12 = Short Form Health Survey 12; TH = telehealth; TVCR; UAMS = University of Arkansas for Medical Sciences; UNM = University of New Mexico; USD = United States dollars; VA = Veteran's Affairs; VAS = visual analog scale

[a] For definitions of interventions and comparisons (e.g., A vs. B), see Table F-7

See Appendix C. Included Studies for full citations

Appendix G. Risk of Bias

Table G-1. Risk of bias: cohort studies, part 1

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
Alemi, 2016	Prospective Cohort	No	Yes	Unclear	No	No
Amorim, 2013	Before-After	Yes	Yes	No	Yes	NR
Angstman, 2009	Retrospective Cohort	Yes	Yes	Unclear	Yes	Yes
Armaignac, 2018	Retrospective Cohort	Clinical outcomes: Yes Cost: Yes	Clinical outcomes: No Cost: Yes	Clinical outcomes: Yes Cost: Unclear	Clinical outcomes: Yes Cost: Unclear	Clinical outcomes: Yes Cost: Unclear
Arora, 2011	Prospective Cohort	Yes	Yes	Yes	Yes	Yes
Astarcioglu, 2015	Prospective Cohort	No	Unclear	Yes	Yes	Unclear
Audebert, 2006	Prospective Cohort	Yes	Yes	Yes	Yes	No
Audebert, 2009	Prospective Cohort	Yes	Yes	Yes	Yes	Yes
Bagayoko, 2014	Prospective Cohort for patient costs Before-After for health center costs	Yes	Yes	NR	Unclear	NR
Baig, 2016	Retrospective Cohort	No	NR	NR	Yes	Yes
Bergrath, 2012	Prospective Cohort	Yes	Yes	Unclear	Yes	Yes
Bernstein, 2010	Retrospective Cohort	Yes	Yes	Unclear	Yes	Yes
Beswick, 2016	Prospective Cohort	Yes	NR	No	No	Yes
Bezalel, 2015	Before-After	No	Unclear	NR	Unclear	Unclear
Blackwell, 1997	Before-After	Yes	Yes	NR	No	No
Bladin, 2015	Before-After	Yes	Yes	Yes	Yes	Yes
Breslow, 2004	Before-After	Yes	Yes	Unclear	Yes	Yes
Britt, 2006	Before-After	No	Yes	Unclear	Unclear	Unclear
Brokmann, 2016	Before-After	Yes	Yes	Unclear	Yes	No
Brokmann, 2016b	Before-After	Yes	Yes	Yes	No	No
Brown-Connolly, 2002	Prospective Cohort	No	Unclear	Unclear	Unclear	No
Brunetti, 2014	Prospective Cohort	Yes	Yes	No	Yes	Yes
Buckley, 2012	Before-After	Yes	Yes	Unclear	Yes	Yes
Burgess, 2002	Prospective Cohort	Yes	Unclear	Unclear	No	No
Carallo, 2015	Prospective Cohort	No	No	Yes	Unclear	Yes

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
Carter, 2017	Retrospective Cohort	Yes	No	No	Yes	No
Chan, 2001	Before-After	Yes	Yes	Unclear	Unclear	No
Chan, 2012	Prospective Cohort	Yes	Yes	Yes	Yes	Yes
Chan, 2015	Retrospective Cohort	Yes	Yes	No	Yes	Yes
Choi, 2006	Before-After	No	Unclear	No	Unclear	No
Chowdhury, 2012	Retrospective Cohort	Yes	Yes	No	Unclear	Yes
Chu, 2015	Retrospective Cohort	No	NR	Unclear	No	No
Collins, 2017	Retrospective Cohort	Yes	Yes	No	No	Yes
Craig, 2004	Prospective Cohort	Yes	Yes	No	Yes	No
Crossland, 2016	Prospective Cohort	Yes	Yes	Yes	No	NR
Darkins, 1996	Before-After	No	Yes	Unclear	Unclear	No
Davison, 2004	Before-After	No	Yes	NR	No	Yes
Dayal, 2016	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
De Luca, 2005	Prospective Cohort	Yes	Yes	Yes	Yes	No
Dharmaaroja, 2010	Before-After	Yes	Yes	No	Unclear	Unclear
Dharmar, 2013	Retrospective Cohort	Yes	Yes	No	Unclear	Yes
Dharmar, 2013	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Dharmar, 2013	Retrospective Cohort	Yes	Yes	Yes	Yes	No
Duchesne, 2008	Before-After	No	Yes	No	Unclear	Unclear
Engel, 2011	Prospective Cohort	No	Yes	NR	Yes	Yes
Ferrandiz, 2007	Prospective Cohort and Pre-Post	Yes	Unclear	Unclear	Yes	Yes
Fong, 2015	Prospective Cohort	Yes	Unclear	No	Unclear	NR
Fortis, 2014	Retrospective Cohort	No	Unclear	No	Yes	Yes
Fox, 2007	Before-After	Yes	Unclear	Unclear	Yes	Yes
Frank, 2015	Before-After	Yes	Yes	Unclear	Yes	No
Gilmour, 1998	Prospective Cohort	No	Unclear	Unclear	Yes	No
Goh, 1997	Prospective Cohort	No	Yes	Unclear	Yes	Yes
Gupta, 2014	Before-After	Yes	Unclear	Yes	Yes	Yes
Handschu, 2008	Prospective Cohort	Yes	Yes	Unclear	Unclear	No
Hashimoto, 2001	Before-After	Unclear	Yes	No	Unclear	Unclear
Heffner, 2015	Retrospective Cohort	Yes	Yes	Yes	Unclear	No
Herce, 2011	Prospective Cohort	No	Yes	Unclear	No	Yes
Hsiao, 2008	Retrospective Cohort	Yes	Yes	Unclear	Yes	Yes
Huang, 2008	Before-After	Yes	Yes	Unclear	Yes	Yes

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
Hubert, 2016	Retrospective Cohort	Yes	Yes	No	Yes	Yes
Ickenstein, 2005	Before-After	Yes	Yes	NR	Yes	No
Ionita, 2009	Retrospective Cohort	Yes	Yes	Yes	Unclear	Yes
Itrat, 2016	Prospective Cohort	Yes	No	Yes	Yes	Yes
Jacobs, 2015	Before-After	Yes	Yes	NR	Unclear	No
Johansson, 2011	Retrospective Cohort	Yes	Yes	Unclear	Yes	Yes
Jong, 2004	Prospective Cohort	No	Unclear	Unclear	No	No
Jue, 2017	Retrospective Cohort	Yes	Yes	NR	Yes	Yes
Kahn, 2016	Retrospective Cohort	Yes	Yes	Unclear	Yes	Yes
Kalb, 2014	Before-After	No	Unclear	Unclear	Yes	Yes
Kim, 2013	Prospective Cohort	Yes	Unclear	Unclear	Yes	Yes
Kim, 2011	Retrospective Cohort	Yes	Unclear	No	No	No
Klein, 2010	Retrospective Cohort	Yes	Yes	No	Yes	Yes
Kobza, 2000	Before-After	Yes	Unclear	NR	Yes	No
Kohl, 2012	Retrospective Cohort	Yes	Yes	No	Yes	Yes
Krupinski, 2004	Retrospective Cohort	Yes	No	NR	Yes	Yes
LaBarbera, 2013	Before-After	Yes	Yes	Yes	Yes	No
Langabeer, 2016	Retrospective Cohort (Case Control)	Yes	Yes	Yes	Yes	No
Lee, 2014	Prospective Cohort	Yes	Yes	Unclear	Yes	Yes
Lilly, 2011	Prospective Cohort	Yes	Yes	Yes	Yes	Yes
Lim, 2012	Prospective Cohort	Yes	No	No	Unclear	No
Long, 2014	Retrospective Cohort	Yes	Yes	Unclear	Yes	No
Macedo, 2016	Before-After	Yes	Unclear	Yes	Yes	Yes
Machado, 2018	Retrospective Cohort	Clinical outcomes: Unclear Cost: No	Clinical outcomes: Yes Cost: Yes	Clinical outcomes: Yes Cost: Unclear	Clinical outcomes: Yes Costs: Unclear	Clinical outcomes: Yes Costs: Unclear
Marcin, 2004a	Retrospective Cohort	Yes	Yes	No	Yes	Unclear
Marcin, 2004c	Retrospective Cohort	Yes	Yes	No	Yes	Yes
Marcolino, 2013	Before-After	Unclear	Yes	No	Yes	Yes
Martinez-Sanchez, 2014	Before-After	Yes	Unclear	Yes	Yes	Yes
Martinoni, 2011	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Mathews, 2008	Before-After	Yes	No	Unclear	Unclear	No
McCambridge, 2010	Before-After	Yes	Yes	Yes	Unclear	NR

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
McCrossan, 2012	Prospective Cohort	Yes	Yes	Yes	No	No
Mielonen, 2000	Prospective Cohort	Yes	Unclear	Unclear	Unclear	No
Migliaretti, 2013	Prospective Cohort	Yes	Yes	NR	Unclear	No
Miyamoto, 2014	Retrospective Cohort	Yes	Yes	No	Unclear	Unclear
Mohr, 2017 Mohr, 2018	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Morrison, 2010	Before-After	Yes	Yes	Yes	Unclear	NR
Mulgrew, 2011	Prospective Cohort	Yes	Unclear	No	Yes	No
Nagao, 2012	Before-After	Yes	Unclear	No	No	Yes
Nagayoshi, 2016	Before-After	No	Unclear	NR	Unclear	Yes
Narasimhan, 2015	Prospective Cohort with historical controls	Yes	NR	Yes	Yes	Yes
Nassar, 2014	Before-After	Yes	Yes	Yes	Yes	Yes
Nguyen-Huynh, 2018	Before-After	No	Unclear	Yes	Yes	Yes
Nickenig, 2008	Prospective Cohort	Yes	Yes	Unclear	Yes	No
Nordal, 2001	Retrospective Cohort	Yes	Yes	Yes	Unclear	Unclear
Ortolani, 2007	Retrospective Cohort	Yes	Yes	No	Yes	Unclear
Ortolani, 2006	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Paik, 2017	Retrospective Cohort	Yes	Yes	Yes	Unclear	No
Panlaqui, 2017	Before-After	Yes	NR	Yes	Yes	Yes
Pedersen, 2009	Prospective Cohort	Yes	Yes	Yes	Yes	Yes
Pedragosa, 2009	Before-After	Yes	Yes	Unclear	Yes	No
Pervez, 2010	Retrospective Cohort	Yes	Yes	No	No	Yes
Rendina, 1998	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Rincon, 2012	Before-After	No	Unclear	NR	No	No
Robison, 2016	Prospective Cohort	No	Yes	NR	Unclear	No
Romig, 2012	Before-After and Prospective Cohort	Unclear	Unclear	Unclear	Yes	NR
Rosenfeld, 2000	Before-After	Yes	Yes	Yes	Yes	Unclear
Rossaro, 2013	Retrospective Cohort	Yes	Yes	Unclear	Yes	Unclear
Ruesch, 2012	Before-After	Unclear	unclear	Unclear	Yes	NR
Sadaka, 2013	Before-After	Unclear	Unclear	Yes	Unclear	No
Saffle, 2009	Before-After	Yes	Yes	No	Unclear	Unclear
Sairanen, 2011	Prospective Cohort	Yes	Yes	No	Yes	Yes

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
Salami, 2015	Retrospective Cohort	Yes	Unclear	No	Yes	Yes
Salazar-Fernandez, 2012	Prospective Cohort	Clinical: Yes Economic: Yes	Clinical: Yes Economic: Yes	Clinical: Yes Economic: Yes	Clinical: Yes Economic: NR	Clinical: No Economic: Unclear
Sanchez-Ross, 2011	Prospective Cohort	Yes	Yes	Unclear	Yes	Yes
Schwab, 2007	Prospective Cohort	Yes	Yes	Yes	Yes	No
Sejersten, 2008	Prospective Cohort	Yes	Yes	No	Yes	Yes
Sharma, 2003	Prospective Cohort	Yes	Yes	NR	No	No
Sharma, 2016	Before-After	No	Unclear	Unclear	Yes	Yes
Shin, 2015	Prospective Cohort	No	No	NR	Yes	No
Smith, 2002	Before-After	Yes	Unclear	NR	No	No
Southard, 2014	Before-After	Yes	Yes	Unclear	Yes	Yes
Stalfors, 2003	Prospective Cohort	No	Yes	Yes	Unclear	No
Steinman, 2015	Before-After and Prospective Cohort	No	Unclear	NR	Unclear	No
Stern, 2014	Before-After	Yes	Yes	Yes	Yes	Yes
Strymish, 2017	Before-After	Yes	Yes	No	Yes	Yes
Switzer, 2009	Prospective Cohort	Yes	Yes	NR	Yes	Yes
Taqui, 2017	Prospective Cohort	Yes	Unclear	No	Yes	Yes
Taylor, 2007	Before-After	Yes	Yes	NR	Yes	Yes
Theiss, 2013	Before-After	Yes	Unclear	No	Yes	Yes
Thomas, 2009	Before-After	Unclear	Yes	Yes	Yes	No
Traub, 2013	Retrospective Cohort	Yes	No	Yes	No	No
Tsai, 2007	Prospective Cohort	Yes	Yes	No	Yes	Yes
Tuulonen, 1999	Before-After	Yes	Yes	NR	Yes	No
Wallace, 2008	Prospective Cohort	No	Yes	NR	Unclear	No
Webb, 2013	Prospective Cohort	Yes	Yes	Yes	Unclear	Yes
Willmitch, 2012	Before-After	No	Unclear	Yes	Yes	No
Wilson, 2005	Before-After	Yes	Yes	Unclear	Yes	Yes
Yang, 2015	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Young, 2014	Before-After	Yes	Yes	Yes	Yes	Yes
Zahlmann, 2002	Prospective and Retrospective Cohort	Yes	Unclear	NR	No	No
Zaidi, 2011	Prospective Cohort	Yes	Yes	Yes	Yes	No
Zanini, 2008	Retrospective Cohort	Yes	Yes	Yes	Yes	Yes
Zarchi, 2015	Prospective Cohort	Yes	NR	Yes	Yes	No

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified?**	**Random sample or consecutive/all patients meeting inclusion criteria?**	**Groups similar or design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**
Zilliacus, 2011	Prospective Cohort	Yes	Unclear	Yes	Yes	Yes

NR = not reported

See Appendix C. Included Studies for full citations

Table G-2. Risk of bias: cohort studies, part 2

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Alemi, 2016	Yes	Yes	Yes	None	High
Amorim, 2013	Yes	Yes	Yes	Supported in part by CLIQS0000235	Moderate
Angstman, 2009	Yes	NA	Yes	Mayo Clinic Departmental funds	Moderate
Armaignac, 2018	Clinical outcomes: Yes Cost: Unclear	NA	Yes	No conflicts reported	Clinical outcomes: Low Cost: High
Arora, 2011	Yes	Yes	Yes	AHRQ; Robert Wood Johnson foundation; New Mexico Department of Health; New Mexico State Legislature	Low
Astarcioglu, 2015	NR	Yes	Yes	NR	High
Audebert, 2006	Yes	Yes	Yes	Bavarian health insurance companies; Bavarian State Ministry for Employment and Social Order, Family and Women; German Stroke Foundation (Stiftung Deutsche Schlaganfall-Hilfe)	Low
Audebert, 2009	Yes	Yes	Yes	German Federal Ministry of Research (BMBF)	Low
Bagayoko, 2014	Unclear	NA	Yes	Global Health Research Initiative - partnership of International Development Research Centre and Foreign Affairs Trade and Development Canada	High
Baig, 2016	Yes	NA	Yes	NR	High
Bergrath, 2012	Yes	Yes	No	German Federal Ministry of Economics and Technology; Philips Healthcare; P3 Communications	Moderate
Bernstein, 2010	Yes	NA	Yes	No conflicts reported	Moderate
Beswick, 2016	Yes	Unclear	Yes	NR	High
Bezalel, 2015	NA	NA	Yes	James A. Haley Veterans' Hospital	High
Blackwell, 1997	Unclear	Unclear	Yes	Optical Prescription Spectacle Makers Industries Limited	High

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Bladin, 2015	Yes	Yes	Yes	Boehringer Ingelheim	Low
Breslow, 2004	Yes	Yes	Yes	VISICU	Moderate
Britt, 2006	NR	NA	Yes	NR	High
Brokmann, 2016	NR	Yes	Yes	European Union and the Ministry of Innovation, Science and Research of North Rhine Westphalia; Philips Healthcare; P3 communications	Moderate
Brokmann, 2016b	No	Yes	Yes	European Union and the Ministry of Innovation, Science and Research of North Rhine Westphalia, German	Moderate
Brown-Connolly, 2002	No	No	No	Blue Cross of California State Sponsored Programs	High
Brunetti, 2014	NR	NR	Yes	None	Moderate
Buckley, 2012	NR	NA	Yes	None	Moderate
Burgess, 2002	NR	Yes	Yes	Department of Defense, Pacific E-health Innovation Center, Pacific Regional Program Office	High
Carallo, 2015	NR	NR	No	No conflicts reported	High
Carter, 2017	NR	Yes	Yes	NR	High
Chan, 2001	NR	NR	Yes	SK Yee Memorial Fund	High
Chan, 2012	NR	NR	Yes	Authors report no relationship with industry	Low
Chan, 2015	Yes	NA	Yes	NR	Moderate
Choi, 2006	Unclear	Unclear	No	Department of Defense Grant	High
Chowdhury, 2012	NR	NA	Yes	NR, no competing interests	High
Chu, 2015	NR	NA	Yes	No conflicts reported	High
Collins, 2017	No	NA	No	None	High
Craig, 2004	Yes	Yes	Yes	Neurology Research Fund; Research and Development Office, Department of Health and Social Services for Northern Ireland	Moderate
Crossland, 2016	No	Yes	No	National Health and Medical Research Council Partnership Project Grant	High
Darkins, 1996	Yes	NR	Yes	NR	High
Davison, 2004	NR	Yes	No	Eastern Region Information Technology; Dean Allen and Barry Allen	High
Dayal, 2016	NR	NA	Yes	No conflicts reported	Low
De Luca, 2005	NR	NR	Yes	NR	Moderate
Dharmaaroja, 2010	NR	NR	Yes	Thammasat University	High
Dharmar, 2013	NR	NA	Yes	No conflicts reported	High
Dharmar, 2013	Unclear	NA	Yes	NR	Low

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Dharmar, 2013	Unclear	NA	Yes	AHRQ, Emergency Medical Services for Children; Office for the Advancement of Telehealth; William Randolph Hearst Foundation	Low
Duchesne, 2008	Unclear	NA	No	Bower Foundation; Mississippi State Department of Health	High
Engel, 2011	NR	NA	Yes	NR	High
Ferrandiz, 2007	Yes	Yes	Yes	Insitutos Carlos III	Moderate
Fong, 2015	Yes	Yes	Yes	None	Moderate
Fortis, 2014	NR	NA	Yes	No conflicts reported	High
Fox, 2007	NR	Yes	Yes	NR	Moderate
Frank, 2015	NR	NR	Yes	VHA	Moderate
Gilmour, 1998	Yes	Yes	Yes	NHS R&D Programme	High
Goh, 1997	NR	NR	Yes	Not reported	High
Gupta, 2014	NR	NA	Yes	No conflicts reported	Moderate
Handschu, 2008	Yes	Yes	Yes	Bavarian State Ministry of Labor and Social Welfare, Family and Women	Moderate
Hashimoto, 2001	NR	NA	Yes	NR	High
Heffner, 2015	NR	NA	Yes	University of Pittsburgh School of Medicine's Dean's Summer Research Program	Moderate
Herce, 2011	NR	Unclear	Yes	NR	High
Hsiao, 2008	Yes	Yes	Yes	University of California at San Francisco Dean's Research Fellowship	Moderate
Huang, 2008	NR	NA	Yes	Children's Miracle Network	Moderate
Hubert, 2016	Yes	NA	Yes	Conflicts and acknowledgement provided, NR actual funding	Moderate
Ickenstein, 2005	NR	NA	Yes	Bavarian State Ministry for Employment and Social Order, Family and Women; German Stroke Foundation; Bavarian health insurance companies	High
Ionita, 2009	NR	NA	Yes	NR	Moderate
Itrat, 2016	Yes	Yes	Yes	The Cleveland Clinic; Milton and Tamar Maltz Family Foundation	Moderate
Jacobs, 2015	NR	NA	No	The Friesland Insurance Company	High
Johansson, 2011	No	NA	Yes	NR	Moderate
Jong, 2004	NR	NR	Unclear	No conflicts reported	High
Jue, 2017	Yes	NA	Yes	None	Moderate
Kahn, 2016	Yes	NA	Yes	National Institutes of Health	Low
Kalb, 2014	NR	NA	Yes	No extramural support	High
Kim, 2013	Unclear	Unclear	Yes	Centers for Medicare and Medicaid Service; ANGELS	High

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Kim, 2011	Yes	NA	No	Ministry of Health and Welfare (Korea)	High
Klein, 2010	NR	NA	Yes	NR	Moderate
Kobza, 2000	NR	NR	Yes	NR	High
Kohl, 2012	No	NA	Yes	NR	Moderate
Krupinski, 2004	No	No	Yes	NR	High
LaBarbera, 2013	NR	NA	Unclear	Jackson Foundation; Friends of Doernbecher; Charlotte Coleman Frey Fellowship	Moderate
Langabeer, 2016	Yes	NA	Yes	NR no conflicts	Moderate
Lee, 2014	NR	NR	Yes	VISN 6 Specialty Care Office; Duke Claude A. Pepper Center	high
Lilly, 2011	Yes	Yes	Yes	University of Massachusetts	Low
Lim, 2012	Yes	Yes	No	Waikato Health Board	High
Long, 2014	NR	NA	Yes	Federal and Arkansas Medicaid; 2010 American Recovery and Reinvestment Act grant for the Arkansas Healthcare, Higher Education, Public Safety, and Research Integrated Broadband Initiative	Moderate
Macedo, 2016	Yes	NA	Yes	Amil Life Sciences	Moderate
Machado, 2018	Clinical outcomes: Unclear Costs: Unclear	NA	Yes	Ohio Health Research Institute	Clinical outcomes: Moderate Cost: High
Marcin, 2004a	NR	NA	Yes	California Telehealth and Telemedicine Foundation; Mercy Foundation North	Moderate
Marcin, 2004c	NR	NA	Yes	The California Telehealth and Telemedicine Foundation; Mercy Foundation North	Moderate
Marcolino, 2013	NR	NA	Yes	No external funding	Moderate
Martinez-Sanchez, 2014	NR	NR	Yes	Cohesion Funds of the Spanish National Health System; Mutua Madrilena Foundation; Spanish Ministry of Science and Innovation	Moderate
Martinoni, 2011	NR	Yes	Yes	Eli-Lilly Italy	Moderate
Mathews, 2008	No	NR	Yes	NR	High
McCambridge, 2010	Yes	Yes	Yes	Dorothy Rider Pool Health Care Trust	Moderate
McCrossan, 2012	Yes	Yes	Yes	Royal Belfast Hospital for Sick Children	Moderate
Mielonen, 2000	NR	NR	Yes	Finnish Office for Health Technology Assessment	High
Migliaretti, 2013	NR	NR	Yes	NR	High
Miyamoto, 2014	No	NA	Yes	Maternal and Child Health Bureau of HRSA; William Randolph Hearst Foundation	Moderate

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Mohr, 2017 Mohr, 2018	No	NA	Yes	Rural Telehealth Research Center	Low
Morrison, 2010	Yes	Yes	Yes	Washington Square Health Foundation,	Moderate
Mulgrew, 2011	NA	NA	Yes	AHRQ	High
Nagao, 2012	No	NA	Yes	Telematics Course Development Fund; Institute for Broadband Enabled Society Seed Funding	High
Nagayoshi, 2016	NR	NA	Yes	No conflicts reported	High
Narasimhan, 2015	No	NR	Yes	National Institutes of Health; Duke Endowment	Moderate
Nassar, 2014	NR	Yes	Yes	National Institute of Arthritis and Musculoskeletal and Skin Disease; US Department of Veterans Affairs	Low
Nguyen-Huynh, 2018	NR	Yes	No	Permanente Medical Group	Moderate
Nickenig, 2008	Yes	Yes	Yes	Institute of Aerospace Medicine - Germany	Moderate
Nordal, 2001	Yes	Yes	Yes	Norwegian Ministry of Social Welfare and Health	Moderate
Ortolani 2007	NA	NA	Yes	Fanti Melloni Foundation	Moderate
Ortolani, 2006	NR	NA	Yes	Fanti Melloni Foundation	Low
Paik, 2017	NR	NA	Yes	None	High
Panlaqui, 2017	NR	NR	Yes	NR	High
Pedersen, 2009	NR	Yes	Yes	The Danish Heart Foundation; The Murermester Laurits Peter Christensen and Wife Kirsten Sigrid Christensen Foundation	Low
Pedragosa, 2009	NR	Unclear	No	Instituto de Salud Carlos III: Evaluación de Tecnologías Sanitarias Salud	High
Pervez, 2010	No	NA	Yes	AHRQ; NIH; American Heart Association–Bugher Foundation; Harvard NeuroDiscovery Center; Deane Institute for Integrative Research in Atrial Fibrillation and Stroke; Esther U Sharp Fund; Conway Fellowship Fund; Lakeside Fund; Levitt Fund	High
Rendina, 1998	No	NA	Yes	NR	Low
Rincon, 2012	NR	None	Yes	No conflicts reported	High
Robison, 2016	NR	NR	Yes	Nemours Fund for Children's Health	High
Romig, 2012	No	No	Yes	The Johns Hopkins Hospital and the Johns Hopkins Department of Anesthesiology and Critical Care Medicine.	High
Rosenfeld, 2000	Yes	Yes	Yes	NR	Low
Rossaro, 2013	No	NA	Yes	National Center for Advancing Translational Sciences; National Institutes of Health	Moderate
Ruesch, 2012	Unclear	Unclear	Unclear	NR	High

Author, Year (See Appendix C for full citation)	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/low loss to followup or attrition?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Sadaka, 2013	Unclear	Yes	Yes	NR	High
Saffle, 2009	Yes	Yes	Yes	U.S. Department of Commerce	Moderate
Sairanen, 2011	No	Yes	Yes	State Provincial Office of Southern Finland	Moderate
Salami, 2015	Yes	NA	Yes	Office of Rural Health - Veterans Integrated Service Network 16 Clinical Systems Program, Telehealth, and Rural Access Program	Moderate
Salazar-Fernandez, 2012	Clinical: Yes Economic: NR	Clinical: Yes Economic: Yes	Clinical: Yes Economic: Yes	NR	Clinical: Moderate Economic: High
Sanchez-Ross, 2011	NR	NR	Yes	No conflicts reported	Moderate
Schwab, 2007	Yes	Yes	Yes	Bavarian State Ministry for Employment and Social Order, Family and Women; German Stroke Foundation	Low
Sejersten, 2008	Yes	Yes	Yes	Carl og Katy Kajsings Legat; Klestrup og hustru Henriette Klestrups Mendel	Moderate
Sharma, 2003	NR	Unclear	Yes	The Fan Fox and Leslie R. Samuels Foundation Inc.	High
Sharma, 2016	NR	NR	Yes	Penn Medicine Center for Health Care Innovation	High
Shin, 2015	Yes	NA	Yes	Industry conflicts declared	High
Smith, 2002	NR	Unclear	No	Commonwealth Department of Health and Aged Care	High
Southard, 2014	NR	NA	Yes	Indiana State Office of Rural health	Moderate
Stalfors, 2003	Unclear	Yes	Yes	Kunskap och Kompetens Foundation; Assar Gabrielsson Foundation; Jubilee Clinic Research Foundation; Goteborg Medical Society; ACTA Foundation	High
Steinman, 2015	NR	NR	No	Brazilian Ministry of Health	High
Stern, 2014	No	No	Yes	Canadian Patient Safety Institute; Central Community Care Access Center; Ministry of Health and Long Term Care	Moderate
Strymish, 2017	NR	NA	No	No conflicts reported	High
Switzer, 2009	Yes	Yes	Yes	NR	Moderate
Taqui, 2017	No	NA	Yes	Cleveland Clinic; Milton and Tamar Maltz Family Foundation	High
Taylor, 2007	Unclear	NA	No	HCA Foundation; Nashville Memorial Foundation; Research to Prevent Blindness	High
Theiss, 2013	NR	Unclear	Yes	German Ministry of Education and Research	Moderate
Thomas, 2009	Yes	NR	Yes	Agency for Healthcare Research and Quality; National Center for Research Resources; National Institutes of Health	Moderate

Author, Year (See Appendix C for full citation)	No or only small amounts of missing data? If missing data, was it handled appropriately?	No/low loss to followup or attrition?	Outcomes prespecified and reported?	Funding Source	Risk of Bias Rating
Traub, 2013	NR	NA	Yes	No conflicts reported	High
Tsai, 2007	Yes	Yes	Yes	Department of Health, Taiwan	Low
Tuulonen, 1999	Unclear	Yes	Yes	NR	Moderate
Wallace, 2008	NR	NR	Yes	No conflicts reported	High
Webb, 2013	Unclear	Yes	Yes	American Society of Echocardiography and the Seabury Foundation	Moderate
Willmitch, 2012	Yes	Yes	Yes	NR	Moderate
Wilson, 2005	Yes	Unclear	Yes	NR	Moderate
Yang, 2015	No	NA	Yes	AHRQ, HRSA Office for the Advancement of Telehealth; California Healthcare Foundation; William Randolph Hearst Foundations	Moderate
Young, 2014	NR	NR	Yes	NIDA grant	Moderate
Zahlmann, 2002	NR	NR	No	NR	High
Zaidi, 2011	NR	Yes	Yes	NR	Moderate
Zanini, 2008	NR	NA	Yes	NR	Moderate
Zarchi, 2015	Yes	Yes	Yes	NR	Moderate
Zilliacus, 2011	Yes	No	Yes	NHMRC Career Development Award and by Strategic Research Partnership Grant from the New South Wales Cancer Council	Moderate

NA = not applicable; NR = not reported

See Appendix C. Included Studies for full citations

Table G-3. Risk of bias: randomized controlled trials, part 1

Author, Year (See Appendix C for full citation)	Randomization adequate?	Allocation concealment adequate?	Eligibility criteria specified?	Groups similar or controlled for important baseline differences?	Participants analyzed in groups originally assigned?	Attrition low and/or adherence high?
Basudev, 2016	Yes	Yes	Yes	Yes	NR	No
Boman, 2014	Unclear	Unclear	Yes	Yes	Yes	Yes
Brennan, 1998 Brennan, 1999	NR	Yes	Yes	Yes	NR	Yes
Burns, 2017	Yes	Yes	Yes	Unclear	NR	Yes
Byamba, 2015	Yes	Unclear	Unclear	Unclear	Yes	Unclear
Cho, 2011	Yes	No	Yes	No	NR	Yes
Chua, 2001	No	NR	Yes	Yes	NR	No
Collins, 2004 Bowns, 2006	Yes	Yes	Yes	Unclear	Yes	No
Davis, 2011	NR	NR	Yes	Yes	Yes	Yes
Demaerschalk, 2010	Yes	Yes	Yes	Yes	NR	No

Author, Year (See Appendix C for full citation)	Randomization adequate?	Allocation concealment adequate?	Eligibility criteria specified?	Groups similar or controlled for important baseline differences?	Participants analyzed in groups originally assigned?	Attrition low and/or adherence high?
Eminovic, 2009	Yes	Yes	Yes	Unclear	Yes	Yes
Fortney, 2007	NR	NR	Yes	Yes	Yes	No
Fortney, 2013	Yes	No	Yes	Yes	Yes	No
Fortney, 2015	Yes	No	Yes	Yes	Yes	No
Fuertes-Guiro, 2016	NR	NR	No	Yes	NR	Yes
Gattas, 2001	NR	NR	No	NR	NR	No
Grabowski, 2014	NR	NR	Yes	Yes	Yes	Yes
Haukipuro, 2000	Unclear	NR	Yes	Yes	NR	Yes
Izquierdo, 2009	NR	No	Yes	Unclear	NR	Unclear
Jaatinen, 2002	No	Unclear	Yes	NR	NR	No
Krier, 2011	No	No	Yes	No	No	Yes
Kunkler, 2007	NR	NR	Yes	Yes	Yes	No
Loane, 1999	Yes	No	Yes	Unclear/NR	Unclear	Unclear
Loane, 2000	Yes	Yes	Yes	NR	NR	Yes
Martin-Khan, 2016	Yes	Yes	Yes	Unclear	NR	Yes
Mazighi, 2017	Yes	Yes	Yes	No	Yes	No
Meyer, 2008	Yes	Yes	Yes	Yes	Yes	Yes
Pak, 2007	Unclear	No	Yes	Yes	Yes	No
Patel, 2015	NR	Yes	Yes	Yes	NR	Yes
Piette, 2017	Yes	Yes	Yes	Yes	Yes	Yes
Poon, 2001	NR	NR	Yes	NR	Yes	Yes
Santamaria, 2004	NR	NR	Yes	No	NR	NR
Smith-Strom, 2018	Yes	Yes	Yes	Yes	Yes	Yes
van Gelder, 2017	Unclear	Yes	Yes	Yes	No	Yes
Vuolio, 2002	Unclear	No	Yes	Yes	NR	Yes
Wallace, 2002 Jacklin, 2003	Yes	No	Yes	Yes	Yes	Yes
Wallace, 2004	Yes	Yes	Yes	Yes	Yes	Yes
Whited, 2002	Unclear	Yes	Unclear	Yes	Yes	Yes
Whited, 2004	Unclear	Yes	Yes	Unclear	NR	Yes
Whited, 2013 Whited,2013b	Yes	Yes	Yes	Yes	Yes	Yes
Wong, 2006	NR	Yes	Yes	Yes	Yes	No

NR = not reported

See Appendix C. Included Studies for full citations

Table G-4. Risk of bias: randomized controlled trials, part 2

Author, Year (See Appendix C for full citation)	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**	**Outcome and confounder measures reliable and implemented consistently across groups?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Basudev, 2016	Yes	Yes	Yes	Diabetes UK; Royal College of General Practitioners	Moderate
Boman, 2014	No	Unclear	Yes	GE Healthcare and Philips Healthcare	Moderate
Brennan, 1998 Brennan, 1999	No	Unclear	Yes	Emergency Medical Associates; VTEL Corporation; Andris Tek, Inc.; Northwest Covenant Medical Center	High
Burns, 2017	No	Yes	Yes	Asset Strategic Plan - Central Integrated Regional Cancer Services; E0I-3, Statewide Telehealth Services; Royal Brisbane And Women's Hospital; Australian Centre for Health Services Innovation	Moderate
Byamba, 2015	No	Yes	Yes	National Science Council Project; Ministry of Health and Welfare, Taiwan; Taipei Medical University	Moderate
Cho, 2011	Unclear	No	Yes	Yonsei University College of Medicine; Ministry of Knowledge Economy; Korea Institute for Advancement in Technology	High
Chua, 2001	Yes	No	Yes	Research and Development Office of the Northern Ireland Department of Health and Social Services	High
Collins, 2004 Bowns, 2006	Yes	Yes	Yes	UK NHS R&D Health Technology Assessment Programme	Moderate
Davis, 2011	No	Unclear	Yes	Veterans Affairs	High
Demaerschalk, 2010	Yes	Yes	Yes	Arizona Department of Health Services; Mayo Clinic	Moderate
Eminovic, 2009	No	No	Yes	Dutch Ministry of Economic Affairs; Dutch Organization for Health Research and Development; KSYOS Health Management Research	Moderate
Fortney, 2007	Yes	Yes	Yes	Veterans Affairs; Veterans Affairs HSR&D; VA South Central Mental Illness Research Education and Clinical Center	Moderate
Fortney, 2013	Yes	Yes	Yes	National Institute of Mental Health	Moderate
Fortney, 2015	Yes	Yes	Yes	Veterans Affairs; Veterans Affairs HSR&D; VA South Central Mental Illness Research Education and Clinical Center	Moderate
Fuertes-Guiro, 2016	Yes	Unclear	Yes	No conflicts reported	High
Gattas, 2001	No	No	No	NR	High Risk
Grabowski, 2014	Yes	No	Yes	The Commonwealth Fund	High
Haukipuro, 2000	No	Unclear	No	Finnish Office for Health Technology Assessment	High

Author, Year (See Appendix C for full citation)	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**	**Outcome and confounder measures reliable and implemented consistently across groups?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Izquierdo, 2009	Yes	Yes	Yes	DHHS, NY State Dept. of Health; Children's Miracle Network	High
Jaatinen, 2002	No	No	Yes	Foundation of High Technology in Satakunta; Satakunta Hospital District	High
Krier, 2011	Yes	Yes	Yes	None	High
Kunkler, 2007	No	Unclear	Yes	Department of Health Research and Development; New Opportunities Fund	High
Loane, 1999	Unclear	Unclear	Yes	NHS R&D Programme	High
Loane, 2000	No	Yes	Yes	NHS R&D Programme; Southern Health and Social Services Board; Glaxo and Steifel	High
Martin-Khan, 2016	Yes	No	Yes	National Health and Medical Research Council (Australia)	Moderate
Mazighi, 2017	Yes	Yes	Yes	French Ministry of Health; SOS-Attaque Cerebral Association; Department a la Recherche Clinique et au Developpement de l'Assistance publique Hopitaux de Paris with the Unite de Recherche Clinique Paris Nord	High
Meyer, 2008	Yes	Yes	Yes	National Institutes of Neurological Disorders and Stroke	Low
Pak, 2007	Yes	Yes	Yes	VA Telemedicine and Advanced Technology Research Center	Moderate
Patel, 2015	No	Unclear	Yes	Nemours Fund for Children's Health	Moderate
Piette, 2017	No	Yes	Yes	Pole de Sante Universitaire Gennevilliers Villeneuve La Garenne	Low
Poon, 2001	No	No	Yes	NR	High
Santamaria, 2004	No	Yes	Yes	Western Australian Department of Health	High
Smith-Strom, 2018	Yes	Yes	Yes	Norwegian Directorate of Health and Innovation, Western Norway Regional Health Authority; Norwegian Diabetes Association; Western Norway University of Applied Sciences; Norwegian Research Council	Low
van Gelder, 2017	No	Yes	Yes	Dutch Kidney Foundation; Amgen	High
Vuolio, 2002	No	Yes	Yes	Finnish Office of Health Technology	High
Wallace, 2002 Jacklin, 2003	Unclear	Yes	Yes	National Health Service Research and Development Health Technology Assessment programme; British Telecom; Merck Foundation	Low
Wallace, 2004	Yes	Yes	Yes	NHS R&D HTA Programme	Low

Author, Year (See Appendix C for full citation)	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**	**Outcome and confounder measures reliable and implemented consistently across groups?**	**Outcomes prespecified and reported?**	**Funding Source**	**Risk of Bias Rating**
Whited, 2002	Yes	Yes	Yes	VA Health Services Research and Development Service; VA Health Services Research and Development Service Research Career Development Award	Moderate
Whited, 2004	No	No	Yes	VA Health Services Research and Development Service; VA Health Services Research and Development Service Research Career Development Award	High
Whited, 2013 Whited,2013b	No	Yes	Yes	Veterans Affairs HSR&D	Moderate
Wong, 2006	Unclear	Yes	Yes	Health Services Research Committee/ Health Care & Promotion Fund	Moderate

NR = not reported

See Appendix C. Included Studies for full citations

Table G-5. Risk of bias: pre-post studies

Author, Year (See Appendix C for full citation)	**Study Design**	**Eligibility prespecified**	**Random sample or consecutive/ all patients meeting inclusion criteria?**	**Design and analyses account for important potential confounding and modifying variables appropriately?**	**Valid and reliable measures used and adequately ascertained?**	**Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?**	**No or only small amounts of missing data? If missing data, was it handled appropriately?**	**No/Low loss to followup or attrition?**	**Outcomes pre-specified and reported?**	**Funding Source**	**Risk of Bias Rating**
Chu-Weininger, 2010	Pre-Post	Yes	Yes	Unclear	Yes	No	Yes	No	Yes	AHRQ; NIH	High
Endean, 2001	Pre-Post	No	Yes	No	NR	No	NR	Yes	Yes	Health Resources and Services Administration (HRSA) grant from the Office for the Advancement for Telehealth	High

Author, Year (See Appendix C for full citation)	Study Design	Eligibility prespecified	Random sample or consecutive/ all patients meeting inclusion criteria?	Design and analyses account for important potential confounding and modifying variables appropriately?	Valid and reliable measures used and adequately ascertained?	Outcome assessors and/or data analysts blinded or are primary outcomes unlikely to be biased?	No or only small amounts of missing data? If missing data, was it handled appropriately?	No/Low loss to followup or attrition?	Outcomes pre-specified and reported?	Funding Source	Risk of Bias Rating
Nikkanen, 2008	Pre-Post	No	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	Moderate
Mahendran, 2005	Pre-Post	Yes	Yes	No	Yes	No	Yes	Yes	Yes	NR	High
Zennaro, 2014	Pre-Post	Yes	No	Unclear	No	Unclear	NR	Yes	Yes	No conflicts reported	High

NR = not reported

See Appendix C. Included Studies for full citations

Table G-6. Risk of bias: economic assessments, part 1

Author, Year (See Appendix C for full citation)	Are competing alternatives clearly described?	Is the economic study design appropriate to the stated objective?	Are all important and relevant costs for each alternative identified?	Are all costs measured appropriately in physical units?	Are costs valued appropriately?	Are all important and relevant outcomes for each alternative identified?	Are all outcomes measured appropriately?	Are outcomes valued appropriately?
Datta, 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Doolittle, 1997	Yes	Yes	Unclear	Unclear	Unclear	NR	NR	NR
Dowie, 2007	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear
Eminovic, 2010	Yes	Yes	Yes	Yes	Yes	NR	NR	NR
Fortney, 2011	Yes	Yes	Unclear	Unclear	Unclear	Unclear	Yes	Unclear
Franzini, 2011	Yes	Yes	Yes	Yes	Yes	No	Yes	NR
Gray, 2009	Yes	Yes	No	Yes	Yes	NR	NR	NR
Harno, 2000	Yes	Yes	Unclear	Yes	Yes	NR	NR	NR
Harno, 2001	Yes	Unclear	Unclear	No	Yes	NR	NR	NR
Jacklin, 2003	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Lamminen, 2001	Yes	Unclear	No	Yes	Yes	Unclear	Yes	Yes
Langabeer, 2017	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

Author, Year (See Appendix C for full citation)	**Are competing alternatives clearly described?**	**Is the economic study design appropriate to the stated objective?**	**Are all important and relevant costs for each alternative identified?**	**Are all costs measured appropriately in physical units?**	**Are costs valued appropriately?**	**Are all important and relevant outcomes for each alternative identified?**	**Are all outcomes measured appropriately?**	**Are outcomes valued appropriately?**
Lilly, 2017	Yes	Yes	Unclear	Yes	Unclear	Unclear	Yes	Yes
Loane, 2001	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Marcin, 2004	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Moreno-Ramirez, 2009	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Natafgi, 2007	Yes	Yes	Unclear	Yes	NR	No	Yes	NR
Noble, 2005	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ohinmaa, 2002	Yes	Yes	Unclear	Yes	No	No	No	Unclear
Pak, 2009	Yes	Yes	Yes	Yes	Yes	NR	NR	NR
Rendina, 1997	Yes	Unclear	No	Yes	Unclear	No	Unclear	Unclear
Scuffham, 2002	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Specht, 2001	Yes	Yes	Yes	Yes	Yes	NR	NR	NR
Stalfors, 2005	Yes	Yes	Yes	Yes	Yes	NR	NR	NR
Thaker, 2013	Yes	Yes	Yes	Yes	No	NR	NR	NR
Tsitlakidis, 2005	Yes	No	Yes	Yes	Yes	NR	NR	NR
van der Pol, 2010	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes
Whited, 2003	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Xu, 2008	Yes	No	Yes	Yes	Yes	NR	NR	NR

NR = not reported

See Appendix C. Included Studies for full citations

Table G-7. Risk of bias: economic assessments, part 2

Author, Year (See Appendix C for full citation)	**Is an incremental analysis of costs and outcomes of alternatives performed?**	**Are all future costs and outcomes discounted appropriately?**	**Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?**	**Funding Source**	**Risk of Bias Rating**
Datta, 2015	Unclear	NA	No	Department of Veterans Affairs Office of Research and Development, Health Services Research and Development	Moderate
Doolittle, 1997	No	NR	No	NIH	High

Author, Year (See Appendix C for full citation)	**Is an incremental analysis of costs and outcomes of alternatives performed?**	**Are all future costs and outcomes discounted appropriately?**	**Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?**	**Funding Source**	**Risk of Bias Rating**
Dowie, 2007	No	NR	Yes	Department of Health and the Charitable Funds Committee of the Royal Brompton; Harefield NHS Trust	Moderate
Eminovic, 2010	Yes	NR	Yes	ZonMw (Dutch Organization for Health Research and Development), through the Health Care Efficiency Research programme	Moderate
Fortney, 2011	Yes	NA	No	VA HSR&D Center for Mental Health and Outcomes Research, VA HSR&D Research Career Awards, VA HSR&D Postdoctoral Fellowship Program, and the VA South Central Mental Illness Research Education and Clinical Center	Moderate
Franzini, 2011	Yes	NR	No	Agency for Healthcare Research and Quality; NIH/NCRR	Moderate
Gray, 2009	No	NR	No	The Princess Alexandra Hospital Private Practice Fund	Moderate
Harno, 2000	Yes	NR	No	The Finnish Office for Health Care and Technology Assessment (FinOHTA); European Union Social Fund	Moderate
Harno, 2001	No	NR	No	The Finnish Office for Health Care and Technology Assessment (FinOHTA); European Union Social Fund	High
Jacklin, 2003	No	NR	Unclear	NHS; BT and the MSD Foundation	Moderate
Lamminen, 2001	No	NA	No	Finnish Cultural Foundation	High
Langabeer, 2017	Yes	NR	No	Internal	High
Lilly, 2017	Yes	NA	No	None	Moderate
Loane, 2001	Yes	NA	Yes	NR	Moderate
Marcin, 2004	Yes	NA	No	California Telehealth and Telemedicine Center	Moderate
Moreno-Ramirez, 2009	Yes	NR	Yes	Instituto Carlos III	Low
Natafgi, 2007	Yes	NA	Yes	Leona M. and Harry B. Helmsley Charitable Trust; Federal Office of Rural Health Policy in the Health Resources & Services Administration (HRSA) to the Rural Telehealth Research & Journal of Telemedicine and Telecare Center; Avera Health	Moderate
Noble, 2005	No	NA	Yes	Unclear	Low
Ohinmaa, 2002	Yes	Unclear	Yes	Finnish Office for Health Technology Assessment (FinOHTA)	High
Pak, 2009	Yes	NR	No	U.S. Army's Telemedicine and Advanced Technology Research Center	Moderate
Rendina, 1997	Yes	NA	No	G. Wiliam Henry and the US NLM	High
Scuffham, 2002	Yes	Yes	Yes	National Health Service Research and Development Programme in Primary Dental Care and the Scottish Council for Postgraduate Medical and Dental	Moderate
Specht, 2001	No	NR	No	VA HSRD	Moderate

Author, Year (See Appendix C for full citation)	**Is an incremental analysis of costs and outcomes of alternatives performed?**	**Are all future costs and outcomes discounted appropriately?**	**Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?**	**Funding Source**	**Risk of Bias Rating**
Stalfors, 2005	No	NR	No	Kunskap och Kompetens Foundation, the Assar Gabrielsson Foundation; Jubilee Clinic Research Foundation; Gothenburg Medical Society; ACTA Foundation	Moderate
Thaker, 2013	No	No	No	NR	Moderate
Tsitlakidis, 2005	Yes	NR	No	NR	Moderate
van der Pol, 2010	Yes	NR	No	Scottish Centre for Telehealth	Moderate
Whited, 2003	Yes	NR	Yes	VA Health Services Research and Development Service	Moderate
Xu, 2008	Yes	NR	No	Commonwealth Department of Health and Ageing (Medical Specialist Outreach and Assistance Programme); Royal Children's Hospital Foundation; Queensland Health	Moderate

NR = not reported; NA = not applicable

See Appendix C. Included Studies for full citations

Appendix H. Strength of Evidence

Table H-1. Strength of evidence

Topic	**Outcome (KQ)**	**Number of Studies (N)**	**Study Limitations** (Low, Medium, High)	**Directness** (Direct, Indirect)	**Consistency** Consistent, Inconsistent, Unknown	**Precision** (Precise, Imprecise)	**Main Findings**	**Strength of Evidence Grade** (Insufficient, Low, Moderate, High)
Inpatient remote ICU	ICU Mortality (KQ1)[a]	11	Medium	Direct	Consistent	Precise	RR 0.69 (95% CI 0.51, 0.89) Lower ICU mortality with telehealth	Moderate
	Hospital Mortality (KQ1)[a]	12	Medium	Direct	Consistent	Precise	RR 0.76 (95% CI, 0.60, 0.95) Lower hospital mortality with telehealth	Moderate
	ICU LOS (KQ2)[a]	12	Medium	Direct	Consistent	Precise	Mean difference -0.39 (95% CI -0.99, 0.15) No significant difference in ICU LOS	Moderate
	Hospital LOS (KQ2)[a]	12	Medium	Direct	Consistent	Precise	Mean difference -0.14 (95% CI -0.96, 0.63) No significant difference in hospital length of stay	Moderate
	Harms (KQ3)	0	NA	NA	NA	NA	None expressly reported in identified articles	Insufficient
	Cost (KQ1)	6	Medium	Indirect	Inconsistent	Imprecise	Unable to summarize across studies: different methods and inconsistent results.	Insufficient
Inpatient specialty consultations	Mortality (KQ1)	12	Medium	Direct	Consistent	Imprecise	No significant difference in mortality	Low
Inpatient specialty consultations	Other clinical outcomes (KQ1)	6	Medium	Direct	Consistent	Imprecise	Clinical outcomes better with telehealth, but not significantly different	Low
	Intermediate outcome (KQ2)	27	Medium	Direct	Consistent	Imprecise	Reductions in LOS and wait time but all not significantly different; satisfaction measures good but not excellent	Low
	Harms (KQ3)	3	High	Direct	Consistent	Imprecise	Complications only reported in small studies of teleproctored surgery with high risk of bias	Insufficient
	Cost (KQ1)	7	High	Direct	Inconsistent	Imprecise	Cost savings due to avoiding transfers or travel, but not in all studies	Low

Topic	Outcome (KQ)	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
Emergency Care: Telestroke	Mortality In-hospital (KQ1)[a]	9	Medium	Direct	Consistent	Precise	RR 0.89 (95% CI 0.63, 1.43) No difference	Moderate
	Mortality 3 month (KQ1)[a]	7	Medium	Direct	Consistent	Precise	RR 0.94 (95% CI 0.82, 1.16) No difference	Moderate
	Function (KQ1)	15	Medium	Mixed	Consistent	Imprecise	Small differences in most studies were not statistically significant	Low
	tPA administration (KQ2)	13	Medium	Direct	Consistent	Imprecise	Reported tPA use increases; four significant the rest not significant or not tested	Low
	Time to Treatment (KQ2)	23	Medium	Direct	Inconsistent	Imprecise	Time to treatment is not significantly shorter in the majority of studies, with a minority reported shorter or longer times	Low
	Harms (all Hemorrhage) (KQ3)	11	High	Direct	Consistent	Imprecise	No difference in harms	Moderate
Emergency Care: specialty consultations	Clinical outcome (KQ1)	13	Medium	Direct	Consistent	Imprecise	Lower, but not statistically significant; mortality reported in most studies. Four studies report better clinical outcomes but only one difference was statistically significant	Low
	Intermediate outcome (KQ2)	19	Medium	Direct	Consistent	Precise	Increase in appropriate transfers and care, decrease in time to decision and time in ED	Moderate
	Harms (KQ3)	0	NA	NA	NA	NA	No studies reported data on harms from telehealth	Insufficient
	Cost (KQ1)	5	Medium	Direct	Inconsistent	Imprecise	Four studies report lower costs with better or no change in clinical outcomes; one reported higher costs	Low
Emergency Care: EMS or Urgent Care	Clinical Outcomes (KQ1)	10	Medium	Direct	Consistent	Precise	Telehealth reduced mortality for STEMI patients	Moderate
	Intermediate Outcomes (KQ2)	20	Medium	Direct	Consistent	Imprecise	Treatment is more timely and fewer air transfers or referrals to higher level of care	Moderate

Topic	Outcome (KQ)	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
	Cost (KQ1)	5	Medium	Indirect	Consistent	Imprecise	Lower costs due to avoided transfers or lower staff costs in most studies	Low
	Harms (KQ3)	1	Medium	Direct	NA	Imprecise	One study reported data that could be interpreted as harms, but not defined as such by the authors	Insufficient
Outpatient	Clinical Outcomes (KQ1): Dermatology	3	Medium	Direct	Consistent	imprecise	No significant different in clinical course	Low
	Clinical Outcomes (KQ1): Wound Care	5	Medium	Direct	Consistent	Precise	Better healing and fewer amputations	Moderate
	Clinical Outcomes (KQ1): Ophthalmology	0	NA	NA	NA	NA	No studies reported data on clinical outcomes	Insufficient
	Clinical Outcomes (KQ1): Orthopedics	0	NA	NA	NA	NA	No studies reported data on clinical outcomes	Insufficient
	Clinical Outcomes (KQ1): Dental	0	NA	NA	NA	NA	No studies reported data on clinical outcomes	Insufficient
	Clinical Outcomes (KQ1): Cancer	1	Medium	Direct	NA	Imprecise	Rate of serious side effects from chemotherapy reported in 1 study	Insufficient
	Clinical Outcomes (KQ1): Psychiatry	3 (in five articles)	Medium	Direct	Consistent	Precise	Decrease in symptoms and high remission rates	Moderate
	Clinical Outcomes (KQ1): Infectious Disease	3	Medium	Direct	Inconsistent	Imprecise	Inconsistent results for virologic suppression across studies	Insufficient
	Clinical Outcomes (KQ1):): Single Conditions with Dx Technology	0	NA	NA	NA	NA	No studies reported data on clinical outcomes	Insufficient
	Clinical Outcomes (KQ1): Single Specialties	6	Medium	Direct	Consistent	Precise	Positive effects on clinical outcomes including response to treatment	Moderate
	Clinical Outcomes (KQ1):Multiple Specialties	4	Medium	Indirect	Inconsistent	Imprecise	Inconsistent results across studies for unanticipated or avoidable health services utilization	Insufficient

Topic	Outcome (KQ)	Number of Studies (N)	Study Limitations (Low, Medium, High)	Directness (Direct, Indirect)	Consistency Consistent, Inconsistent, Unknown	Precision (Precise, Imprecise)	Main Findings	Strength of Evidence Grade (Insufficient, Low, Moderate, High)
	Intermediate Outcomes: Access (KQ2)	35	Medium	Direct	Consistent	Precise	Access in terms of time to or comprehensiveness of service is improved	Moderate
	Intermediate Outcomes : Management and Utilization (KQ2)	31	Medium	Indirect	Inconsistent	Imprecise	Mixed results with majority finding some benefit in terms of avoiding visits and similar diagnosis or management but a subset of studies report differences in diagnosis and management.	Low
	Intermediate Outcomes: Satisfaction (KQ2)	22	Medium to High	Direct	Inconsistent (across respondent types; consistent within types)	Imprecise	Satisfaction generally the same; patients higher if time/travel is avoided. Providers the same or slightly worse for telehealth	Low
	Cost (KQ1)	32	Medium to High	Direct	Consistent	Imprecise	Most but not all studies report cost saving, but calculations vary and most are dependent on patient avoided travel and loss of time	Low
	Harms (KQ3)	2	Medium	Indirect	Consistent	Imprecise	Two studies reported on different complications and serious adverse events related to treatments for different conditions	Insufficient

ED = emergency department, EMS = emergency medical services, ICU = intensive care unit, KQ = key question, LOS = length of stay, NA = not applicable, tPA = tissue plasminogen activator

[a] Based on studies included in meta-analysis

Appendix I. Exploratory Decision Modeling Methods and Results

Decision Model Topic Selection

Unlike a traditional decision analysis, where the question of interest is typically pre-specified, the novel purpose of this decision analysis was to address questions the systematic review (SR) alone cannot answer; the scope was dependent on the findings of the SR. Specifically, we used a decision model to estimate the potential economic impact of telehealth consultations for a selected clinical condition. In order to determine the clinical condition that was ultimately modeled, the studies included in the SR were categorized into one of three clinical practice settings: outpatient, inpatient, and emergency department or emergency medical services. These three settings were chosen as they were believed to be distinct in terms of the kind of consultations that may occur, represent different payment methodologies, and may require different technology and infrastructure. After the included studies were classified by practice setting, two investigators independently evaluated the studies included in the SR to identify a relevant topic, then sought feedback from authors of the SR and the project's technical expert panel.

The clinical areas within each practice setting were considered as potential topics for decision models (DMs) based on multiple criteria. Clinical areas with substantial published decision analysis or economic evaluation papers were excluded so that possible areas were limited to those with novel scientific questions. Next, those clinical specialties within practice settings with less than two published analyses that included both cost and outcome endpoints were excluded on the basis that they would lack adequate published information to inform a credible decision analysis. Additionally, studies that were classified as 'multiple' clinical areas or that included a broad mix of clinical indications, as was the case in many of the emergency department articles, were excluded as their scope was deemed too broad for our exploration of modeling approaches. The remaining clinical areas within each practice setting were considered by the two investigators for adequacy and scientific merit of potential decision analytic modeling.

Areas excluded given the identification of prior economic evaluations:

- Outpatient: dermatology, orthopedics
- Inpatient: intensive care units (ICU)
- Emergency department: psychiatry, radiology

Areas excluded due to our assessment of lack of publications/data to inform decision analysis:

- Outpatient: chronic pain, cardiology, dentistry, endoscopy, genetic counseling, hepatology, nephrology, oncology, pathology, rheumatology, urology
- Inpatient: burns/trauma, OB/GYN, psychology, wound care
- Emergency department: burns, cardiology

Final selection of two candidate areas for the decision analyses was made by consensus between the two members of the decision analysis team and then presented to the entire study team for consideration. These topics were then presented to the Technical Expert Panel for specific input on the modeling frameworks using an online survey, and ultimately neurosurgery consultations for patients with traumatic brain injury was selected.

Cost Model for Telehealth Neurosurgical Consultations

Model Context

Understanding the impact telehealth could have on cost is a major factor when considering policy changes to promote telehealth or when deciding to invest in implementing a telehealth system. In order to test the idea that a model could address questions the SR could not, we created a decision model designed to help health decision makers understand how telehealth consultations may impact health care costs for a given situation. We selected the use of telehealth for neurosurgical consultations by rural or community hospitals for patients with moderate to severe traumatic brain injury (TBI) for this model. This topic was selected for two reasons: 1) the systematic review did not identify a body of existing evidence that could adequately inform decisions about this use; and 2) neurosurgery is a specialty that is not widely available in all locations (such as rural areas) where people sustain TBIs.

The SR identified one randomized controlled trial (RCT) and three observational studies that assessed the impact of telehealth, but for three different patient populations in three different countries. A study in North Ireland found that patients with moderate TBI who were treated with telehealth had lower inpatient mortality but equivalent 3-month mortality as patients treated without telehealth.[3] Another study in North Ireland, the only RCT in this group, reported higher rates of laboratory tests and imaging in the telehealth group.[4] This study was the only to report economic outcomes and found telehealth consultations to cost on average approximately 47% more than in-person consultations. A study conducted in Italy reported no difference in mortality rates after telehealth was made available for patients hospitalized with minor TBI,[5] and a study in Israel identified no significant difference in mortality when patients with neurological symptoms (not necessarily TBI) were either transferred to a center with specialist care or managed with a telehealth consult.[6]

Traumatic brain injury (TBI) represents a significant source of mortality and serious disability globally.[7,8] Patients with TBI pose a challenge to the health care system in terms of resource demands for diagnosis and treatment planning for several reasons. Assessing a TBI patient and determining the severity of injury and appropriate treatment is complex. Much of the damage from TBI may not be from the primary injury, but from complications that develop in the hours and days following injury—these consequences are referred to as secondary injuries.[9] For example, brain swelling can lead to increased intracranial pressure and more cell damage. Whether or not these secondary injuries occur, how quickly they can be identified, and their severity all vary. This may make it difficult to accurately identify the extent of the injury at the time of initial assessment. Additionally, the current tool frequently used in TBI assessment, the Glasgow Coma Scale (GCS), can be difficult to administer, particularly out-of-hospital, and requires both training and experience for it to be used reliably.[10] While the severity of injury for some patients is likely to be obvious, warranting direct transport to a trauma center (e.g., those who have a low GCS score indicating coma or those with poly trauma), for a subgroup of patients with TBI, the severity of injury may not be readily apparent, and they may be transported to a hospital that is not a trauma center and does not have neurosurgical and neurotrauma expertise.

Patients in level I and II trauma centers are managed by neurosurgeons or neurointensivists. However, TBI patients are often transported or present to lower level centers/community hospitals given the uncertainties inherent in assessment and progression of TBI outlined above. These hospitals often have limited numbers of neurosurgeons or may lack these specialists altogether. Prior studies suggest that patients with mild TBI can be safely managed without neurosurgical consultation, even in the presence of abnormal CT scans.[11] However, in patients who may have moderate to severe TBI, care providers without specialty training and limited experience may be more reluctant to bypass neurosurgical consultation given the uncertainty, the potential severity, the potential need for neurosurgical intervention (NSI), and for fear of missing a feature of TBI that could lead to adverse consequences. Standard care at many of these hospitals is to stabilize the patient and transfer to a trauma center where this expertise is available.

There are several problems with transferring all suspected serious TBI patients and indications that this is not an efficient use of resources. A significant portion of patients transferred to trauma centers are discharged after a short stay or without undergoing surgery or treatment only available at the trauma center. This "over-transferring" blocks beds from patients who need trauma center care, reducing access. Also, transferring injured patients by air, sea, or land is costly, maybe harmful to the patient, and may place a burden on family who must travel to where their family member is treated. It is also important to acknowledge that many treatments for TBI are not benign and a transferred patient could be subjected to care with risks that may not outweigh the benefits.

An alternative to transferring all patients with a TBI to a trauma center is to use telehealth for neurosurgical consultation. This approach has the potential to allow providers at hospitals without this expertise to consult neurosurgeons to assess whether patients need to be transported. This could increase efficiency by allowing neurosurgeons to provide consultative services without travel, by avoiding transport and higher levels of care when they are not needed, by making them more available when they are, and provide both patients and onsite treating clinicians with peace of mind.

To supplement the systematic review and provide additional information for this specific use case, we developed and report a cost model of this type of telehealth consultation service for patients with moderate-severe TBI who are not transported to a high-level trauma center. Given that the telehealth intervention occurs in a short time period following injury and that the most severe TBI patients are likely to immediately transfer regardless of the availability of telehealth, we held patient outcomes constant (by assuming they would be equivalent). Although we found limited direct evidence, we believe this assumption is plausible based on indirect evidence from studies by Gale and colleagues on the impact of transfer distance and delay on outcomes in TBI.[12] This study found that emergency personnel in the field were triaging and transporting more severe cases directly to higher-level trauma centers, and that neither time nor distance to the trauma center independently contributed to mortality. These findings were incorporated into the model by assuming that most severe patients will result in immediate transport regardless of the availability of telehealth and will not be affected by the existence of the two options (telehealth and standard care) and holding the outcomes of patients the same in the two branches of the model.

Because there is not sufficient direct evidence on how or whether patient outcomes differ when the consultation is in person or via telehealth, we did a "what if analysis" assuming equivalent clinical outcomes, focusing on understanding the drivers of cost differences. This is a critical assumption that must be considered when interpreting the model findings as the estimates of economic impact are specific to this particular segment of the TBI population and are limited to considering cost differences, without incorporating potential variations in clinical outcomes.

Analytic Approach

The objective of the model was to explore the cost implications of using telehealth as an alternative to transferring all TBI patients from a community or rural hospital to a trauma center. The model assesses costs from the perspective of a health care system that must decide how to allocate the scarce resources of neurotrauma expertise and trauma center beds. This scenario could be evaluated at different levels or perspectives and including different types of costs. Approaches could focus on the patient's family's travel costs, the telehealth return on investment for an individual hospital, the impact on a health system or region that includes a mix of hospital types, or the cost to society of using limited resources inefficiently.

We chose to create a model from the perspective of a health care system because health systems organize care for patients across multiple settings and, in this way, are similar to some current organizational and payment demonstrations that cross settings. Also, health care systems are a type of entity likely to consider investing in telehealth. The decision for a health system, that is, the alternatives explored in the model, are: Alternative 1—transfer all patients to a trauma center as soon as possible, or Alternative 2—invest in telehealth to allow remote neurosurgical consultation. With a telehealth consultation, experts view scans, monitors, and the patient and interact with the treating physicians and nurses. The consulting specialists can contribute to the initial assessment and recommend transfer or advise on management in place if the patient is not transferred.

Data to parameterize the model were obtained from the published literature. The results of the model were costs and incremental costs.

The basics of the model are outlined below:

Model structure: Decision tree

Audience: Health care system decisionmakers/administrators; people considering whether to invest in telehealth for an integrated health care system

Perspective: Health care system

Target patient population: New head injuries initially transported to a community or rural hospital (not a level I or II trauma center)

Intervention: Telehealth consultations between the treating medical team at the community hospital and a neurosurgeon or neurointensivist at a trauma center about whether to transfer the patient to a trauma center or manage the patient in place with ongoing consultation.
Comparator: In-person assessment and management at the trauma center after transfer**Time horizon:** 30 days**Outcomes of interest:** Cost to deliver care, provider time, patient time, patient travel time

Model Structure

The decision analytic model was formulated as a decision tree (Figure I-1) using TreeAge Pro 2017. The base case patient in the model was an adult in whom moderate to severe TBI occurs in a rural area and did not result in a direct, emergent transfer to a level I or II trauma center, rather the patient was transported to a community or local hospital.

Patients with moderate to severe TBI who were not initially transported to a level I or II trauma center were assumed to either die early from their injury, either at the scene or during transport, or survive early mortality to be evaluated and treated. In our base case analysis, we assumed that early mortality rates between the two groups were equivalent,[12] though mortality is a possible patient outcome later, and patient outcomes were allowed to vary later in the trajectory. This is a critical assumption and may not directly apply to all TBI patients.

Our analysis was designed to identify the components of costs for telehealth with local patient management and usual care (immediate transfer) in this situation so that a health system considering telehealth could better understand what drives the costs of these two options.

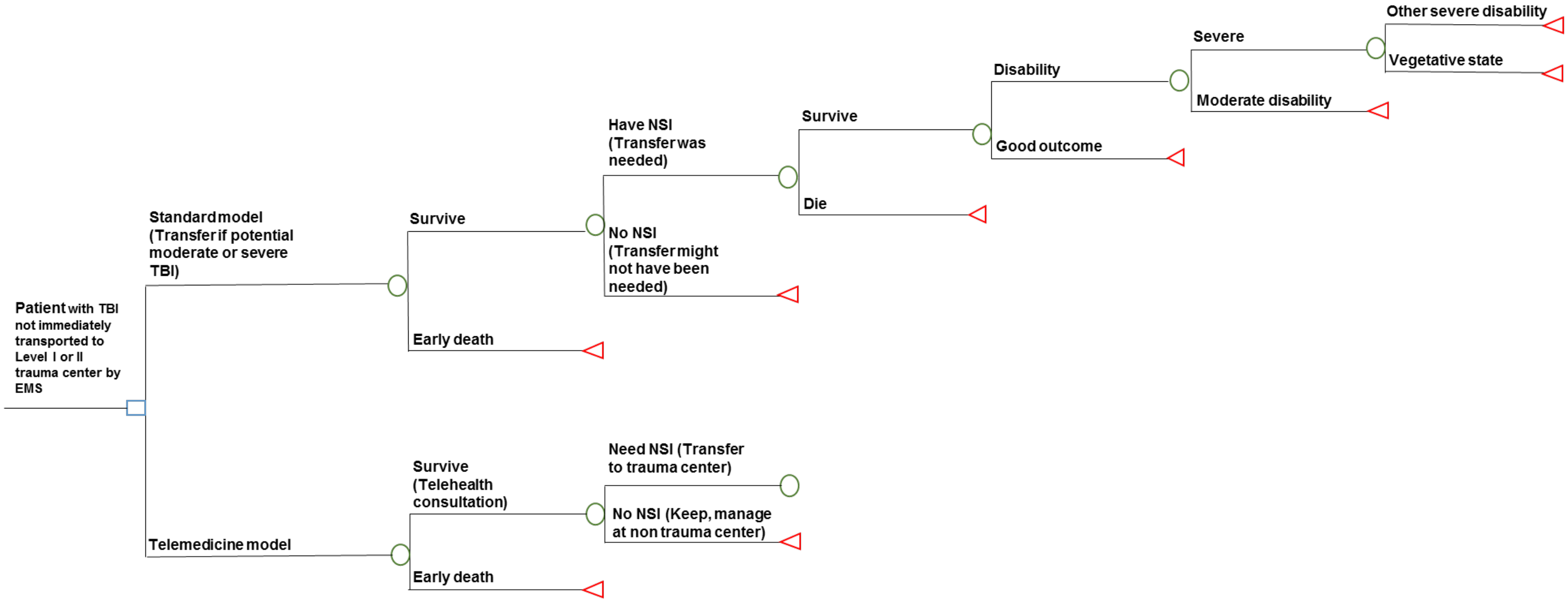
With telemedicine, some patients who would have been transferred are managed locally. We initially attempted to model both differences in costs and outcomes for these patients; however, we did not identify sufficient evidence to support whether the outcomes of these patients would be better or worse if they were transferred. Additionally, in many cases telehealth is implemented (and advocated for) based on the assumption of equivalence. Technology, image quality, and the accuracy of telehealth diagnoses have improved, and the studies included in the systematic review do not report harms due to inaccurate telehealth diagnoses. One potential cause of difference for outcomes of TBI, delay to time for treatment, has not been found to impact patient mortality for patients in well-organized trauma systems, though the comparisons made in this study are different from those evaluated in our model.[12]

Given no direct evidence of difference in clinical outcomes, we set outcomes to be equivalent to isolate the effect of telemedicine on costs. Because of the lack of direct evidence, there is uncertainty about which approach has better outcomes. Based on consultation with experts and the limited evidence available, we claim that our assumption of no difference is plausible, but acknowledge that other assumptions would be plausible as well.

Following initial survival of their injury, patients were modeled to undergo NSI depending on need, assessed through in-person consultation or teleconsultation. Transfer to a level I or II trauma center in the telemedicine model was contingent upon need for NSI following teleconsultation (i.e., patients who did not need NSI were managed at the rural or community facility). NSI was assumed to include one or more of the following procedures:[13] placement of an intraparenchymal intracranial pressure (ICP) monitor, placement of an external ventricular drain, craniotomy, angiographic study, brain targeted therapy (osmotic therapy, hyperventilation, or sedation to lower ICP), placement of a lumbar drain, or diagnosis of a missed spinal injury.

In order to allow for future evaluation of patient outcomes, the modeling framework was constructed to include optional tracking of patient status, however this feature is not included in the currently reported results. Patient outcomes were categorized based on the Glasgow Outcome Scale (GOS) at 6 months: (1) death, (2) persistent vegetative state, (3) severe disability (loss of independence) (4) moderate disability, and (5) good outcome (return to pre TBI level of function or independent function). These outcomes were assumed to be equivalent for patients in the standard and telemedicine models who were not triaged for immediate transport by personnel in the field.[12] Patients that survived their initial injury and did not undergo a NSI were assumed to have a good outcome.

Figure I-1. Neurosurgical telehealth consultations decision-analytic model (decision tree)



EMS = emergency medical services; NSI = neurosurgical intervention; TBI = traumatic brain injury
Squares represent choice nodes; circles represent chance nodes; triangles represent end nodes

Probabilities

The probabilities of possible events are summarized in Table I-1. Data to inform the individual node probabilities were currently unavailable from the published literature, thus the probabilities in each comparator were assumed to be equal. Though we note that a current project at the University of New Mexico funded through the Center for Medicare & Medicaid Innovation (CMMI) is collecting these data.

Table I-1. Parameters used in the neurosurgical decision-analytic model

Parameter	**Baseline**	**Low**	**High**	**Reference**
Probabilities				
Early Death	0.09	0.07	0.11	14
Neurosurgical Intervention (NSI)	0.10	0.08	0.12	14
Death after NSI	0.10	0.08	0.12	14
Disability after TBI	0.34	0.29	0.44	12
Severe Disability (conditional, vs. moderate)	0.50	0.41	0.61	12
Vegetative State (conditional, vs. other severe disability)	0.20	0.13	0.36	12
Costs				
In-person neurosurgical consultation	$103.00	$52	$155	15*
Neurosurgical teleconsultation	$100.85	$50	$151	15*
Ambulance transportation				
Land-based	$450.07	$225	$675	16
Air/Sea ambulance	$10,105.34	$5,053	$15,158	16
Percent land-based transfers	0.75	0.60	0.90	
Neurosurgery	$25,376	$12,688	$38,064	17***
ICU care	$11,913	$5,957	$17,870	17****
Hospitalization (nontrauma center)	$5,002	$2,501	$7,503	17******
Hospitalization (trauma center, no NSI)	$7,682	$3,841	$11,523	17*****
Hospitalization (trauma center with NSI)	$11,913	$5,957	$17,870	17****
Disability (moderate)	$85,000	$42,500	$127,500	18, Assumption
Disability (severe)	$1,000,000	$500,000	$1,500,000	18, Assumption
Vegetative state	$3,000,000	$1,500,000	$4,500,000	18, Assumption

NSI = neurosurgical intervention; TBI = traumatic brain injury
*CPT code 99221
**CPT code G0425
***DRG 025
****DRG 082, Traumatic stupor and coma, coma >1 hour with major complications
*****DRG 083, Traumatic stupor and coma, coma >1 hour with complications
******DRG 084, Traumatic stupor and coma, coma >1 hour without complications

Costs

We estimated costs from the health care system perspective. Cost estimates were obtained from a variety of sources including the literature and primary analyses (Table I-1).

For ambulance transfers from local hospitals to trauma centers, we abstracted mean unit costs of air and land ambulance transportation from the Marketscan® databases[16] from 2015 and assumed those mean costs of initial transportation were equivalent between the two scenarios and thus excluded them from the model. For the telemedicine model, we assumed that when transportation occurred, 75 percent occurred by road (as opposed to air or sea transport).

We also included costs of initial in-person consultation following TBI, telemedicine consultation following TBI, intensive care unit (ICU) costs, and hospitalization costs.

Hospitalization costs were categorized by the site of service using diagnosis related group classifications of complications within the same class of traumatic stupor and coma. While diagnostic related groups (DRGs) are the basis for payments, not actual costs, they are constructed to represent costs. Trauma centers generally receive higher reimbursements through modifiers, and the different levels are used as proxies as follows: trauma center admissions requiring NSI were assumed to be at the cost of admissions with major complications. Trauma center admissions without NSI were assumed at the cost of admissions with complications as a proxy for higher cost admissions at trauma centers relative to community (nontrauma) hospitals. Nontrauma center admissions were assumed at the no complication DRG.

We assumed that patients who were subject to early mortality incurred ICU costs but no additional hospitalization costs. We used a discount rate of 3 percent, as recommended by the 2nd Panel on Cost-Effectiveness in Healthcare and Medicine.[19]

Base Case Analysis

We estimated the incremental costs between the two decision options.

Sensitivity Analyses

We performed univariate (one-way) sensitivity analyses to assess the robustness of the model results. Each input parameter was varied independently as part of this sensitivity analyses to the minimum and maximum of its 95% confidence interval (CI) (or +/- 20% when the CI was not available), holding all other input parameters at their base case value. The resulting incremental cost values for each input's minimum and maximum were stored and plotted in tornado diagrams of descending order of influence on the overall model results.

Base Case Analysis Results

We present the results of the base-case analysis in Table I-2. Compared with the standard model, the telemedicine model results in cost savings of $1,937 per patient.

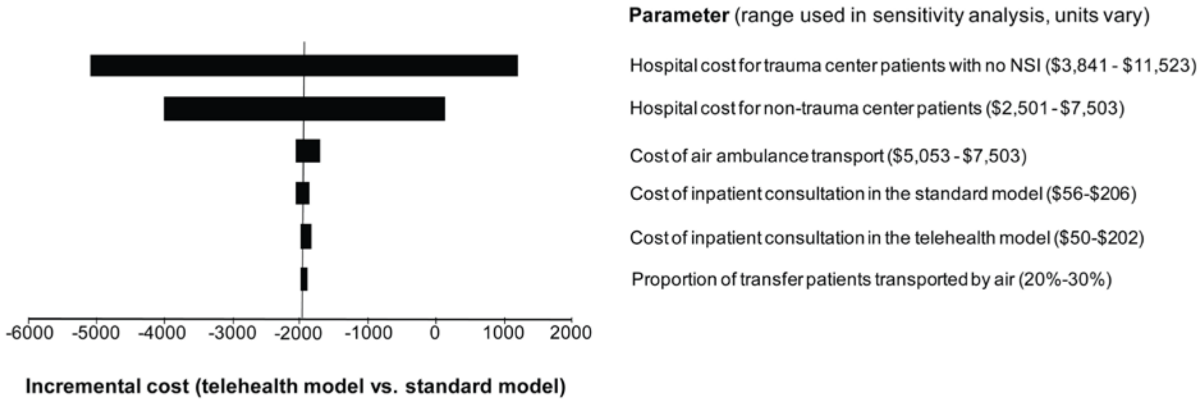
Table I-2. Modeled costs and incremental costs comparing the telemedicine model to the standard model

	Standard Model	Telemedicine Model
Mean cost	$42,377	$40,440
Incremental cost difference		$1,937

Univariate Sensitivity Analysis

We present the results of the univariate sensitivity analysis as a tornado diagram for the impact on incremental cost (Figure I-2) comparing the telemedicine model to the standard model. The width of the bars represents the potential range of the estimate given the potential variation in each variable with the other variables held constant. As indicated by their order (highest impact on top), assuming equal patient outcomes, the incremental cost of telehealth compared with the standard model was most sensitive to the cost of hospitalizations without NSI in a trauma center. Continuing down the diagram the next most influential features are the cost of hospitalizations in nontrauma centers, and the cost of air ambulance transportation. The lower positions in the diagram and the narrower bars show that the cost of the consultation, whether in person or via telehealth, make a much smaller contribution to the variance in the cost estimate.

Figure I-2. Tornado diagram of one-way sensitivity analysis showing impact of different variables on the incremental cost comparing the telemedicine and standard models



NSI = neurosurgical intervention

Model Summary

This analysis suggests that, assuming equivalent patient outcomes, for TBI patients not initially transported to a trauma center, the telemedicine model results in a decrease in health care system costs compared with standard management involving immediate transfer from the community hospital to a trauma center of any patients with potentially moderate or severe TBI. The analyses highlights that savings are driven by differences in the cost of hospitalizations at trauma centers and non-trauma hospitals (DRG reimbursements are used as a proxy for these differences as they are assumed to be relatively related to costs within the health system). This estimated decrease is realized by health systems through lower costs for managing a TBI patient in community hospitals relative to managing patients transferred to a trauma center where the patient did not require NSI. However, it is important to remember that this analysis assumes patient outcomes are equivalent for patients who are managed using a telehealth consultation and patients transferred to a trauma center for in-person assessment and management (standard care); an assumption for which the evidence is not robust.

Sensitivity analyses indicate that several model cost input parameters contribute to the overall uncertainty in the model results, and that the cost of the patient's hospitalization in different types of hospitals (with different costs) is the most important factor and more important than the cost of the telehealth consultation. Ultimately, assuming equivalent patient outcomes, the relative difference in hospital admission costs between community hospitals and trauma centers drives our findings. This means that cost savings are realized if telehealth allows a patient to remain and be treated in the lower cost hospital. But the magnitude of the savings is dependent on how much the costs differ for the specific hospital options for each patient.

Limitations of Cost Model

We based our selection of topics for the decision analysis on information available midway through the review as we wanted to create the products in parallel and report the results together. Our topic selection may have been different had we completed the review first or if we had established a priori data requirements for the decision analysis and structured the review to provide these. Though we used the SR to identify a topic for the DM, the modeling process allowed us to better understand some of the limitations in the existing literature, particularly in how studies report and analyze costs. In an iterative fashion, while constructing the DM, we revisited the included articles in the SR to better determine how investigators defined, reported and measured costs related to telehealth consultations. Ultimately, we found considerable variation in methods for acquiring and reporting cost data, making it difficult to assess cost outcomes across studies.

There are also several limitations to the decision modeling process that are important to consider. As with all models, the results are highly dependent on the analytic framework, assumptions, and available data to inform the calculations. An important assumption in this neurosurgical cost minimization model was equivalence in patient outcomes between the two approaches to patient management. Making this assumption allows consideration and evaluation of health care delivery costs in different settings given identical outcomes. This was done as rigorous data on outcome differences were not available.

Other models could be constructed that incorporate clinical outcomes as well as costs. These would provide more information and would allow the consideration of the balance of costs and outcomes. For example, if mortality or functional outcomes are worse for telehealth, then savings from telehealth could be outweighed by loss of life or disability. Alternatively, if outcomes are the same, consideration of the use of telehealth could focus exclusively on costs. It is also possible that telehealth could produce better outcomes if in-person consultations result in unneeded transfers and care or if transfers for in-person care negatively impact the patient's family by requiring them to travel further in order to be with the patient.

If systematic differences or uncertainty exist, then the cost modeling framework would be less relevant and a different model incorporating outcomes would be needed to make valid comparisons of the economic value of the two approaches to care. The model was built to allow inclusion of patient outcomes following treatment for cost benefit analyses in the future. When more and better data become available, the impact on mortality or quality adjusted life years (QALYs) could be used to inform judgements about the value of additional costs or savings given the patient benefits.

Most of the input parameters for the model were taken from the literature – informed by our systematic review, but some were also assumptions based on clinician and economist input. Initial transportation costs also represent an important cost component, which we assumed to be equivalent between the standard and telemedicine models as a conservative assumption. More granular data on the distances of patient transportation between the two scenarios could be important. Costs and potential outcomes could be affected by the differences in time and distance when all patients in the standard model are being transported to a trauma center versus a closer community hospital.

A more definitive test of the hypothesis that telehealth consultations provide better value for money could come from a trial-based economic evaluation, where patients are randomized to either standard management or a telehealth consultation. Given the limitations of the data available, we chose conservative values when multiple options were available, thereby underestimating overall effects.

Key Findings and Implications

The base case analysis found that, given the assumptions above, compared with the standard model of no telehealth consultation and transfer of patients with suspected moderate or severe TBI to a trauma center, the telemedicine model results in an incremental cost savings of $1,937 per patient from the perspective of the health care system and payers. Sensitivity analyses indicate that telehealth may be cost-saving to the health care system and payers, but these savings are dependent on the exact costs and relative differences in costs for the different types of hospitalizations (i.e., the costs of the Level I or II trauma center for a patient not requiring a neurosurgical intervention (NSI) and the costs for a patient not transferred and cared for at the local hospital).

Specifically, the sensitivity analyses identified that the parameter that had the highest influence on the model results and that could change the direction of conclusion (e.g. cause the telehealth model to be more expensive) was if the cost of treating patients who did not require NSI in a trauma center reached the top of its range. In addition, when community hospital costs for NSI patients approached the upper end of its range, closing the difference in cost between community hospital and trauma center admissions, the telemedicine model became more costly. Furthermore, the assumption of equivalence in outcomes is fundamental to the relevance of these findings. In a scenario where mortality outcomes are not equivalent, any difference in costs could be easily outweighed by incremental differences in life years gained or lost.

These findings may be most relevant to alternative payment and service delivery models, such as accountable care organizations, and value based insurance designs, which have the ability to allocate patients to different settings, or from the perspective of payers/insurers who are responsible for reimbursement across several types of hospitals. Telehealth consultations appear to increase efficiency for a multi-hospital health system or payers, in that telehealth can be used to decide to treat patients in a lower cost setting (in this case in the local hospital), rather than transferring a patient who does not need NSI to a higher cost setting (e.g. a tertiary care center). However, if telehealth is only evaluated from the perspective of a single hospital, the conclusion might differ. For example, a community hospital may see an increase in revenue from patients who are retained in-house rather than transferred with telehealth but would not see the savings a health system would from avoiding a more expensive hospitalization. From these two different perspectives, the return on an investment in telehealth would differ because the amount of savings or change in revenue are likely different. Modeling could be expanded to compare these perspectives and identify when telehealth does result in savings.

It is also important to consider that the differences in costs may also vary across regions, depending on what services are available and how the health care system is organized. For example, some regions have diverse systems with independent community hospitals while others are covered by larger systems consisting of both community and tertiary care centers under the same umbrella organization. According to the 2016 Snapshot of U.S. Health Systems from the Comparative Health System Performance Initiative, these larger systems represent almost 43% of hospitals in the U.S.[20] with at least 18 hospitals per system. For these larger systems, the lower overall cost of care when telehealth is used to support treatment of patients who do not need NSI in lower cost hospitals represents a real opportunity for both cost and staff efficiency.

Furthermore, the reimbursement structure or payment model matters substantially in both the cost estimates and the incentives. For example, in an accountable care model, a large health system could reduce overall costs of care by shifting patients to the lower cost setting while retaining the same per person payment/reimbursement. However, under fee-for-service contracts, the hospitals may be reimbursed based on the location of care (regardless of what was needed) and the insurer/payer may or may not realize a difference in costs, depending on the reimbursement scheme and DRG modifiers. Thus, if the reimbursement in the community hospital were the same as the trauma center for a patient who did not undergo NSI, then there would be no cost difference.

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