Draft Comparative Effectiveness Review

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Telehealth for Acute and Chronic Care Consultations

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Purpose of Review

To evaluate the effectiveness of telehealth consultations for inpatient, emergency, and outpatient care.

Key Messages

- Remote intensive care unit (ICU) consultations likely reduce ICU mortality and ICU length of stay (LOS); specialty telehealth consultations likely reduce the time patients spend in the emergency department; 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 telehealth consultations may: reduce inpatient LOS and costs; may improve outcomes and reduce costs for emergency care due to fewer transfers; and may reduce outpatient visits and costs due to travel (low strength of evidence in favor of telehealth).
- Current evidence reports no difference in overall hospital LOS with remote ICUs, 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 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 as well as outcomes when telehealth is used for consultations.

This report is based on research conducted by the XXXXX Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. XXX-20XX-XXXXX). 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 health care decisionmakers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of health care 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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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 health care in the United States. These reviews provide comprehensive, science-based information on common, costly medical conditions, and new health care 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

AHRQ expects that these systematic reviews will be helpful to health plans, providers, purchasers, government programs, and the health care system as a whole. Transparency and stakeholder input are essential to the Effective Health Care Program. Please visit the Web site (www.effectivehealthcare.ahrq.gov) to see draft research questions and reports or to join an e-mail list to learn about new program products and opportunities for input.

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, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

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Key Informants

In designing the study questions, the EPC consulted several Key Informants who represent the end-users of research. The EPC sought the Key Informant input on the priority areas for research and synthesis. Key Informants are not involved in the analysis of the evidence or the writing of the report. Therefore, in the end, study questions, design, methodological approaches, and/or conclusions do not necessarily represent the views of individual Key Informants.

Key Informants must disclose any financial conflicts of interest greater than $10,000 and any other relevant business or professional conflicts of interest. Because of their role as end-users, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any conflicts of interest.

The list of Key Informants who provided input to this report will be added for the final version.

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 $10,000 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.

The list of Technical Experts who reviewed the report will be added for the final version.

Peer Reviewers

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 does not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $10,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential non-financial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential non-financial conflicts of interest identified.

The list of Peer Reviewers who reviewed the report will be added for the final version.

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 1997 to November 2016. 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 included in 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 synthesized the findings using 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 7,714 potentially relevant citations. Upon review, 7,071 were excluded and the full text of 643 articles was pulled for review. Of these, 145 articles met our criteria and were included—31 articles evaluated inpatient consultations, 33 emergency care, and 81 outpatient care.

The overall results varied by setting and clinical topic, but generally found telehealth either better or no different than comparators on some outcomes. Remote intensive care unit (ICU) consultations likely reduce ICU mortality and ICU length of stay (LOS); specialty telehealth consultations likely reduce the time patients spend in the emergency department; 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 telehealth consultations may reduce inpatient LOS and costs; may improve outcomes and reduce costs for emergency care due to fewer transfers; and may reduce outpatient visits and costs due to travel (low strength of evidence in favor of telehealth). Current evidence reports no difference in overall hospital LOS with remote ICU consultations, 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 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, the 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 several factors (e.g., how alternatives are organized, that is, if the telehealth and in-person options are part of the same health care system) in addition to any difference in cost of a telehealth versus an in-person consultation.

Conclusions. In general, the evidence supports the effectiveness of telehealth consultations; however, the evidence is stronger for some applications, and less strong or insufficient for others. Exploring the use of a cost model underscored that the economic impact of telehealth consultations depends on the perspective used in the analysis. Future research should focus on better measuring harms or unintended consequences, and collecting data on the costs and economic impacts from different perspectives (e.g., health care systems, payers, patients, or society).

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Evidence Summary

Background

Telehealth is the use of information and telecommunications technology to provide or support health care 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 slow.[9,10]

With improvement in technologies,[11] changes in payment policies, and evolving models for health care in general and telehealth in particular, the possibility exists for an 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 decisionmakers 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 decisionmakers.

This review focuses on the effectiveness of telehealth for provider-to-provider consultations. **Telehealth consultations** are defined as the use of telehealth designed 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 health care 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?
   The 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 health care 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 methods for this systematic review follow the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*[12] and are 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 1997 through November 2016 (note: this will be updated during the public and peer review period). 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, and 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 qualitative synthesis. We were unable to conduct meta-analyses due to the heterogeneity of outcomes, study designs, and settings. 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*.[12] 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*.[12] 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.

Systematic Review Results

The literature searches yielded 7,714 potentially relevant citations. Upon review of the article titles and abstracts, 7,071 were excluded and the full text of 643 articles were pulled for review. Of these, 145 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 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 (67 articles or 46%); 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 almost two-thirds of the studies (63%). Most of the studies (72%) 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). One-quarter were randomized controlled trials, and approximately 3 percent were pre-post studies in which outcomes for the same patients were compared prior to 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 or emergency medical services (ED/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, C, and D, and the accompanying text.

Inpatient Telehealth Consultations

Remote Intensive Care Units

- Intensive care unit (ICU) mortality and length of stay (LOS): The results of the majority of studies suggest that remote ICUs (ICUs with the critical care specialists at a different location than the patients) decrease ICU mortality and LOS (moderate strength of evidence).
- Overall hospital mortality: Remote ICUs appear to decrease hospital mortality, although the impact is less clear with some studies reporting lower mortality and some finding no significant differences (low strength of evidence).
- Hospital LOS: Most studies reported no significant reduction after the implementation of ICUs (low strength of evidence).
- Costs: Not every study analyzed the costs of remote ICUs or their impact on revenue; those that did used different methods, and their conclusions were inconsistent, with half reporting savings or increased revenue and half reporting increased costs (insufficient evidence).
- Harms: None of the included studies specifically addressed potential harms (insufficient evidence).

We identified 13 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. All but one of the studies of remote ICUs (teleICUs) are "before-after" studies that compare outcomes from a period before the implementation of the remote ICU to the period after this model of care was in operation in the same hospital or group of hospitals; one compared hospitals that implemented teleICUs to matched hospitals that did not. These studies did not provide detail on the nontelehealth care, though it likely included a mix of care by nonspecialists, less 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. However, none of these factors clearly differentiate between studies reporting a clear benefit from remote ICUs and those reporting no benefit or possible benefit.

Inpatient Specialist Consultations

- Clinical outcomes: Mortality or serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability) improves with telehealth consultations across specialties, but these differences are not always statistically significant (low strength of evidence).
- Intermediate outcomes: The impact of telehealth consultations on intermediate outcomes such as hospital length of stay, 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).
- Costs: Costs were compared in only three studies, two of which report savings (low strength of evidence).
- Harms: Only one study explicitly examined harms (insufficient evidence).

We identified 19 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 patient's location 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, split between retrospective and prospective cohort designs that compare hospitals with and without telehealth. Another four studies were before-after studies of telehealth implementation, and there was one randomized trial. The cohort studies did not provide details on the nontelehealth care while the trial compared endoscopic surgeries done by a less experienced surgeon with a teleproctor to the surgeries done by the expert surgeons. Overall, inpatient telehealth consultations are not well-described, making it problematic to relate characteristics of the intervention or environment to effectiveness.

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)	10	Lower ICU mortality with telehealth	Moderate
	Hospital Mortality (KQ1)	8	Lower (but not always statistically significant) mortality or no difference with telehealth	Low
	Cost (KQ1)	5	Unable to summarize across studies: different methods and inconsistent results	Insufficient
	ICU LOS (KQ2)	8	Shorter ICU length of stay with telehealth	Moderate
	Hospital LOS (KQ2)	8	No difference in hospital length of stay	Low
	Harms (KQ3)	0	None reported in identified articles	Insufficient
Inpatient specialty consultations	Clinical outcome (KQ1)	11	Better clinical outcomes with telehealth but small differences and most not significantly different	Low
	Cost (KQ1)	3	Cost savings due to avoiding transfers or travel when telehealth is used	Low
	Intermediate outcome (KQ2)	14	Reductions in LOS and waiting time but all not significantly different; satisfaction measures good but not excellent	Low
	Harms (KQ3)	1	One study of teleproctored endoscopic surgery reported no difference in complications or harms compared to standard procedures	Insufficient

ICU = intensive care unit; KQ = Key Question; LOS = length of stay

Emergency Care Telehealth Consultations

We split emergency care into three subtopics:

- Telestroke: The results find that telestroke does not result in changes in mortality or in harms (low strength of evidence). However, telestroke does increase tPA use, an intermediate outcome (low strength of evidence).
- Specialty consultations in ED: 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). Teleconsultations have a positive effect on intermediate outcomes such as appropriate triage and transfers and shorter time in the ED

(moderate strength of evidence). Analysis of costs was available in only a few studies and the results favored savings but were not consistent. Some studies reported increases in costs with telehealth and others reported savings (low strength of evidence), and no information was available about harms (insufficient evidence).

- EMS and Urgent Care: Six studies evaluated telehealth for EMS and urgent care. In general, the studies were either narrowly focused or provided limited data and analyses. Only one study provided information on a clinical outcome (mortality) and no studies reported harms (insufficient evidence). Telehealth led to a reduction in air transfers and referrals to higher-level care following urgent care (low strength of evidence), and these reductions contributed to estimates of lower costs (low strength of evidence).

The 12 studies that investigated telestroke all compared outcomes to a prior time period or another hospital without telestroke. In these cases, patients received care for their stroke but after a delay, which may have limited their treatment options. Ten of the 11 studies of specialist consultations in EDs were similar to telestroke in that they were before-after or cohort studies that did not provide detailed information on the care without telehealth. The one exception was a study that compared no consultation or phone consultations with telehealth consultations for the care of pediatric patients.[13] In the eight 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 (KQ1)	8	No difference in mortality when telehealth and no telehealth are compared	Low
	tPA administration (KQ2)	7	tPA use increases (significant in 3 studies; not in 3 studies) with use of telehealth	Low
	Harms (KQ3)	4	No difference in harms or increase in negative outcomes	Low
Emergency Care: Specialty Consultations	Clinical outcomes (KQ1)	5 (6 articles)	Lower mortality or better outcomes with telehealth, but not always statistically significant	Low
	Cost (KQ1)	3	2 of 3 studies report lower costs with telehealth	Low
	Intermediate outcomes (KQ2)	12	Increase in appropriate transfers, decrease in time to decision and time in ED with telehealth compared to standard care	Moderate
	Harms (KQ3)	0	No studies reported data on harms from telehealth	Insufficient
Emergency Care: EMS or Urgent Care	Clinical Outcomes (KQ1)	1	Single study of prehospital telehealth triage of patients with cardiogenic shock in Italy (n=121 patients)	Insufficient
	Cost (KQ1)	3	Lower costs due to avoided transfers when telehealth is used	Low
	Intermediate Outcomes (KQ2)	4	Fewer air transfers or referrals to higher level of care with telehealth	Low
	Harms (KQ3)	0	No studies reported data on harms	Insufficient

ED = emergency department; EMS = emergency medical services; KQ = Key Question; tPA = tissue plasminogen activator

Outpatient Telehealth Consultations

- Clinical outcomes: Clinical outcomes were reported in approximately one-quarter of the studies of telehealth consultations and in 5 of the 10 clinical topics. The reported outcomes were general and included response to treatment, symptoms, and clinical course. In four topics, the evidence demonstrates benefits (better healing in wound care, fewer missed fractures in orthopedics, higher response to treatment and reduced symptoms in psychiatry, and improvement in chronic condition outcomes), while in dermatology, patients either improved or there were no differences in clinical outcomes when telehealth was used instead of in-person assessment (moderate strength of evidence).
- Intermediate outcomes
    - Access: Telehealth consultations improved access by reducing wait times and time to treatment in dermatology and increasing the number of patients receiving indicated diagnostic tests (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. In some specialties, such as orthopedics, telehealth consultations produced similar management plans and increased adherence to guidelines. Across clinical topics the findings were inconsistent about agreement on diagnosis and management, with some studies reporting telehealth and the alternative form of care were consistent while other studies identified differences in diagnoses and proposed management plans (low strength of evidence).
    - Satisfaction: Patient 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 the differences were rarely statistically significant (low strength of evidence).
- Costs: Studies reported lower costs due to reductions in the number of transfers or lower costs specifically due to transportation but the rigor of the measurement, imprecision of estimates and inconsistency in the magnitude of the effects reduces confidence in these findings (low strength of evidence).
- Harms: None of the studies explicitly examined harms (insufficient evidence).

The 81 included articles evaluating telehealth consultations in the outpatient setting are summarized in Table C below. Detailed results split into 10 clinical topics are provided in the full report and an overview by clinical topic is provided in Table D. All of these studies addressed at least one intermediate outcome and we organized these into three categories: access, management and utilization, and satisfaction.

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)	21	Improved or similar clinical outcomes with telehealth compared to other modes of consultation	Moderate
Cost (KQ1)	29	Most but not all 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)	10	Access in terms of time to or comprehensiveness of service was improved with telehealth	Moderate
Intermediate Outcomes: Management and Utilization (KQ2)	32	Mixed results with majority finding some benefit in terms of avoiding visits and similar diagnosis or management but a subset of studies report disagreements in diagnosis and management with telehealth compared to standard care.	Low
Intermediate Outcomes: Satisfaction (KQ2)	18	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

Table D. Outpatient care telehealth consultations: overview by clinical topic

Clinical Topics	Number of Articles	Clinical Outcomes Including Harms	Intermediate Outcomes	Cost
Dermatology	21	✖ no differences in clinical course	✓ increased access	**?** mixed**:** lower costs in some but not all due to avoided travel and lost productivity
Wound Care	5	✓ better healing (2 studies)	✓ fewer hospitalizations	✓ lower costs
Ophthalmology	3	⊘	✓ fewer surgeon visits; high satisfaction	✖ no difference except patient travel
Orthopedics	7	✓ fewer missed fractures (1 study)	✓ improved quality, similar management	✓ lower costs
Dentistry	3	⊘	✓ reduced time to treatment	✖ outreach clinics were less expensive than telehealth
Cancer	5	⊘	✓ quality of care and satisfaction better or no difference	✓ lower costs
Psychiatry	6	✓ higher response to treatment; decreased symptoms	✓ higher satisfaction	⊘
Single Specialties with Diagnostic Technology	10	⊘	✓ better access and management of care	✓ lower costs due to patient costs
Single Specialties	11	✓ improvements in chronic condition outcomes	**?** effects on satisfaction and management are unclear	✖ some limited impact on costs
Multiple Specialties	10	⊘	✓ improved management and higher satisfaction **?** unclear impact on emergency department and hospitalizations	**?** mixed**:** lower costs in two studies; higher in one large trial

Key: ✓ superior (telehealth benefit), ✖ no difference or inferior (telehealth no benefit), **?** inconclusive (inconsistent results), ⊘ no evidence

For the 10 clinical topics, five reported clinical outcomes (dermatology, wound care, orthopedics, psychiatry and mixed single specialties). In four of these five the body of evidence supports better outcomes with telehealth, while in one (dermatology) no difference in clinical course was reported. For all 10, there were reported improvements in at least some intermediate outcomes. Cost outcomes were identified for nine out of ten 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.

An 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 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.

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. This is commonly done in decision modeling and allowed 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 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 included studies 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 as a way to acknowledge that these finding 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 did not attempt quantitative synthesis using meta-analysis; 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 a “what if” 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 decisionmaker 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 over 140 articles that evaluated the effectiveness of telehealth consultations, there are several questions that 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 the rural or under resourced organizations likely to benefit from telehealth. Future studies are also needed that both expand and standardize outcomes using common metrics across uses of telehealth for consultation to facilitate comparisons across clinical areas. This would help decisionmakers prioritize investments in telehealth. Studies are also needed that consider different perspectives (e.g., patient, payer, hospitals, referring providers, consultants). For example, it is important to decide for a decision analysis if the alternative to a telehealth consultation is a face-to-face consultation or non-receipt of a service/no consultation. Additionally, very few studies measured and reported on harms, adverse events or unintended consequences. Without better information about harms, decisionmakers can only speculate about what they might be.

Efforts to conduct a decision analyses also highlighted the importance of clearly specifying the options being compared, or what is "usual care." The use of telehealth for consultations seems to greatly exceed the amount of published evaluation, suggesting that data may be available but as yet unpublished, and that additional data could be analyzed and used to strengthen the conclusions that can be made about telehealth consultations. A major evolution of the research in this area would be to focus in the future on hybrid studies, that is, studies that combine effectiveness and implementation assessments.

The decision analysis efforts also highlighted the importance of perspective in the context of evaluating telehealth. The assessment of telehealth consultations differs by perspective (payer, a health system, a hospital, a practice group, an individual provider, a patient, or society). Most studies did not clearly state a perspective, though a single organization (e.g., a hospital or practice group) was implied. This seems unnecessarily limiting, and more studies at a broader level 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.

Another key item missing in current studies is specific information about the characteristics of the context and how they influence the effect of telehealth on outcomes. Having more information on costs and outcomes (effectiveness) could be facilitated by collecting economic data alongside trials or observational studies. More definitive tests of hypotheses 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. Alternatively, 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.

Conclusions

Although it is not possible to make a general statement about the effectiveness of telehealth consultations across all settings and uses; it is possible to conclude that telehealth is likely more effective than usual care in specific situations: remote ICU consultations reduce ICU mortality and LOS; 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 have a positive impact on clinical outcomes (e.g., improvements in wound healing and symptoms) and increase access to care.

For other uses the strength of evidence is lower, but there is some evidence of benefit for some uses while for other uses studies reported no difference with telehealth. Telehealth consultations may improve inpatient care, emergency stroke care, and the management of and satisfaction with outpatient consultations across several specialties. Current evidence reports no difference in overall hospital LOS with remote ICU consultations, 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). Potential harms 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, methods of collecting information, and methods of measuring costs and charges. Studies of economic outcomes in an interdependent health care system also may produce mixed results, as costs and savings may not accrue to the same organization.

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. 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 into potential underlying causes of the inconsistency of results across evaluations of telehealth by quantifying the importance of differences in costs across settings and estimating where savings are likely to accrue in the system. While our 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 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 health care 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 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 slow.[9,10]

With improvement in technologies,[11]changes in payment policies, and evolving models for health care in general and telehealth in particular, the possibility exists for an 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.

This project focuses on one role: telehealth for consultations. Telehealth for consultations uses technology to allow health care providers to involve other providers, often specialists, in 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,[12] burn care,[13] and infectious disease.[14-16] 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 project is to maximize the utility of available research by presenting the results in formats that support decisionmakers 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 decisionmakers.

Definitions of Telehealth and Telehealth Consultation for This Project

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

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. The questions were reviewed, reorganized, and refined by the project team and revised after input from the Technical Expert Panel (TEP). There was no formal topic refinement for this project.

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

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 health care 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:
   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 HIPAA requirements,
f. Settings including:
    - Type of health care 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 vs. 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 [RVUs]) or limits on visits.
    - Any eligibility requirements for payment based on patient, provider, setting, or context 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)?

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 health care organizations).
- Payers for health care 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).

Comparator

- Other locations, patients, or time periods that used any alternative to telehealth. 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 health care.
    - Provider satisfaction, behavior, and decisions such as choice of treatment or antibiotic stewardship.
    - Time to diagnosis and time to treatment.
- 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 outcome as Key Question 4.

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.

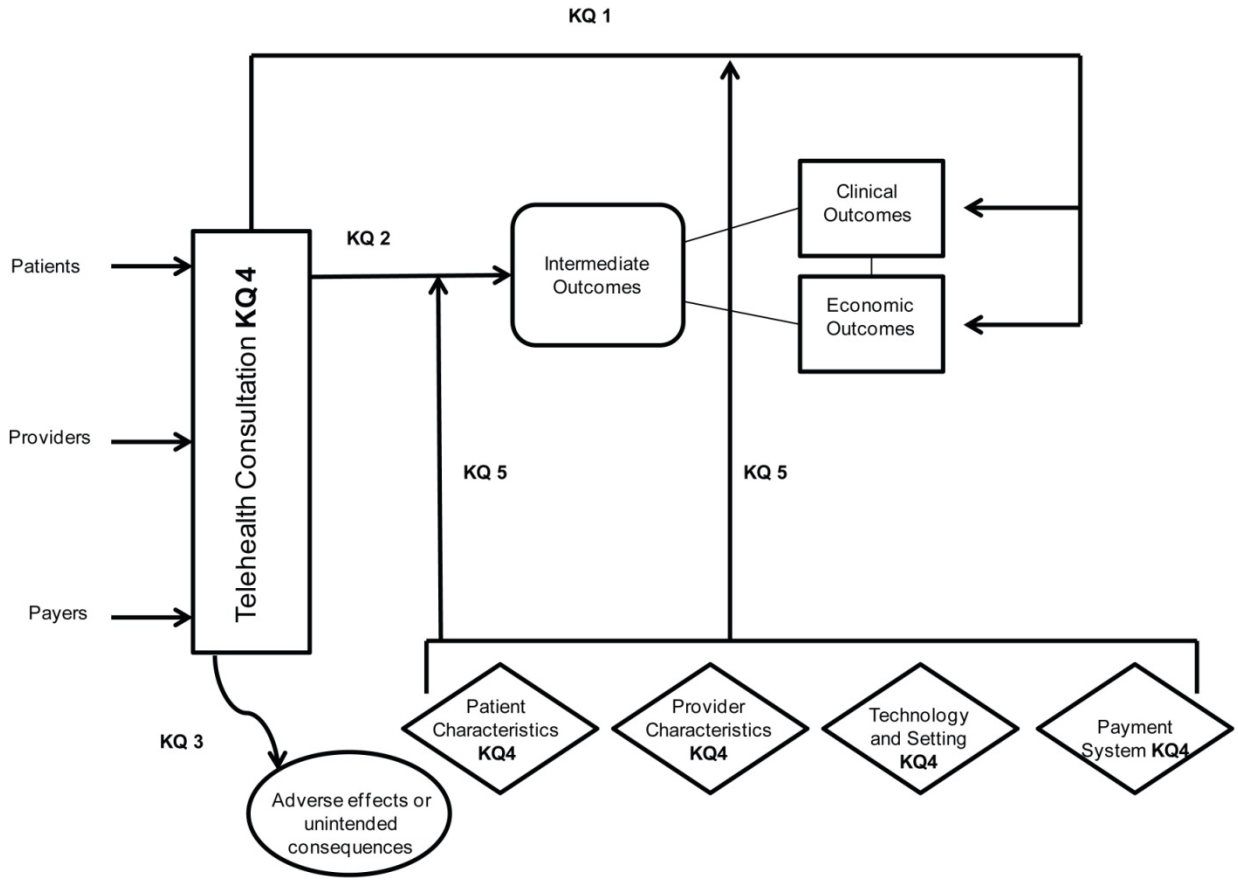
Study Designs

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

Analytic Framework

Below (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 & Quality (AHRQ) *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (available at http://www.effectivehealthcare.ahrq.gov/methodsguide.cfm) and the PRISMA checklist.[17,18] The full protocol for the review contains a detailed description of the methods and is available at the Effective Health Care Web site (http://effectivehealthcare.ahrq.gov/index.cfm). The protocol was registered with PROSPERO (CRD42017058304).

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

Systematic Review Methods

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 accessed existing SRs to identify studies for inclusion. We excluded descriptive studies with no outcomes data or studies that include only outcomes data from one point in time (post only). We also excluded modeling studies or studies that use synthetic data, and excluded commentaries, letters, and articles that describe telehealth systems or implementations but do not assess impact. We considered whether an excluded article contains 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.

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 starting in 1997 through November 2016 (note: this will be updated through May 2018 during the public and peer review period). 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 (EPC) 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, health care 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 (TEP) 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*.[17] 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 (SEADs) processes. Any disagreements about inclusion or exclusion were resolved by discussion and consensus across the investigators.

Data Abstraction and Data Management

After studies were deemed to meet inclusion criteria (Included Studies are listed in Appendix C), the following data were abstracted: 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 previous PICOTS section. Information relevant for assessing applicability 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 if they were reported. All study data was 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*.[17] Studies 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 study evaluated was independently reviewed for risk of bias by two team members. Any disagreements were resolved by consensus. If consensus could not be arrived at by the two reviewers, the principal investigator and 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 and ranges, descriptive analysis and interpretation of the results are provided.

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) by using the approach described in the *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*.[17] 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*.[17] 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) 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.

An 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 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.

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. This is commonly done in decision modeling and allowed 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

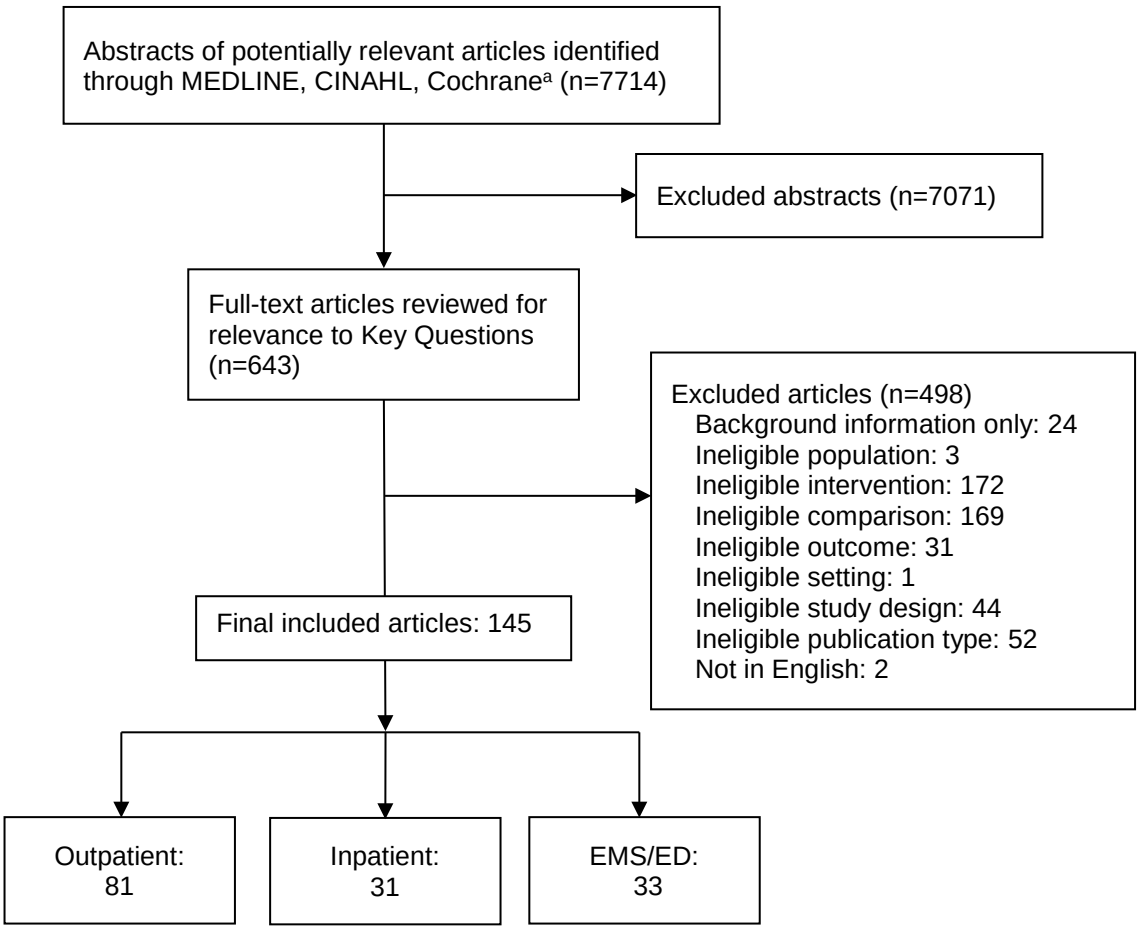
Overview

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 7,714 potentially relevant citations after reviewing titles and abstracts, 7,071 were excluded and the full text of 643 articles were pulled for review. Of these, 145 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; EMT = 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 145 included articles. The numbers for mode of telehealth add up to more than 145 because an article may be included in more than one category.

The most frequent geographic location for the included studies of telehealth consultations was the United States (67 articles or 46%); however more than half of the studies were conducted in other countries. Fifty articles (approximately 35%) were conducted in Europe, ten in Asia, nine in Australia or New Zealand, two in South America, three 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 almost two-thirds of the studies (63%). Store and forward of images and information was used in almost 32 percent of the studies; 13 percent studied systems that facilitated review of electronic records, and 8 percent involved streaming data. 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 (66%), or both real time and asynchronous communications were used (10%). Twenty-one percent of studies evaluated consultations that involved asynchronous exchanges.

The study designs and sample sizes also varied. Most of the studies (72%) 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). One-quarter (25%) were randomized controlled trials, 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 (43% of studies with 101 to 500 patients and 14% with 501 to 1000 patients). The studies were evaluated for risk of bias (see Methods and Appendix E for details), and 22 percent were rated as low risk of bias, 47 percent as moderate, and 32 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 forty 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 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 (ED) 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). 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; all possible uses of telehealth for consultations are not represented. Based on prior work on a telehealth evidence map,[8] and input from our TEP and other stakeholders there may be topics for which telehealth consultations are used that are not covered in this review. Examples include infectious disease, 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	67	46.2%	19-85
	Non-UK Europe	36	24.8%	86-121
	United Kingdom	14	9.7%	122-135
	Asia	10	6.9%	136-145
	Australia or New Zealand	9	6.2%	146-154
	NR	3	2.1%	155-157
	Canada	3	2.1%	158-160
	South America	2	1.4%	161,162
	Africa	1	0.7%	163
Study Design	Observational (Prospective cohort, retrospective cohort, before-after)	105	72.4%	19,21-37,39-47,49-54,56-64,67,68,72-74,79-83, 86-90,92,93,95-100,102,105,107,109-112,114-120, 123,126-129,131,136,137,139-141,144-146,148, 150-153,156-158,160-163
	Randomized controlled trial	36	24.8%	20,38,55,65,66,69-71,75-78,84,85,91, 101,103, 104,106,108, 121,122,124,125,130,132-134,138, 142,143,147,149,154,155,159
	Pre-post (same patients)	4	2.8%	48,94,113,135
Sample Size	Under 100	34	23.4%	20,23,24,38,43,45,47,48,50,51,54,72,94,95,97, 105-108,111,120,126-128,131,137,140,147-149, 157-159,161
	100-500	62	42.8%	19,22,28,29,31-33,42,49,52,55,62,64,67,69-71, 74-80,83-85,87,89,98-104,110,112-115,117-119, 123,125,130,132,133,135,138,139,141,143, 150-156,163
	501-1000	20	13.8%	30,35-37,44,56,63,65,66,68,82,90,91 ,96,121,129,136,142,144,145
	1001-10,000	21	14.5%	25,27,34,46,53,57,59-61,73,86,88,92,93,109, 116,122,124,134,160,162
	10,001+	4	2.7%	26,41,58,81
	NR/unclear	4	2.7%	21,39,40,146
Mode of Telehealth[a]	Video	92	63.4%	19,20,22-28,30-36,38-43,45,47-49,51,55, 57,59,60,63,67-69,71,72,78,79,81-85,87,95-98, 100-105,107-111,113,114,116,117,122-128, 132,134,136,139-143,146,148,149,151-158,161, 162

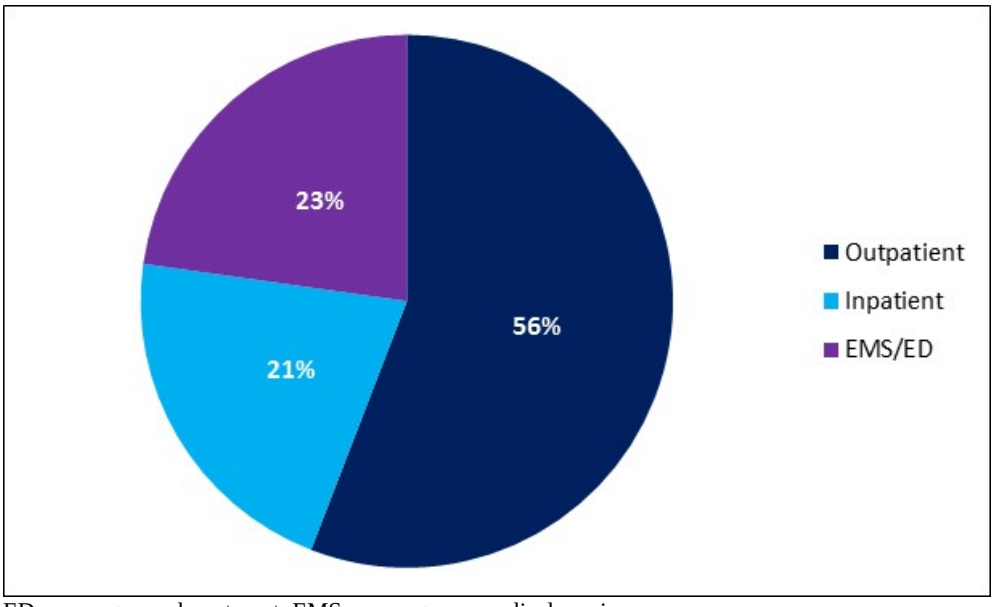
Characteristic	Categories	Number of Articles	Percentage of Articles	References
	Data store and forward	46	31.7%	34,36,37,54-56,60,73-77,80,82,86,88-91,93,94, 98,108-110,116,119-121,129,132,137,138,140-142, 144,147,150,151,154,157,159-161,163
	Electronic chart/record review	19	13.1%	34,36,42,52,56,57,65,66,70,74-77,85,99,112, 113,135,136
	Unspecified/ unclear	14	9.7%	21,29,44,46,53,62,64,92,106,115,130,131,133,146
	Data streaming	12	8.3%	34,36,45,50,58-61,82,118,145,157
Timing	Real-time	95	65.5%	19,20,22-28,30-33,38,40-50,57-64,67-69,71,72, 78,79,81-85,87,95,96,98,100-105,107,109-111, 113-115,117,118,122-128,130-132,134,136,137, 139-142,144-146,148-157,162
	Asynchronous	31	21.3%	37,52-54,65,66,73-77,86,88-94,99,106,112,120, 121,129,133,135,138,147,159,163
	Both	15	10.3%	21,34-36,51,55,56,80,97,108,116,119,143,158,160
	NR/unclear	4	2.8%	29,39,70,161

NR = not reported; UK = United Kingdom

[a] Total is more than 145 as articles may be included in more than one category

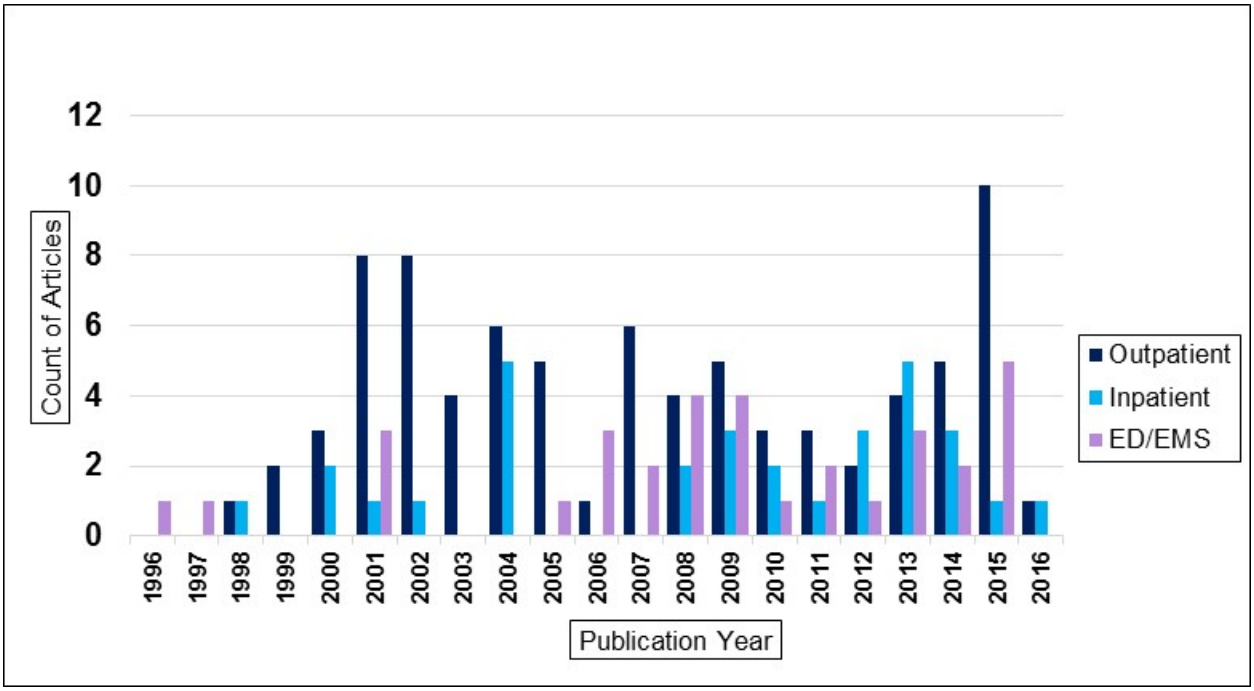
As the volume of the literature is large, we divided it according to the patient setting for both additional description and for presenting the results. We used the three categories: inpatient, emergency department or emergency medical services (ED/EMS), and outpatient. Each study included in this systematic review is assigned to one of these three settings. Figure 3 shows the distribution of the included studies across these three categories. Outpatient is largest, including more than half the studies, with the remainder split almost equally between inpatient and ED/EMS. 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 studies (n=145)



ED = emergency department; EMS = emergency medical services

Figure 4. Telehealth consultation articles (n=145)



ED = emergency department; EMS = emergency medical services

The evidence tables, included in Appendixes F (Data Abstraction) and G (Risk of Bias), include additional detailed information from each article. Also, tables in the results section highlight study characteristics as well as 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 hospitals 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 by the specific discipline. Tables 2 and 5 include the number of articles that addressed each topic, a summary assessment of key outcomes across the studies, and the citations. Tables 3, 4, and 6 provide more detail, focusing on the key results for each study and the accompanying text discusses how the studies address the Key Questions for this review. Detailed information that we abstracted from each article is provided in Appendix F. The criteria and the overall rating for risk of bias assessment of each article are in Appendix G and the strength of evidence assessment for each topic is in Appendix H.

Remote Intensive Care Units

We identified 13 articles that report the results of 12 studies evaluating the use of telehealth to provide remote ICU services. Remote ICU services involve off site staff (intensivists, critical care nurses, and sometime administrative assistants) that monitor ICU patients and provide consultation and management assistance with the care of these patients by alerting onsite staff to issues, recommending treatment, and mentoring/coaching 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 to allow one-way observation of the patient and care provided, mirroring of bedside monitors, and real-time voice communication. Some studies included access to the patient record system while others required special transmission of records from the hospital to the remote ICU staff location.

Key Points

- ICU mortality and length of stay (LOS): The results of the majority of studies suggest that remote ICUs decrease ICU mortality and LOS (moderate strength of evidence).
- Overall hospital mortality: Remote ICUs appear to decrease hospital mortality, although the impact is less clear with some studies reporting lower mortality and some finding no significant differences (low strength of evidence).
- Hospital LOS: Based on the included evidence, Remote ICUs do not have a significant impact on hospital LOS (low strength of evidence), with most studies reporting no significant reduction after the implementation of ICUs.
- Costs: Not every study analyzed the costs of remote ICUs or their impact on revenue; those that did used different methods, and their conclusions were inconsistent, with half reporting savings or increased revenue and half reporting increased costs (insufficient evidence).
- Harms: None of the included studies specifically addressed potential harms (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
13	✓ ICU Mortality lower ✓ Hospital Mortality ⦸ Harms	✓ ICU LOS shorter × Hospital LOS	? Cost or revenue impact	27,34,36,45,46, 57-61,81,82

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

Detailed Results

Table 3 includes the results for mortality, LOS, and costs from the included studies of remote ICUs. One identified study did not report these outcomes so it is included in the narrative but not the table.[45] All but one of the studies of remote ICUs are "before-after" studies. They compare outcomes from a period before the implementation of the remote ICU to the period after this model of care was in operation in the same hospital or hospitals. One study used a retrospective case control design, selecting hospitals that had implemented teleICUs, matching them to hospitals that had not and analyzing data for periods before and after the telehealth implementation dates in both groups of hospitals.[82] The studies did not provide detail on the nontelehealth care, though it likely included a mix of care by nonspecialists, less care by specialists, and transfers to other hospitals.

Effectiveness in Improving Clinical and Economic Outcomes

The ICU mortality rates before remote ICU ranged from 6.5[81] to 15.8 percent,[57] and the statistically significant reductions after remote ICU ranged from 2 to 6 percentage points, with 1.5 percent as the lowest rate reported after remote ICU implementation.[36] The one study that calculated odds ratios adjusted for predicted risk and whether patients had do not resuscitate (DNR) orders. This study reported the odds of mortality in the ICU were 40 percent lower (AOR 0.60, p=0.002) with remote ICU than in the before period (comparison period), and mortality after remote ICU was implemented was 29.5 percent lower than predicted using the Acute Physiology and Chronic Health Evaluation (APACHE) IV model.[57]

The largest study retrospectively matched 132 hospitals that adopted remote ICUs to 389 that did not and compared 90-day mortality for over 1 million patients. The change in relative mortality rates from the pre telehealth to the post telehealth period was small using a difference-in-difference analysis across all the patients; however the effect varied widely across the hospitals (range of ratio of odds: 0.45 to 2.54) with 12.2 percent of hospitals experiencing a significant reduction and 6.1 percent experiencing a significant increase.[82] No other study followed patients for this long or analyzed a sample this large; but given this was accomplished using administrative data it was not possible to assess differences in remote ICU programs or determine when mortality was related to the reason for the ICU admission.

The effect of remote ICUs on in-hospital mortality is less clear. While the hospital mortality rates were also lower with remote ICU, the differences were small with half of the included studies reporting small improvements that were not statistically significant.

Five 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. Two studies reported benefits: one reported that the contribution of ICU patients to

revenue increased as shorter ICU lengths of stay allowed more patients to be treated, which increased capacity and revenue,[34] and a second study reported that the ICU total costs were lower (ratio of after to before 0.69, p=0.031) and attributed this to a decrease in complications after remote ICU implementation.[36] Other studies reported higher costs[27,46] or reported very basic estimates.[61] Given that the evidence is inconsistent and imprecise, we were unable to categorize how remote ICUs affect costs.

Effectiveness in Improving Intermediate Outcomes

Length of stay in the ICU or for hospitalizations is the intermediate outcome assessed in studies of remote ICU. The results mirrored those of mortality with remote ICUs decreasing ICU LOS but not impacting hospital LOS. Studies reported shorter LOS after remote ICU was implemented, and most reductions were statistically significant. Mean LOS before remote ICU ranged from 2.6 days[46] to 4.3 days.[58] The lowest LOS after remote ICU was 2 days in the study that reported largest decrease (from 3.06 to 2.0).[36] Hospital LOS ranged from means of 5.2[60] to 12.7 days[34] before remote ICU, and the differences with after implementation were only significant in two studies: one that reported a decrease from 11.86 to 10.16 days[58] and one that reported an increase from 5.2 to 6.2 days.[60] The authors of the study in which hospital LOS increased postulate that the increase is due to the fact that more patients survived to remain in the hospital longer.

The one study not included in Table 3 evaluated whether the impact of remote ICU expansion affected nursing staff satisfaction and their perceptions of the quality of care.[45] This small study (N=27 in the intervention ICU and N=11 in the comparison group) surveyed nursing staff before remote ICU was available and 2 months after implementation of a program that added two-way audiovisual communication and real-time physiologic monitoring data to a system that already had critical care coverage by phone and remote access to electronic patient records. Staff with the augmented remote ICU reported higher satisfaction after implementation while scores in the comparison group declined.

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

None of the studies expressly reported on harms or adverse events. One study reported that 90-day mortality increased in 6.1 percent of the 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.[82] One study reported that the rate of complications experienced by ICU patients declined with remote ICU.[36]

Table 3. Remote intensive care units: selected outcomes

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Breslow, 2004[34] United States, Virginia 1 hospital 2140 Before-After Moderate A: Before telehealth B: After telehealth	ICU **A: 8.6%** **B: 6.3%, p<0.05** Hospital **A: 12.9%** **B: 9.4 %, p<0.05**	Mean LOS, in days ICU **A: 4.3** **B: 3.63 p<0.05** Hospital A: 12.77 B: 11.4 NS	Revenue, contribution per month All patients: A: $795,245 B: $1,319,236 (no test reported)
Fortis, 2014[81] United States, Minneapolis, Minnesota 5 ICUs, including 1 teaching hospital 12160 Before-After High A: Before telehealth B: After telehealth	Mortality, unadjusted ICU **A: 6.5%** **B: 4.9%** **p<0.0002**	Patients readmitted to ICU within 48 hours # (%) **A: 54 (0.89)** **B: 29 (0.49), p=0.0064**	NR
Franzini, 2011[27] Thomas, 2009[59] United States, Gulf Coast region 5 hospitals 4142 Before-After Moderate for cost/Low for other outcomes A: Before telehealth B: After telehealth	ICU A: 9.2% (8.0% to 10.5%) B: 7.8% (6.7% to 9.0%) NS RR[a]: 0.88; 95% CI 0.71 to 1.08 Hospital A: 12.0% (10.6% to 13.5%) B: 9.9% (8.6% to 11.2%) A to B decrease: 2.1%, NS RR[a]: 0.85; 95% CI 0.71 to 1.03 Overall: no difference SAPS II ≤ 50 (less serious): no difference SAPS II > 50 (17% of patients) ICU: 40% reduction Hospital: 37% reduction	Mean LOS, in days (95% CI) ICU A: 4.3 (4.0 to 4.5) B: 4.6 (4.3 to 4.9) Hospital A: 9.8 (9.4 to 10.2) B: 10.7 (10.2 to 11.1) 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: 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.

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Kahn, 2016[82] United States 132 telemedicine; 389 matched nontelemedicine hospitals 1,123,563 Retrospective cohort Low A: Site without telehealth B: Site with telehealth	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 Pre period vs. post period 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	NR	NR
Kalb, 2014[157] NR, authors US-based 11 hospitals n=NR Before-After High A: Pre-TeleICU implementation B[1]: Post-TeleICU (2011, Quarter 3) B[2]: Post-TeleICU (2012, Quarter 1)	ICU Mortality Ratio (APACHE IV-adjusted) **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, in days (# of days of mechanical ventilation/APACHE IV predicted days of mechanical ventilation) A: 1.08 B[1]: 0.92, NS vs. A B[2]: 0.96, NS vs. A	NR
McCambridge, 2010[57] United States, PA 1 hospital 1913 Before-After Moderate A: Before telehealth B: After telehealth	ICU **A: 15.8%** **B: 11.5%, p=0.006** Hospital **A: 21.4%** **B: 14.7%, p<0.001** Overall **AOR[b]: 0.605, p=0.002**	Mean LOS, in days ICU A: 4.1 B: 3.8, NS Hospital A: 9.2 B: 9.2, NS Ventilator use **A: 36.1%** **B: 31.5%, p=0.04**	NR

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Morrison, 2010[46] United States, IL 2 hospitals 4088 Before-After Moderate Comparison: A: Before telehealth B^1: After telehealth, 1 year after baseline B^2: After telehealth, 1 year after eICU fully operational	Total A: 9.9% B^1: 11.1% B^2: 10.0% A vs. B: NS B vs. B^2: NS ICU A: 6.6% B^1: 7.9% B^2: 7.4% A vs. B^1: NS B^1 vs. B^2: NS Non-ICU A: 3.5% B^1: 3.5% B^2: 2.9% A vs. B^1: NS B^1 vs. B^2: NS	Mean LOS, in days ICU A: 2.60 B^1: 2.92 B^2: 3.18 A vs. B^1: NS B^1 vs. B^2: NS Hospital A: 7.72 B^1: 7.98 B^2: 7.89 A vs. B^1: NS B^1 vs. B^2: NS	Mean Cost[c] A: 22.43 B^1: 21.41 B^2: 23.21 A vs. B^1: NS **B^1 vs. B^2: p=0.03**
Rosenfeld, 2000[36] United States, Baltimore, MD 1 hospital 628 Before-After Low Comparison: A^1: before telehealth, baseline 1 A^2: before telehealth, baseline 2 B: After tele ICU	ICU A^1: 9.8% A^2: 3.5% B: 1.5% **A^2 vs. A^1: p<0.05** **B vs. A^1: p<0.05** **B vs. A^2: p<0.05** Hospital A^1: 11.6% A^2: 6.9% B: 4.5% **A^2 vs. A^1: p<0.05** **B vs. A^1: p<0.05** **B vs. A^2: p<0.05** Complications **A^1: 15.1%** **A^2: 18.8%** **B: 9.5% p<0.05**	Mean LOS, in days (95% CI) ICU A^1: 2.71 A^2: 3.06 B: 2.0 **B vs. A^1: p<0.01** **B vs. A^2: p<0.01** Hospital A^1: 9.18 A^2: 10.11 B: 9.28 B vs. A^1: NS B vs. A^2: NS	ICU total costs **B vs A^1 : 0.75 (p=0.002)** **B vs. A^2: 0.69 (p=0.031)** Hospital total costs B vs A^1: 0.88, NS B vs. A^2: 0.81, NS 64% of difference in cost between baselines and intervention were associated with higher incidence of complications during baseline periods.
Ruesch, 2012[61] United States, Alaska 1 hospital 1308 Before-After High A: Before telehealth B: After telehealth	ICU A: 17 B: 24 Hospital A: 22 B: 36	LOS[a], 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 over 2.5 million, comparing a calendar quarter pre implementation and the last quarter of the evaluation.

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality**	**Intermediate Outcomes**	**Costs/Revenue or Other Resource Use**
Sadaka, 2013[60] United States, Missouri 1 hospital 2823 Before-After Low A: Before telehealth B: After telehealth	ICU **A: 7.9%** **B: 3.8%** **OR: 0.46, p=0.0001** Hospital A: 8.8% B: 6.9% OR 0.76, NS	Mean LOS, in days ICU **A: 2.7** **B: 2.2** **HR: 1.16, p=0.01** Hospital ***A: 5.2*** ***B: 6.2*** ***HR: 1.30, p<0.01***	NR
Willmitch, 2012[58] United States, Florida 5 hospitals 24,656 Before-After Moderate Comparison: A: Before telehealth B[1]: After telehealth, 1 year B[2]: After telehealth, 2 years B[3]: After telehealth, 3 years	Relative Risk A vs. B[1]: 0.92, NS A vs. B[2]: 0.88, NS **A vs. B[3]: 0.77, p<0.001**	Mean LOS[a], in days ICU A: 4.35 B[1]:4.34 B[2]: 3.95 B[3]: 3.80 **A vs. B[3]: p<0.001** Hospital A: 11.86 B[1]: 11.81 B[2]:10.88 B[3]: 10.16 **A vs. B[3]: p<0.001**	NR

AOR = adjusted odds ratio; APACHE IV = Acute Physiology and Chronic Health Evaluation IV; CI = confidence interval; HR = hazard ratio; ICU = intensive care unit; LOS = length of stay; NR = not reported; NS = not significant; OR = odds ratio; RR = risk ratio; SAPS II = Simplified Acute Physiology Score II; SE = standard error

[a] Severity-adjusted

[b] Adjusted for APACHE IV status

[c] Adjusted total hospital costs divided by 1000

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.***

Key Characteristics of Remote ICU Studies and Association With Outcomes

All the included remote ICUs studies were conducted in the United States, all but one used a before-after design, and all but one reported some combination of mortality, LOS, and costs. Despite these similarities the study results varied. We reviewed selected key factors that could help explain the differences in outcomes across studies. Table 4 summarizes 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. However, none of these clearly differentiate between studies reporting a clear benefit from remote ICUs and those reporting no benefit or possible benefit.

The majority of the 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 different amounts of remote coverage were needed to achieve this goal. All of the studies included a physician intensivist, though one added this after 9 months of nursing support alone.[61]

All but one included nursing[36] 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.[58] In one study that reported no benefit, remote ICU was associated with decreases in mortality and a nonsignificant increase in costs for sicker patients and no improvement in mortality and higher costs for less sick patients. This suggests that the benefit may not be uniform across all critical care patients.[27,59] The largest study examined several characteristics of the subgroup of hospitals that experienced a reduction in 90-day mortality after the implementing remote ICU and found these were more likely to be high volume and located in urban areas.

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[34]	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[81]	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[27] Thomas, 2009[59]	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*
Kahn, 2016[82]	521 132 Hospitals adopted telehealth 389 match 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*
Kalb, 2014[157]	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 subgroups*

Study	Hospital Number Characteristics	Remote ICU Coverage Staffing	"After" Period for Outcomes Measurement	Impact of Remote ICU *Subgroup Assessments*
McCambridge, 2010[57]	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[46]	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*
Rosenfeld, 2000[36]	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[61]	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[60]	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[58]	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.*

[a] Other studies studied in-hospital and in-ICU mortality rather than 90-day mortality

Inpatient Specialist Consultations

We identified 19 articles reporting on 18 studies about using telehealth to provide specialty consultations for inpatients that met the inclusion criteria for this review. 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 patient's location or at the time when the consultation is needed. The 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. In general, the specialist consultations are needed to inform decisions. These decisions 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. The consultation may also serve to make or confirm a diagnosis, they may advise on treatment, or actually provide treatment.

Key Points

- Clinical outcomes: Mortality or serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability), improve with telehealth consultations across specialties but these differences are not always statistically significant (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).
- Costs: Costs were compared in only three studies, two of which report savings (low strength of evidence).
- Harms: Only one study explicitly examined harms (insufficient evidence).

The studies of inpatient specialist consultations cover a wide range of clinical indications ranging from neonate to geriatric care and from care planning to remote proctoring of surgery. Table 5 summarizes the results across the included studies by clinical specialty, while 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 Articles	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
Neonates Cardiology	4	✘ death or cardiac arrest ✓ fewer very low birthweight deliveries	✓ LOS and time to diagnosis decreased	⊘	29,30,35, 37
Pediatric Inpatient	4	✘ in hospital mortality	? mixed: no decrease in LOS; decrease in transfers; fair (parent) to good (staff) satisfaction	✓ cost saving and increased revenue	28,31-33
Pediatric Sexual Abuse Assessment	1	⊘	✓ improved quality of assessment	⊘	19
Geriatrics	2	✘ falls	✓ decrease time to consult; increase capacity	✓ cost saving due to avoided travel	139,146
Neurology	3	? mortality	✓ health service utilization and fewer transfers	⊘	93,119,123
Post stroke care	1	✓ Lower odds of poor outcome	⊘	⊘	116
Psychiatric Care Planning	1	⊘	✓ positive rating and willing to use for next visit	✓ lower cost if at least 30 cases per year	107
Plastic Surgery	1	⊘	? mixed: more patients sent to day surgery; no difference in in-person visits or admissions	✘ no evidence of savings	129
Endoscopic Surgery	1	✓ no complications or harms	✘ longer surgery	⊘	38
Multiple Specialties	1	✘ no difference in mortality	⊘	⊘	162

LOS = length of stay
Key: ✓ superior (telehealth benefit), ✘ no difference (no significant difference) or inferior (telehealth no benefit), **?** inconclusive (inconsistent results or insufficient), ⊘ no evidence

Detailed Results

Table 6 includes the key results for clinical outcomes (including harms), intermediate outcomes, and costs from the 18 articles on inpatient specialty consultations. The studies of inpatient consultations are more varied in terms of setting and study design than the studies of remote ICU. Ten of the studies were conducted in the United States, and the others were conducted in eight different countries (Australia, Brazil, Finland, Germany, Hong Kong, Israel, Italy, Northern Ireland, and United Kingdom). Studies of inpatient consultations were predominately cohort studies, split between retrospective and prospective cohort designs, and included four "before-after" studies and one randomized trial. The observational studies did not provide detail on the nontelehealth care while the trial compared endoscopic surgeries done by a less experienced surgeon with a teleproctor to the surgeries done by the expert surgeons. The prospective cohort studies included multiple sites with the largest study including 10 hospitals (3060 patients in 5 intervention and 5 matched comparison hospitals).[116]

Effectiveness in Improving Clinical and Economic Outcomes

Mortality

The 9 of 11 articles about inpatient consultations that evaluated clinical outcomes reported mortality rates. Declines in mortality were not significant in one study of telehealth cardiology for neonates implemented in nine hospitals,[37] in studies of pediatric inpatient consults,[28,31-33] or in a study of a hospital wide-multispecialty consult program.[162] 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. Some limited benefit was reported in two studies of neurology inpatient teleconsultations and in one study of specialized post stroke care:

- In a comparison of two hospitals, one that used a real-time video link 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)[123]
- 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 (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)[93]
- The odds of death or institutional care were not significantly different when comparing five hospitals that participated in the Telemedical Project for Integrative Stroke Care to five matched control hospitals. But when the outcome was redefined as death, institutional care or severe disability both the 12-month and 3-month odds of poor outcome were significantly lower in hospitals with telestroke.[116]

Other Clinical and Economic Outcomes

The other clinical outcomes reported were a significant decline in the rate of very low birthweight deliveries in hospitals without neonatal intensive care units after the establishment of telehealth consultations and rounds[30] and one study of geriatric consultations reported no

significant difference in the average number of falls per month in the evaluation of telenursing geriatric consultations to residential homes for the elderly.[139]

Only three studies reported any assessment of economic outcomes. Two studies estimated an economic benefit: a study of pediatric intensive care consultations provided to a rural hospital estimated annual savings of $300,000 per year for patients and additional revenue for the rural hospital of $279,000 for the patients treated using telehealth consultations and who were not transferred to another location.[32] An evaluation of a telegeriatrics program calculated lower annual costs with telehealth consultations (73,078 vs 98, 909 AUS $), but that savings was only realized in instances where roundtrip travel would have exceeded 125 kilometers for an in-person consultation.[146] The third study found no evidence of cost saving for the hospital to offset the capital investment required for a teleconsult service for plastic surgery and burns.[129]

Effectiveness in Improving Intermediate Outcomes

Most of the outcomes reported in the evaluation of inpatient specialty consultations were intermediate outcomes. Studies reported LOS, rates of transfers to other hospitals, satisfaction, and quality/process indicators.

- Two of the three studies analyzing cardiology consultations and echocardiogram via telehealth report reductions in LOS,[29,37] while one found no difference in overall transfer rates and a trend toward lower inappropriate transfer rates.[35]
- 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 setting up a pediatric telehealth consult system with a tertiary children's hospital.[28] Satisfaction with pediatric telehealth consults was generally good, though the mean rating by parents were lower than those of staff.[31-33] A study that compared five hospitals with access to expert telehealth consultation on pediatric sexual abuse evaluations to three hospitals without telehealth found that the quality of the assessments was higher with telehealth.[19]
- Geriatric telehealth consultation for home care improved patient performance of self-management, reduced wait time, and increased patient satisfaction,[139] while a video geriatric rounds program provided consultations that were similar in length to in-person visits.[146]
- 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.[123]
- A telehealth consult service allowed some patients with suspected intracranial bleeds to be treated at hospitals without neurosurgical services, reducing the number of transfers.[119]
- The majority of patients, families, and providers who used video telehealth for psychiatric inpatient care planning preferred to have their next conference via video.[107]
- The study that randomized endoscopic surgery to be proctored in person or remotely found that the teleproctored surgery took longer, though the statistically significant difference of approximately 4 minutes on average is unlikely to be clinically meaningful.[38]

Harms, Adverse Events, or Negative Unintended Consequences

Only one study reported on harms or complications. 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.[38]

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. As hospitalizations are generally not long term, the involvement of the consult with a specific patient is limited. While some studies mention whether the patient is involved or present, others do not. Studies also do not report details of the consulting interaction. 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 the 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** **Number of Patients** **Study Design** **Risk of Bias** **Comparison Groups**	**Clinical Outcomes** **Harms**	**Intermediate Outcomes**	**Economic Outcomes**
Neonate Cardiology	Huang, 2008[35] United States, CA 1 community hospital, 1 University Children's Hospital 665 Before-after Moderate A: Before telehealth B: After telehealth	NR	Echocardiogram upon admission: **A: 27%** **B: 40%** **p<0.001** Inappropriate transfers A: 7 B: 2, p=0.06	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
	Webb, 2013[37] United States, Multiple locations 9 sites 674 Prospective Low A: Site without telehealth B: Site with telehealth	Death 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** Time to diagnosis, mean minutes. **A: 147** **B: 100, p<0.001** Transport to tertiary care **A: 10%** **B: 4%, p<0.01**	NR
	Kim, 2013[30] United States, AR 6 hospitals 3 with, 3 without telehealth 767 Prospective cohort Moderate A: Before telehealth, without NICU B: After telehealth, without NICU	Very Low Birthweight Deliveries **A: 13%** **B: 7%, p=0.0099** No changes in comparison hospitals Statewide infant mortality decreased during study period.	NR	NR
	Rendina, 1998[29] United States, NC 2 hospitals 314 Retrospective cohort Low A: Site without telehealth B: Site with telehealth	NR	Mean LOS in NICU, in days (%) **A vs B: -12.5 (-17%), p<0.05**	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Pediatric Inpatient Care	Labarbera, 2013[28] United States, OR 1 community hospital; consult from tertiary children's hospital 153 Before-after Low A: Before telehealth B[1]: After telehealth B[2]: After telehealth and hospitalist program at community hospital	Mortality A: 3% B[1]: 1.8% B[2]: 3.6%, NS	Mean LOS, in days Total 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**	
	Marcin, 2004a; 2004b[31,32] United States, CA 1 hospital 429 Retrospective cohort Low Moderate A: Telehealth consultations B: All Pediatrics ICU patients C: historic controls D: patients transferred from other hospitals	Mortality A: 2.1% B: 1.6% C: 2.6% D: 3.5%	Mean Satisfaction on a 5-point scale, with 5=extremely satisfied Nurses/respiratory therapist: 4.53 Referring MD: 4.56 Parent or guardian: 4.05	Estimated annual cost savings $172,000 Estimated savings on transport: $300,000 Estimated revenue available for rural hospital $186,000 Estimated revenue m available for rural hospital due to no transport: $279,000
	Marcin, 2004c[33] United States, CA[a] 1 hospital 224 Retrospective cohort Low A: Historical control B: Telemedicine cohort C: No telemedicine cohort D: Combination of B and C	Observed/Expected Mortality Odds Ratio (95% CI) A: 0.95 (0.26 to 3.48) B: Reference C: 0.44 (0.07 to 1.96) D: 0.73 (0.06 to 1.44) NS	LOS, in days ICU A: 3.5 B: 5.9 C: 3.4 D: 3.8, NS Mean parent satisfaction: 3.8 on a 5-point scale	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Pediatrics Sexual Abuse Exams and Assessment	Miyamoto, 2014[19] United States, CA 5 rural telemedicine hospitals 3 comparison hospitals program 183 Retrospective cohort Low A: Site without telemedicine B: Site with telemedicine	NR	OES child abuse examination quality - score range 0-5, with 5 as good Overall assessment A: 3.24 B: 3.88, NS Total quality score: **A: 29.21** **B: 31.20, p<0.05**	NR
Geriatrics	Chan, et al., 2001[139] Hong Kong 1 Nursing home 198 Before-after High A: Before telehealth B: After telehealth	Average # of falls per month: A: 9.8 B: 6.8	Failed inhaler technique A: 93% B: 50% Waiting time for consult, in weeks A: 4-13 B: within 2 Patient satisfaction: 96% favorable	11% needed onsite visit at a cost to nursing home
	Gray, 2009[146] Australia NR Prospective cohort High A: Site without telehealth B: Site with telehealth	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 in minutes for new patients (95% CI) A: 19.0 (15.2 to 22.8) B: 19.7 (17.0 to 22.4)	Costs per year A: $90909 B: $73078 In the base-case, cost savings became effective when roundtrip travel time is ≥125 km between locations.
Neurology	Craig, 2004[123] North Ireland 2 hospitals 292 Prospective cohort Moderate A: Site without telehealth B: Site with telehealth available but not used for every patient	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 # primary care visits at 3 mo. followup A: 2.49 B: 2.14, NS	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
	Klein, 2010[119] Israel 3 hospitals 323 Retrospective Cohort Moderate A: No telehealth; mandatory transfer B: Telehealth consult C: Use of algorithm-based guideline	Mortality N (%) A: 0 (0) B: 1 (1.0) C: 1 (1.4) NS Need for Neurosurgery N (%) A: 17 (11.2) B: 9 (9.2) C: 9 (12.3) NS	Transferred N (%) A: 152 (100) B: 40 (40.9) C: 54 (74) Delayed transfer N (%) A: NA B: 2 (2.04) C: 1 (1.3) NS Length of stay N A: 4.19 B: 4.48 C: 3.92 NS Need for neurological rehabilitation N (%) **A: 4 (2.6)** **B: 8 (8.2)** **C: 15 (20.8)** **p<0.001**	NR
	Migliaretti, 2013[93] Italy Number of hospitals NR 2357 Prospective cohort Moderate A: Before telehealth B: After telehealth	Mortality Risk without telehealth All OR[a]: 1.25, (0.83 o 1.91) NS People over 70: **OR[a] 1.14, (1.04 to 1.82)**	NR	NR
Post Stroke Care	Audebert, 2009[116] Germany 5 intervention hospitals 5 matched comparison hospitals N=3060 Prospective cohort Low Comparison: A: Site without telehealth B: Site with telehealth	Reduced Death or Institutional Care 12 months OR: 0.89, NS 30 months OR: 0.93, NS Poor outcome: death, institutional care, severe disability 12 months **OR: 0.65, p<0.001** **30 months** **OR: 0.82, p=0.031**	NR	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Psychiatric Care Planning	Mielonen, 2000[107] Finland 2 remote centers 34 patients 124 health care staff Prospective cohort High Comparison A: Site without telehealth B: Site with telehealth	NR	Staff satisfaction: video as good as conventional meeting: 47% video almost as good as conventional: 48% Preference for next meeting to be video health care staff: 86% patients: 84% relatives of patients: 92%	Cost per patient were FM2510 videoconferences FM4750 conventional Video is cheaper if there are 30 cases per year. With 50 cases the savings would be FM117,000
Regional Plastic Surgery Service	Wallace, 2008[129] United Kingdom 1 hospital providing consults to over 60 sites Telehealth available for 389 of 996 referrals and used for 243 Prospective High Comparison A: Site without telehealth B: Site with telehealth	NR	Difference in 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 (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)**	No evidence of cost saving for hospital (details not reported) Capital outlay was significant (£70K)
Teleproctored Endoscopic Surgery	Burgess, 2002[38] United States, HI 1 hospital 87 RCT High A: No telehealth B: telehealth	No cases of complications/harms	Average Time to complete operative case in minutes: ***A: 24.67*** ***B: 28.54, p<0.027***	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison Groups	Clinical Outcomes Harms	Intermediate Outcomes	Economic Outcomes
Multiple specialties	Steinman, 2015[162] Brazil, Sao Paulo Two hospitals 257 (telehealth; comparison total not reported) Before-after and prospective cohort High Comparison Before telemedicine After telemedicine A: No telehealth,1 year after telehealth implementation B: Telehealth, 1 year after telehealth implementation	Mortality Before-After: No significant difference for patients with acute MI, severe sepsis, stroke Mortality AMI A: 14.4% B: 7.6% Septic shock A: 70.9% B: 40.4% Ischemic stroke A: 75.6% B: 32.1 % Hemorrhagic stroke A: 36.9% B: 15.6%	NR	NR

AMI = acute myocardial infarction; AOR = adjusted odds ratio; AV = atrioventricular; CI = confidence interval; ED = emergency department; HR = hazard ratio; ICU = intensive care unit; LOS = length of stay; MI = myocardial infarction; NA = not applicable; NICU = neonatal intensive care unit; NR = not reported; NS = not significant; OES = office of emergency services; OR = odds ratio

[a] Time periods overlap with other Marcin articles

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

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.***

Emergency Care Results

The research evaluating telehealth consultations in emergency care is presented in three sections. The first summarizes the literature on the use of telemedicine for stroke, the most frequently studied application of telehealth for this setting. The second section reviews studies of telehealth consultations used by emergency medicine services (EMS) in providing out of hospital care or by clinicians providing urgent care. The third section reports on consultations by various specialists provided as part of care in an emergency room or department. 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. Tables 8, 9, and 10 provide each more detail, focusing on the key results for each study, and the accompanying text discusses selected studies. Detailed information that we abstracted from each article is provided in Appendix F. The criteria and the overall rating for risk of bias assessment of each article are in Appendix G, and the strength of evidence assessment is in Appendix H.

Key Points

- Stroke: The results suggest that telestroke does not result in changes in mortality or in harms (low strength of evidence). However, telestroke does increase tPA use, an intermediate outcome (low strength of evidence).
- Specialty consultations in ED: 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). Teleconsultations have a positive effect on intermediate outcomes such as appropriate triage and transfers and shorter time in the ED (moderate strength of evidence). Analysis of costs was available only in a few studies, and the results favored savings but were not consistent (low strength of evidence), and no information was available about harms (insufficient evidence).
- EMS and Urgent Care: Six studies we identified evaluated telehealth for these uses. In general, the studies were either narrowly focused or provided limited data and analyses. Only one study provided information on a clinical outcome (mortality) and no studies reported harms (insufficient evidence). Telehealth led to a reduction in air transfers and referrals to higher-level care following urgent care (low strength of evidence), and these reductions contributed to estimates of lower costs (low strength of 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 Articles	Clinical Outcomes	Intermediate Outcomes	Cost	Citations
Stroke	12	✖ no difference in mortality ✖ no difference in harms	✓ increased tPA use	⦸	25,62-64,78,87,98,109,141, 144,150,155
Specialty consultations	12	✓ lower mortality, better outcomes ⦸ harms	✓ better transport triage, shorter ED time, better quality of care	✓ 2 studies report savings; 1 increased costs	22-24,26,67,79,94,118, 137,140, 142,143
EMS and Urgent Care	8	? mortality reported in only in 1 study ⦸ harms	✓ fewer transfers	✓ lower costs related to fewer transfers	68,80,111,112,130,136,145,153

ICU = intensive care unit; LOS = length of stay; tPA = tissue plasminogen activator
Key: ✓ superior (telehealth benefit), ✖ no difference or inferior (telehealth no benefit), ? inconclusive (inconsistent results), ⦸ no evidence

Detailed Results

Acute Stroke or Telestroke

Twelve 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 thrombolytic therapy (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 2 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 communication technology to provide timely consultations for patients who at locations or times when vascular neurologists are not physically available. Telestroke programs may involve video and/or audio communications and the transfer data from an ambulance or emergency department to the specialist who can then advise on transport or treatment. Usual care is to provide tPA after the in-person assessment if appropriate. In usual care, patients received care for their stroke but after a delay which may have limited their treatment options.

Table 8 provides selected information and the results from the identified studies of telestroke. The studies were conducted in several countries with half in the United States. Study designs included two randomized trials,[78,155] three prospective cohorts,[98,109,141] two retrospective cohorts,[62,64] and four before-after comparisons.[25,87,144,150]

Effectiveness in Improving Clinical and Economic Outcomes

Mortality was the primary clinical outcome reported in seven telestroke studies. Two studies reported a significant decline in the mortality rate; one from 10 to 8 percent in-hospital mortality and from 19 to 17 percent at 3 months,[109] and the other from 6.8 to 1.3 percent 10-days post stroke.[98] One study that compared patients who received telehealth and stayed at the initial "spoke" or outlying hospital had higher in hospital mortality rates than patients treated at the "hub" stroke center or patients treated at the spoke and transferred to the hub. [65] The other six

studies found no significant differences in mortality rates, and there was no consistent trend in the direction of effect (i.e., differences were higher, lower, and the same).[25,62,64,78,141,150,155]

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

Effectiveness in Improving Intermediate Outcomes

The primary intermediate outcome is the rate of providing tPA. This is a process measure, not a patient result, but timely delivery of treatment is the primary goal of most telestroke programs. All seven studies we included that analyzed tPA rates reported increases with telehealth, though this increase was only significant in three with an average increase of 4.16 percent across the three studies. In two of these three the rate of tPA use was initially 0 or near 0 (0.81%), and in one, the rate before telestroke was 2.8 percent. The increases were to 5,[109] 4.3,[63] and 6.8 percent.[25]

Harms, Adverse Events, or Negative Unintended Consequences

The primary concern with telehealth for stroke is that a patient will be given a contraindicated treatment that will lead to negative outcomes or complications. Specifically, tPA given incorrectly can result in hemorrhage. Four of the studies addressed harms reporting that there was no difference in incorrect treatment,[25] negative outcomes,[141] or hemorrhage.[62,63]

A related concern is the time it takes to evaluate a patient and start treatment. Evaluating this across studies is problematic as it is measured differently and often reported as a mean or median number of minutes rather than as the number of patients evaluated within the timeframe that tPA can be used. Any reported information about harms is included in Table 8, and although the results are consistent (few harms reported), they are difficult to synthesize given the differences in reporting.

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 more hospitals with stroke expertise (often, but not always, referred to as the hub) provide consultations to the hospitals that do not have that expertise (the spokes). The one study that did not follow this model[141] set up a telehealth system to allow off site neurologists to provide after-hours coverage.

The number of hospitals in these arrangements varies, with some involving only two hospitals 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 literature 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 (i.e., whether video was one or two way, what test results or images could be transmitted) provided in these articles. The studies do not report characteristics of the providers or the environments and only limited information on the patients (e.g., demographics to allow some assessment of whether the patients changed before and after telehealth or were different at the intervention and comparison hospital). Emergency care is often less studied given the time constraints and challenging environments. When emergency care is the subject of study, less data many be collected, producing less information about the context, and restricting synthesis to the major outcomes and limiting subgroup analysis.

Table 8. Telestroke: selected outcomes

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	 **Mortality** **Discharge Disposition/Short-Term Outcomes** **Long-Term Outcomes**	 **tPA Administration** **Time to Treatment** **Other Intermediate Outcomes**
Amorim, 2013[25] United States, PA 12 community hospitals 1 academic hospital 2588 Before-After Low A: Not telestroke B: Telestroke	In-hospital mortality A: 7.4% B: 10.9%, NS Discharge outcomes: Home A: 33.3% B: 26.5%, NS Rehabilitation A: 33.3% B: 32%, NS Incorrect treatment A: 0.2% B: 0.3%, NS	Overall IV tPA use **A: 2.8%** **B: 6.8%, p<0.001** Protocol violations **A: 0.2%** **B: 0.3%, p=0.7** Onset-to-treatment minutes A: 129.8 B: 124.4, NS Door-to-treatment minutes A: 74.2 B: 74.0, NS
Audebert, 2006[109] Germany Bavaria 2 academic hospitals 5 comparison hospitals 5 community intervention hospitals 3122 Prospective cohort Low A: Site without telestroke B: Site with telestroke	**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**

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality** **Discharge Disposition/Short-Term Outcomes** **Long-Term Outcomes**	**tPA Administration** **Time to Treatment** **Other Intermediate Outcomes**
Bladin, 2015[150] Australia 1 regional hospital,1 metropolitan hospital 282 Before-After Low A: Not Telestroke B: Telestroke	Mortality A: 7% B: 10%, NS	tPA use 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 door to needle time, in minutes (IQR) A: 101 (75-153) B: 85 (72-117), NS Median onset to needle time, in minutes (IQR) A: 218 (180-258) B: 173: (148-234), NS Median LOS, in days (IQR) A: 3 (1-6) B: 4 (2-6), NS
Choi, 2006[63] United States, TX 2 community hospitals one university hospital 625 Before-After High A: Not Telestroke B: Telestroke	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: **A: 2 (0.81%)** **B: 14 (4.3%), p<0.001** Median door to needle time (IQR), in minutes A: NR B: 85 minutes (range 27 to 165)
Demaerschalk, 2012[78] United States 2 stroke hubs and multiple rural spokes 276 Pooled Analysis of 2 RCTs Low A: Not Telestroke, telephone B: Telestroke	90 day functional outcome Barthel Index 95 - 100 A: 55% B: 46% NS 90 day modified Rankin Scale Dichotomized 0-1 A: 45% B: 36% NS 90 day mortality A: 12% B: 16% NS	Intravenous rt-PA usage A: 24% B: 29% OR 1.27, NS Correct thrombolysis eligibility decision **A: 83%** **B: 96%** **OR 4.2, p=0.002**

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality** **Discharge Disposition/Short-Term Outcomes** **Long-Term Outcomes**	**tPA Administration** **Time to Treatment** **Other Intermediate Outcomes**
Dharmasaroja, 2010[144] Thailand, Thammasat 1 hub hospital 25 spoke hospitals 576 Before and After High	Telehealth, not telehealth comparison unclear	tPA use: A: 8% B: 27%
Fong, et al., 2015[141] Hong Kong 1 hospital with offsite neurologists 152 Prospective Cohort Moderate A: Not Telestroke B: Telestroke	Mortality A: 11.9% B: 8.3%, NS 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 door to needle time, in minutes (IQR)* ***A: 71 (60-89)*** ***B: 97 (85-119), p<0.001*** *Median onset to needle time, in minutes (IQR)* ***A: 133 (109-154)*** ***B: 148 (134-170), p=0.012***
Handschu, 2008[98] Germany, Bavaria 2 stroke centers 2 local hospitals 151 Prospective cohort Moderate A: Not Telestroke B: Telestroke	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 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 ***A: 27.1 minutes*** ***B: 49.8 minutes, p<0.01*** LOS, in days A: 12.3 B: 11.4, NS

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Comparison**	**Mortality** **Discharge Disposition/Short-Term Outcomes** **Long-Term Outcomes**	**tPA Administration** **Time to Treatment** **Other Intermediate Outcomes**
Heffner, 2015[64] United States, PA 1 hub hospital 5 spoke hospitals 479 Retrospective Cohort Low Comparison A^1: Not telestroke, treated at hub hospital A^2: Not telestroke, treated at spoke then transferred to hub hospital B: Telestroke, treated at spoke hospital	In-hospital mortality, OR[c] (95% CI) **B vs. A^1: 11.046 (2.785 to 43.81)** **B vs. $A^1 + A^2$: 6.835 (2.157 to 21.659)** Higher mortality in the telehealth group	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
Ionita, 2009[62] United States, NY 1 hub hospital 10 community hospitals 155 Retrospective cohort Low A: Not Telestroke B: Telestroke	Inpatient mortality A: 14 (11%) B: 3 (11%), NS Poor mRS score[d] 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
Meyer, 2008[155] United States ,CA 1 hub hospital 4 spoke hospitals 222 (Included in Demaershalk, 2012 above) RCT Low A: Not Telestroke B: Telestroke	Overall mortality (%) A: 14 (13) B: 21 (19) OR: 1.6, NS BI score of 95-100 at 90 days, (%) A: 56 (54) B: 45 (43) OR: 0.6, NS mRS score of 0-1 at 90 days, (%) 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

Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Mortality Discharge Disposition/Short-Term Outcomes Long-Term Outcomes	tPA Administration Time to Treatment Other Intermediate Outcomes
Pedragosa, 2009[87] Spain 1 hub hospital 1 community hospital 399 Before-After Moderate A: Before telestroke B: After telestroke	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 0-3 hour window** **A: 30%** **B: 68%, p=0.04** Specialized neurologist evaluation: **A: 17%** **B: 38%, p<0.001**

AOR = adjusted odds ratio; BI = Barthel Index; CI = confidence interval; IQR = interquartile range; IV tPA = intravenous 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; tPA = tissue plasminogen activator

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

[b] An excellent mRS outcome is 0-1

[c] Adjusted for all risk factors and variables

[d] A poor mRS score is 4-6

Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.***

Emergency Care Specialist Consultations

Twelve articles reported on eleven studies of specialist consultations provided to ED providers. Given the variety of injuries, illnesses and conditions that are treated in EDs, it is not practical to have all potential specialty needs addressed in person. The studies we identified reflected this and included a range of specialties: trauma, burns, pediatrics, neurology, psychiatry, cardiology and orthopedics; however, no type of specialty consult was addressed in more than two studies. In ED consultations, like specialty consultations for in-patient care, the interactions between the providers about a specific patient are limited to a single consultation in a short time period. In the case of emergency care, consultations often need to be executed under time pressure or chaotic conditions. Ten of the 11 studies of specialist consultations in EDs were similar to telestroke in that they were before-after or cohort studies that did not provide detailed information on the care without telehealth. The one exception was a study that compared no consultation or phone consultations with telehealth consultations for the care of pediatric patients.[67]

Table 9 provides general information and the results from these studies. Half of these studies were conducted in the United States[22-24,26,67,79] while two studies (in three articles) were conducted in Hong Kong[140,142,143] and one each in Japan,[137] Italy,[94] and Turkey.[118] Half of the studies are small, including less than 100 patients[23,24,94,137,140] while at the other extreme, one study evaluated a statewide network and included data on over 14,000 patients.

Effectiveness in Improving Clinical and Economic Outcomes

The five studies reporting clinical outcomes all reported improvement, that is, lower mortality, morbidity or better function; however, these differences were not always significant. For example, a study comparing telephone, teleradiology and video consults for head injuries reported that mortality was significantly lower for video consults compared with telephone-only consultations.[142] In another study the mortality rate 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.[22]

Costs were evaluated in three studies. The 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.[22] The evaluation of a statewide network providing psychiatric consultations also reported savings in both inpatient charges and total health care charges 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, but details about what specific costs were included was not provided.[26] A study of neurological consults in Hong Kong found that the average cost per patient increased with video consults by approximately 2000 Hong Kong dollars, and the researchers attributed this to the increased time before a decision was made and the 30 percent failure rate of the video technology used.[142]

Effectiveness in Improving Intermediate Outcomes

The impact of telehealth consultations appears greater on intermediate outcomes such as LOS in the ED, appropriate transfers, time to treatment and quality of care and the effect on these is generally positive. For example pediatric video consultations compared with phone only or no consultation increased quality of care in one study[67] and reduced medication error in pediatric emergency care in another;[79] burn consultations reduced emergency air transports from 100 to 44.3 percent;[23] psychiatric consults reduced hospital admissions and increased odds of 30 and 90 day outpatient followup.[26] The two studies that used video for neurology consultations reported that the 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.[142,143]

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 Specialist Consultations and Correlation With Outcomes

All of the ED telehealth consultations involved visual data. Most were centered on video that allows visual assessment of patients and observation of ED procedures and audio communication. Only one study included only images.[94] 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. The non-United States studies appear to have similar goals though increasing access to care in rural areas was not explicitly stated as the goal of the 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 specialty consultations: selected outcomes

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Trauma	Duchesne, 2008[22] United States, MS 7 rural EDs 402 Before-After High A: Before telehealth B: After telehealth	Mortality, (%) A: 4 (7.8) B: 17 (4.8),NS	Discharge outcomes Home: A: NR B: 61.3% Admitted to local community hospital: A: NR B: 13.6% Transfer to trauma center: A: 100% B: 11% LOS at local community hospital, in hours **A: 47** **B: 1.5, p<0.001** Mode of transfer A: 74.9% ground B: 70.5% ground	Hospital costs **A: $7,632,624** **B: $1,126,683** **p<0.001**
ED: Burns	Saffle, 2009[23] United States 3 hospitals and 1 burn center 98 Before-After Moderate A: Before telehealth B: After telehealth	Mortality, (%) A: 1 (3.6) B: 0	**Air emergency transport** **A: 100%** **B: 44.3% p<0.05** 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

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED: Cardiology	Astarcioglu, 2015[118] Turkey 1 rural hospital 108 Prospective Cohort High A: Not telehealth B: telehealth	False STEMI did not occur in Group B, but did in 8.3% of Group A NS	Mean door to balloon time in minutes **A: 130** **B: 109** **p<0.001** Mean door to door time in minutes **A: 109** **B: 91** **p<0.001** Mean time from catheterization lab to balloon in minutes A: 18 B: 16 NS False STEMI: A: 8.3% B: 0% NS	NR
ED-Peds	Dharmar, 2013[67] United States, CA 5 EDs 320 Retrospective Cohort Moderate Comparison A^1: Before telehealth, no consult A^2: Before telehealth, phone consult B: After telehealth	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 among referring physician **B: 47.8%** **A^2: 13.3%, p<0.01** Changes in therapeutic interventions among referring physician **B: 55.2%** **A^2:C: 7.1%, p<0.01**	NR

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
ED-Peds Neurology	Dharmar, 2013[79] United States, CA 8 EDs 1 academic children's hospital 234 Retrospective cohort Low A^1: No telehealth, no consult A^2: No telehealth, phone consult B: Telehealth	Mortality A^1: 2 A^2: 1 B: 3	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
	Goh, et al., 1997[140] Hong Kong 2 referring hospital; 1 consulting medical center 63 Prospective Cohort High A: Before telehealth B: After telehealth	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%, NS Overall adverse events during transfer **A: 32.1%** **B: 6.4%, p=0.017**	Therapeutic interventions prior to 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 Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Neurology Psych	Wong, 2006[142] Poon, 2001[143] (pilot for Wong) Hong Kong 710 RCT Moderate Comparison: A: No telehealth B[1]: Telehealth, tele-radiology B[2]: Telehealth, video consult	Mortality at 6 months after admission, (%) A: 81 (34.5) B[1]: 59 (24.7) B[2]: 79 (33.5) **B[1] vs. A: p=0.025** B[2] vs. A: p=0.923 **B[2] vs. B[1]: p=0.043** Favorable outcome at 6 months after consultation, (%) 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]: 1.0 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 A: 14,075 B: 14,455 C: 16,370 30% failure of video
	Narasimhan, 2015[26] United States: SC 18 hospitals 14,522 Prospective cohort ; matched comparison group intervention group with Retrospective matched Cohort Moderate A: Site without telehealth B: Site with telehealth	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 within 30 days of a visit to ED, in USD: inpatient charges: **-2,338, p=0.041** total health care charges: -649 NS, p=0.614

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Psych	Southard, 2014[24] United States, IN 1 rural ED 62 Before-After Moderate A: Before telehealth B: After telehealth	NR	Mean LOS in ED consult, 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** Mean 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%	NA
Ortho: Pediatric Fractures	Zennaro, 2014[94] Italy One hospital 42 Pre-Post Moderate A: Not telehealth B: Telehealth	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

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Cancer	Hashimoto, 2001[137] Japan One district hospital 29 Before-after High A: Before telehealth B: After telehealth	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

CI = confidence interval; ED = emergency department; LOS = length of stay; NA = not applicable; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized control trial; 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

Emergency Medical Services/Urgent Care

Table 10 contains details and results on eight studies in which telehealth was used to advise EMS or urgent care providers. These studies are narrow in the sense that they focus on specific decisions or populations. In the groups without telehealth, the emergency personnel or clinicians made decisions about transfer or treatment without consultant input.

Effectiveness in Improving Clinical and Economic Outcomes

Only one study reported that the telehealth consultations had a significant impact on clinical outcomes. This EMS study assessed the impact of using telemedicine to triage heart attack patients and decide if patients should be transported directly to a location that can perform percutaneous coronary interventions. The researchers found that patients whose triage included telehealth experienced significantly lower in-hospital mortality and higher 1-year survival rates.[112]

Three studies included comparisons of costs of staff and equipment or estimates of savings. Two concluded that telehealth led to savings[111,136] while the third found telehealth costs were higher, both for the National Health Service and patients.[130]

Effectiveness in Improving Intermediate Outcomes

The available studies conclude that telehealth reduced the number of referrals or transfers to emergency or primary care or the time to definitive care. 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.[136,153] One study reported that transmitting electrocardiogram data and facilitating EMS personnel communication with a cardiologist during patient transport resulted in significantly lower door to balloon time for patients experiencing an acute MI.[80]

Two urgent care studies included evaluations of minor injury centers in which nurse practitioners provided treatments with telehealth input from physicians in Ireland and the United Kingdom,[111,130] and a study in the United States in which telehealth was used to provide care for semi and nonurgent problems at a short-term correctional facility.[68]

Harms, Adverse Events, or Negative Unintended Consequences

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

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

The small number of studies evaluating EMS and urgent care applications of telehealth consultations and their narrow focus made it difficult to identify any subgroups or characteristics that differentiated successful telehealth interventions for EMS and urgent care.

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

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
EMS	Kim, 2011[145] South Korea, Wonju 6 ambulances; 1 hospital 938 Retrospective cohort High A: Not telehealth B: Telehealth	NR	Mean time to the scene, in minutes A: 6.6 B: 6.6, NS Mean treatment time at the scene, in minutes A: 6.3 B: 4.4, p<0.001 Mean transport time, in min 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

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
	Mathews, 2008[153] Australia 1 community 191 A. 78 B. 113 Before-After Moderate A: Before telehealth B: After telehealth	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 (0.1-98.8) B: 2.0 (0.1-144.8), NS	NR
	Ortolani, 2007[112] Italy Retrospective cohort Moderate/High A: Not telehealth B: telehealth	In-hospital cardiac mortality: **A: 44%** **B: 21%** **OR: 0.35, 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 (150-366) B: 142 (106-187)	NR
	Sanchez-Ross, 2011[80] United States, NJ 1 university hospital 142 Prospective Cohort Moderate A: Not telehealth B: Telehealth	Mortality A: 6% B: 1.1% NS	Median door to balloon time, in minutes [IQR] **A: 119 [96 to 178]** **B: 63 [42 to 87], p<0.0004** Median LOS [IQR] A: 5.5 [3.5 to 10.5] days B: 3 [2 to 4] days p<0.001	NR
	Tsai, 2007[136] Taiwan, Pengu Island 822 Prospective cohort Low A: Not telehealth B: telehealth	NR	Flights per month A: 19.6 B: 12.5	Annual savings on emergency air medical transports, in USD: $448,986

Clinical Topic	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Comparison	Clinical Outcomes Harms	Intermediate Outcomes	Economic
Urgent Care	Darkins,1996[111] Ireland 1 Minor Treatment Center 16,701 Before-After High A: Before telehealth B: After telehealth	NR	Referred to ED: A: 2.3% *B: 1.5% Referred to primary care: A: 11.9% *B: 3.8% *n=9972; 51 (0.5%) seen using telehealth	A: 50,000 pounds for onsite staff B: 7,250 pounds for equipment
	Ellis, 2001[68] United States, NY 1 Correctional Facility 530 Retrospective High A: Not telehealth B: telehealth	NR	A: 1 hour 35 minutes at ED plus 1.5 hours transport B: 13 minutes on screen, 17 minutes write up and fax time Transported A: NR B: 36% Returned to ED within 7 days of assessment A: 5.5% B: 6.0%	
	Noble, 2005[130] UK Single hospital ED 253 RCT Moderate A: Not telehealth B: telehealth	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 difference (95% CI) [95% bias corrected CI] in mean costs per patient for 7 days following randomization, in GBP: NHS Cost: 39.47 (-1.28, 80.21) [28.31, 73.67] Patient/family cost: 14.28 (-26.59, 55.15) [-11.18 to 25.85] Total cost: 53.75 (-6.97, 114.46) [24.10 to 101.81]

CI = confidence interval; ED = emergency department; GBP = British Pound; IQR = interquartile range; LOS = length of stay; NHS = National Health Services; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized controlled trial; USD = United States dollars

Bold=statistically significant; telehealth superior

Outpatient Consultation Results

Collaboration with a specialist as part of outpatient care is what is mostly commonly thought of as a health care consultation. More than half of the studies we identified 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 the consultation. They also vary in the outcomes used to assess effectiveness. To capture and organize this variety, we present the results in three ways. First, we provide 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 the clinic topics and summarize how the results for outpatient consultations address the Key Questions for this review.

Organization of Evidence

The 81 included articles evaluating telehealth consultations in the outpatient setting are summarized in Table 11 below. They are grouped in 10 clinical topics, seven of which are specific specialties wherein we identified three or more articles (i.e., dermatology, wound care, ophthalmology, orthopedics, dentistry, cancer and psychiatry). 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 or for consultations about a specific condition. We split the remaining specialties that contain one or two articles each into two categories. The first consists of consultations involving the use of a diagnostic technology as part of the consultation. This includes echocardiograms, ultrasounds, endoscopies, and Dopplers. In these studies the consultation includes the real time transmission of images and data and may include the specialist guiding the technician on their use. Applications of telehealth consultations in this category include fetal cardiology, ultrasound for high risk pregnancies, endoscopies for cancer and ear, nose, and throat (ENT) diagnosis and Dopplers for the identification of vascular problems. The other group includes articles about specific specialty consultations that do not involve diagnostic technology. Most of these studies evaluate the use of telehealth consultations in the management of chronic conditions including hypertension, diabetes, arthritis and chronic pain.

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

Key Points

- Clinical outcomes: Clinical outcomes were reported in approximately one-quarter of the studies of telehealth consultations and in 5 of the 10 clinical topics. In four topics, the evidence demonstrates benefits (better healing in wound care, fewer missed fractures in orthopedics, higher response to treatment in psychiatry, and improvement in chronic condition outcomes), while in dermatology the findings are no difference in clinical outcomes (moderate strength of evidence).
- Intermediate outcomes

- Access: Telehealth consultations improved access by reducing wait times and time to treatment in dermatology and increasing the number of patients receiving indicated diagnostic tests (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 the differences were rarely statistically significant (low strength of evidence).

- Costs: Studies report lower costs due to reductions in transfers or less transportation but the rigor of the measurement, imprecision of estimates and inconsistency in the magnitude of the effects reduces confidence in these findings (low strength of evidence).
- Harms: None of the studies explicitly examined harms (insufficient evidence).

Table 11. Outpatient care consultations: summary of evidence

Clinical Topics	Number of Articles	Clinical Outcomes Including Harms	Intermediate Outcomes	Cost	Citations
Dermatology	21	✖ **no difference in** clinical course	✓ increased access	**?** mixed**:** lower costs in some but not all due to avoided travel and lost productivity	49,52-54,65,66,75-77,88,89,91,102,114,121,125,127,133,135,138,154
Wound Care	5	✓ better healing (2 studies)	✓ fewer hospitalizations	✓ lower costs	40,120,147,156,159
Ophthalmology	3	⊘	✓ fewer surgeon visits; high satisfaction	✖ no difference except patient travel	97,105,161
Orthopedics	7	✓ fewer missed fractures (1 study)	✓ improved quality, similar management	✓ lower costs	73,74,90,100,101,103,104
Dentistry	3	⊘	✓ reduced time to treatment	✖ outreach clinics were less expensive than telehealth	86,96,128
Cancer	5	⊘	✓ quality of care and satisfaction better or no difference	✓ lower costs	42,110,117,132,148
Psychiatry	6	✓ higher response to treatment; decreased symptoms	✓ higher satisfaction	⊘	55,69-71,84,85
Single Specialties with Diagnostic Technology	10	⊘	✓ better access and management of care	✓ lower costs due to patient costs	21,39,47,50,51,108,126,131,152,163
Single Specialties	11	✓ improvements in chronic condition outcomes	**?** effects on satisfaction and management are unclear	✖ some limited impact on costs	20,41,43,48,83,92,113,115,149,158,160

Clinical Topics	Number of Articles	Clinical Outcomes Including Harms	Intermediate Outcomes	Cost	Citations
Multiple Specialties[a]	10	⊘	✓ improved management and higher satisfaction **?** unclear impact on emergency department and hospitalizations	**?** mixed: lower costs in two studies; higher in one large trial	44,56,72,95, 99,106,122, 124,134,151

Key: ✓ superior (telehealth benefit), ✗ no difference or inferior (telehealth no benefit), **?** inconclusive (inconsistent results), ⊘ no evidence

[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

Effectiveness in Improving Clinical and Economic Outcomes

Approximately one-quarter of studies reported clinical outcomes. These were concentrated – though not exclusively limited to – among studies in which the consulting relationship was ongoing and involved treating and managing a condition over time as opposed to a single consultation. For example, four studies about psychiatric consultations, two about wound care, and five about chronic conditions all reported positive outcomes such as reduced symptoms, faster healing, or improved physiologic tests. Most, but not all of these studies, involved real time, video consultations wherein the patient was 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 for more information. In dermatology, three studies in which the consultation was not continuing but limited to diagnosis and initial management recommendations reported improvement in patients' conditions or that the clinical course did not differ between telehealth and in-person consultations.

Over one-third of the studies 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 most studies reported some cost savings for teleconsultations, the savings were mostly limited to avoided travel costs and loss of production for patients. In a minority of cases, telehealth consultations were not less expensive: a study of dental consultations to underserved communities concluded that telehealth consultations were more expensive than outreach visits by dentists, 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 the real time video consultation.

Effectiveness in Improving Intermediate Outcomes

Most of the 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-two studies reported outcomes related to utilization and management. In some clinical categories, a single study addressed these outcomes, while in other clinical categories, as many as ten articles studied utilization and management. Not unexpectedly, telehealth consultations reduced the number of in-person specialist and hospital visits; they also are 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., was the cause 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).

Eighteen 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 the associated and time and expense, while providers tended to be slightly less satisfied with telehealth consultations though this difference was not statistically significant.

Ten studies evaluated telehealth consultations in terms of improving access to services. These were concentrated in dermatology (5 studies) and specialty consultations that included diagnostic technology (3 studies). In the dermatology studies, telehealth consultations reduced wait time and time to treatment. In the studies of diagnostic technology, the number of patients receiving indicated tests and receiving them in less time increased with telehealth.

Harms, Adverse Events, or Negative Unintended Consequences

None of the studies of outpatient telehealth consultations explicitly addressed harms or unintended consequences. In part, this reflects the relatively short-term followup in most studies and the focus on intermediate outcomes. Although there are 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 diagnoses), these do not rise to the level of harms. The lack of information on harms does not mean they do not exist, rather this suggests a need to identify potential harms and assure they are included in future studies.

Key Characteristics of Studies and Association With Outcomes

As is evident from the detailed results, the outpatient studies of telehealth consultation include several disciplines. Just under half were conducted in the United States, and there is representation from several countries. For most clinical topics, the studies are from a variety geographic locations. There are some exceptions, for example, the four included studies of telehealth psychiatric consultations were all conducted in the United State while all the included ophthalmology and dental studies were conducted in other countries. The body of literature also includes studies with different designs and with sample sizes ranging from 11 to over 4000. 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, the outpatient studies did not report 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 the payment model for the consultations or the other care either replaced or necessitated by the consultation.

There were two characteristics of the telehealth consultations that we included in the in-text tables in this section that were not included in the inpatient and emergency care sections. These are whether the consultations were asynchronous or real time and when the consultation about a patient was for a single instance or if there were continuing interactions between the consultant and the 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); there is a similar distribution between consultations that were one-time (slightly less than two-thirds) and continuing (approximately 40%). We also looked at the percentage of studies with the characteristic to see if they were more or less likely to report positive results. More studies in which the consultations were real time reported a benefit (65%) than studies in which the consultation was asynchronous (50%). This may be because more information can be exchanged when the consultant and referring physician interact in real time or the relationship may be different and affect trust or the degree to which recommendations are implemented. The difference is smaller when comparing one-time and continuing consultations. In both cases about half of the studies reported a benefit (53% for continuing and 50% for one-time).

The difficulty in drawing conclusions from this information or generalizing further is that these characteristics are confounded with the clinical topic. For example 14 of the 20 dermatology studies are asynchronous while all the studies that involve 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, beginning to look at characteristics across studies and outcomes is an important initial step in increasing our understanding of when and how telehealth consultations are most likely to be effective.

Table 12. Characteristics of outpatient consultations and outcomes

Characteristic	Real Time	Asynchronous	One Time	Continuing
Percent of all outpatient studies	65%	44%	59%	39%
Percent of studies with the characteristic reporting a benefit[a]	65%	50%	50%	53%

[a] 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 10 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. We identified more studies of telehealth consultation for dermatology than any other outpatient specialty. The majority of studies use store and forward approaches in which images and medical history are made available to a dermatologist who reviews them at a different time, makes a diagnosis, and sometimes treatment recommendations (15 studies). A smaller number of studies (6 studies) use video to facilitate real time evaluation and discussion among the dermatologist, the referring physician, and the patient. In 17 of the 21 studies, the consultation is a one-time interaction about the patient, though the physicians may collaborate on many patients over time. In four studies, the dermatologist is involved in ongoing care and followup.

A minority of the dermatology studies (3 of 21) evaluated clinical outcomes. In one study 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.[91] 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 that evaluated 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.[66,77]

Most of the studies evaluated teledermatology in terms of one or more intermediate outcomes (assessment, satisfaction, and care management) or costs. 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,[53] and time from consultation to operation was 60.57 days for in-person and 26.10 days with telehealth consultations.)[89] 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** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Armstrong, 2007[49] United States, MA 1 community hospital 1 general hospital 451 Prospective cohort Moderate Real time Continuing A: Not Telehealth B: Telehealth	NR	Total hourly operating costs, in USD: A: $346.04 B: $273.66 Hourly reimbursement, in USD: A: NR B: $487.00

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Bezalel,2015[53] United States, FL 1 VA Hospital 3701 Before-After Moderate Asynchronous Continuing A: Not Telehealth B: Telehealth	**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[138] Mongolia 20 rural health clinics 1 National Dermatology Center 450 Cluster RCT Moderate Asynchronous One time A: Not Telehealth B: Telehealth	**Referrals:** **A: 28 (12.2%)** **B: 7 (3.1%), p<0.01**	Patients travel expense, in USD: A: $ 3174 B: $320 Total reduction in costs: $76.36 per patient
Collins,2004[133] United Kingdom 8 General Practices 1 hospital 208 Survey of RCT patients High Asynchronous Continuing A: Not Telehealth B: Telehealth	Response rate to patient satisfaction survey: A: 70% B: 72% Satisfaction with care you received: A: 90% B: 81%, NS Satisfaction with management of skin problem: A: 87% B: 84%, NS	NR

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Eminovic, 2009[91], 2010[121] Netherlands 35 general practices 2 hospitals 605 RCT Moderate Asynchronous One time A: Not Telehealth B: Telehealth	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 A: €354.0 (95%CI 228.0 to 484.0) B: €387 (95%CI 281 to 502.5) Mean out-of-pocket cost A: €16.3 (95% CI 8.1 to 24.5) B: €12.4 (95% CI 5.4 to 19.6) Mean Travel costs A: €15.2 B: €11.5 Mean Employer costs A: €47.3 (95% CI 18 to 83.1) B: €46.2 (95% CI 18.4 to 86.1)
Ferrandiz, 2007[89] Spain Seville 6 primary care 1 University hospital 134 Prospective cohort (pre-post for clinical accuracy) Moderate Asynchronous One time A: Not Telehealth B: Telehealth	Mean consultation to operation wait time, in days **A: 60.57** **B: 26.10, 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
Gilmour,1998[127] United Kingdom 3 health centers 3 hospitals 126 Prospective High Real time One time A: Not Telehealth B: Telehealth	Diagnostic concordance rates Identical diagnoses: 59% TH unable to make diagnosis: 11% TH missed a secondary diagnosis: 6% TH made wrong diagnosis: 4% ***Definitive diagnosis made:*** ***A: 97%*** ***B: 60%, p=0.002*** 81% management plan correct	NR

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Hsiao, 2008[52] United States, CA 1 VA Medical Center 3 remote primary care clinics 169 Retrospective cohort Moderate Asynchronous One time A: Not Telehealth B: Telehealth	Mean days to Initial evaluation: **A: 48** **B: 4, p<.0001** Mean days to biopsy: A: 57 B: 38, NS Mean days to surgery: **A: 125** **B: 104, p=0.006**	
Krupinski, 2004[54] United States, AZ 1 medical center 1 hospital 100 Retrospective Cohort High Asynchronous One time A: Not Telehealth B: Telehealth	**Recorded notes on action taken:** **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[102] Finland 1 health center 1 University hospital 191 Prospective Cohort High Real time One time A1: Ophthalmology A2: Dermatology B1: Tele-Ophthalmology B2: Tele-Dermatology	NR	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

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Loane,1999[125] UK Northern Ireland 4 health centers 2 hospitals 164 RCT Low Real time One time A: Not Telehealth B: Telehealth	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 A: 48.0 B: 31.6 Total mean time involved in attending appointment, including waiting, consultation and travel, in minutes A: 84.4 B: 59.3 Total mean distance involved in attending appointments, in km A: 25.4 B: 10.4	NR
Loane, 2001[154] New Zealand 2 rural health centers 1 hospital 203 RCT Moderate Real time Continuing A: Not Telehealth B: Telehealth	Average consultation time, in minutes A: 21.60 B: 20.04	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

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Mahendran, 2005[135] England 163 Pre-Post High Asynchronous One time A: Not Telehealth B: Telehealth	Assessment of TH diagnosis compared with conventional Identical diagnosis: 48% Actual diagnosis included as a possibility: 17% Incorrect diagnosis or could not be made: 20% Image of insufficient quality for assessment: 15%	NR
Moreno-Ramirez, 2009[88] Spain 12 Primary Care Centers 1 hospital 4018 Economic Analysis Moderate Asynchronous One time A: Not Telehealth B: Telehealth	NR	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
Nordal,2001[114] Norway 1 municipality 1 hospital 121 Crossover Moderate Real time One time A: Not Telehealth B: Telehealth	Diagnostic agreement 72% complete concordance 14% had partial concordance 13% were discordant Dermatologist satisfaction 14% of ratings favored telehealth 22% favored face-to-face Patient reports 61% no disadvantage to video 18% reduced contact with specialist 7% discomfort being recorded. 86% favored having GP present for teledermatology	

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Pak, 2009[65] Pak, 2007[66] United States, TX 698 for costs 508 for outcomes RCT and Cost Analysis Moderate (clinical) High (cost) Asynchronous One time A: Not Telehealth B: Telehealth	CHANGES IN CLINICAL COURSE Improved A: 65% B: 64% No change A: 32% B: 33% Worse A: 3% B: 4%, NS	Total cost per patient, 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
Whited, 2002[75] United States, NC 2 VA hospitals 3 outpatient clinics n=275 RCT Moderate Asynchronous One time A: Not Telehealth B: Telehealth	Time to initial definitive intervention in days, intention to treat analysis: **A: 114.3** **B: 73.8, p=0.0001** Time to initial definitive intervention, in days actual clinic visit analysis **A: 135.6** **B: 93.4, p=0.0027**	
Whited,2004[76] United States, NC 275 RCT Low Asynchronous One time Time to initial definitive intervention, in days A: Not Telehealth B: Telehealth	Clinicians' satisfaction with consult Agree: A: 23% B: 92% Neutral: A: 42% B: 5% Disagree: A: 35% B: 3% Patients' overall satisfaction with TH consultation outcome: 82% Preferred TH: 41.5% Preferred usual care: 36.5% Neutral, no preference: 22%	NR

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Intermediate Outcomes** (Clinical outcomes are UNDERLINED AND CAPITALIZED)	**Cost/Revenue Outcomes**
Whited, 2013[77] United States Randomized: 392 Analyzed: 261 RCT High Asynchronous One time A: Not Telehealth B: Telehealth	CLINICAL COURSE RATINGS BASELINE TO 1ST VISIT Resolved: A: 2% B: 2% Improved: A: 21% B: 23% Unchanged - not clinically relevant: A: 15% B: 12% Unchanged - clinically relevant: A: 51% B: 57% Worse: A: 11% B: 6% NS BASELINE TO 9 MONTHS Resolved: A: 26% B: 25% Improved: A: 46% B: 47% Unchanged - not clinically relevant: A: 11% B: 10% Unchanged - clinically relevant: A: 13% B: 10% Worse A: 4% B: 8% NS	NR

CI = confidence interval; GP = general practitioner; k = kappa; NR = not reported; NS = not significant; RCT = randomized controlled trial; TH = telehealth; USD = United States dollars; VA = Veterans Affairs
Bold=statistically significant; telehealth superior. ***Bold and italicized=statistically significant; telehealth inferior.***

Wound Care

Five studies reported on different approaches to telehealth for wound care (Table 14). The studies consisted of small numbers of home care, wound clinic, and long-term care patients. The four studies reporting clinical outcomes used different approaches to telehealth (one real time video[156] and three record and image review[120,147,159]) but both reported healing was better with telehealth expert consultations than with usual care. In all of these studies, consultations

continued over the course of the patients' treatment. Costs of telehealth consultations were lower than the cost of in-person consultations, and overall health care 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**	**Clinical Outcomes** **Harms**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Kobza, 2000[156] United States Hospital based home care agencies 76 Before and After High Real Time Continuing A: Not telehealth B: Telehealth	Stage II pressure ulcers healing rate, % A: 34 B: 83 Healing time decreased in all categories with telehealth Discharge with healed wounds: A: 37% B: 58%	Average home visits: A: 60 B: 33 Hospitalizations A: 18% B: 6%	NR
Stern, 2014[159] Canada, Ontario 12 long term care facilities 137 Before-After Moderate Asynchronous Continuing A: Not telehealth B: Telehealth	Average rate of healing: 1.0058 times slower in intervention period (95% CI 0.985 to 1.027), NS Time to healing: Intervention hazard ratio: 1.48 (95% CI 0.79 to 2.78,) NS	Estimated mean VAS wound-specific pain scores: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 was 1.3 times larger during intervention (95% CI 0.58 to 2.90) NS	Reduce direct care costs by $649 per resident

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical Outcomes** **Harms**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Santamaria, 2004[147] Australia, Kimberly 4 clinics 93 RCT-cluster High Asynchronous Continuing A: Not telehealth B: Telehealth	Healing rate, per week: **A: - 4.9%** **B: 6.8%, p=0.012** Amputation A: 6 B: 1	NR	Total Cost[a], in AUD A: $862,161 B: $670,226
Specht, 2001[40] United States, IA 1 long term care facility 11 Prospective High Asynchronous Continuing A: Not telehealth B: Telehealth	NR	Patient time spent away from facility, in hours A: 8.5 hours B: 20 minutes	Average cost of chronic wound consultation, in USD A: $246.28 B: $136.16
Zarchi, 2015[120] Denmark 4 home-care organizations 90 Prospective cohort Moderate Asynchronous Continuing A: Not telehealth B: Telehealth	1-Year wound healing [Adjusted hazard ratio (95% CI), p-value; group A=reference] 2.19 (1.15 to 4.17), p=0.017	NR	NR

AUD = Australian dollars; CI = confidence interval; ED = emergency department; NR = not reported; NS = not significant; RCT = randomized controlled trial; VAS = visual analogue scale

[a] 43 subjects per group were used in the costing analysis to eliminate the effect of the larger group of intervention patients

Bold=statistically significant; telehealth superior

Ophthalmology

None of the three studies of ophthalmology telehealth consults reported clinical outcomes (Table 15). One study compared telehealth and nontelehealth costs in ophthalmology and found no difference in the per visit cost and estimated that the only savings were from patients avoiding travel.[105] Telehealth did reduce the number of visits to a surgeon in a study of cataract management[97] and another study found a reduction in the potential number of hospital referrals when telehealth consultations were used for screening and triage.[161]

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**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Taleb, 2005[161] Brazil 1 Center 40 Prospective Moderate Asynchronous One-time A: Not telehealth B: Telehealth	Agreement on diagnosis: 95% of cases. Provider would have referred to ophthalmologist, 90% A: GP referrals 90% B: Telehealth Specialist 78%	NR
Tuulonen,1999[105] Finland, Oulu 70 1 rural health care center 1 University clinic Before-After Moderate Real time One-time A: Not telehealth B: Telehealth	Total mean time spent, in hours, including travel: A: 8.5 B: 2.0 Mean time absent from work, in hours A: 6.6 B: 3.3 Very satisfied with overall care, % A: 69 B: 86 Selecting telemedicine for next visit, % A: 81 B: 96 Reduction in travel as reason for wanting telemedicine for next visit, % A: 97 B: 96	Overall cost of visits, in USD A: 111 B: 110 No difference Decreased travel saved $55 per visit for telemedicine patients, not included in overall cost.

Author, Year **Geographic Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Zahlmann, 2002[97] Germany 5 ophthalmologists 62 Prospective and Retrospective High Both (asynchronous followed by real time) One-time A: Not telehealth B: Telehealth	Mean number of visits to referring ophthalmologists: A: 1.85 B: 2.02, NS Mean number of visits to surgical ophthalmologists **A: 2.05** **B: 1.07, p=0.0001** Mean travel time, in hours A: 2.53 B: 2.17, NS Mean satisfaction with overall treatment on a 10 point scale with 10 being negative **A: 0.95** **B: 0.14, p=0.019**	NR

GP = general practitioner; NR = not reported; NS = not significant; USD = United States dollars
Bold=statistically significant; telehealth superior

Orthopedics

Seven articles reported the results of five studies of the use of telemedicine in orthopedics (Table 16). Three studies used video visits to assess fractures[90] or to evaluate a range of orthopedic conditions encountered in primary care.[100,101] One of these found that using telehealth to transmit records and x-rays resulted in fewer missed fractures and fewer unnecessary hospital trips.[90] Availability of orthopedic video consultations with primary care practices resulted in lower costs, successful exams, and management plans that were not significantly different.[100,104] A U.S. Veterans Administration project had specialists review records of patients with recent fractures and write recommendations about medications and bone density testing for the primary care clinician. These consults conducted via the electronic record significantly increased adherence to guidelines for recommended treatments.[73,74]

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**	**Intermediate**	**Cost/Revenue**
Harno, 2001[100] Finland 2 hospitals 225 Prospective cohort Low Real-time One-time A: Not telehealth B: Telehealth	Mean time of visit, in minutes: A: 12 B: 13	Total cost per patient, in Euros A: 154.44 B: 41.22 Outpatient is 45% higher Marginal cost decreased 48 Euros for each visit
Haukipuro, 2000[101] Ohinmaa, 2002[103] Vuolio 2003[104] (1-year followup) Finland 145 1 outpatient clinic RCT Moderate (Haukipuro, Vuolio) Low (Ohinmaa) Real-time One-time A: Not telehealth B: Telehealth	Average time spent by patient, 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 Management plan for first-admission patients Operation: A: 54% B: 64% Follow-up or further examinations: A: 18% B: 18% Problem solved at 1st visit: A: 28% B: 18%, NS	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

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Intermediate**	**Cost/Revenue**
Jacobs, 2015[90] Netherlands, Ameland 2 general practices 806 Analyzed: 794 Before-After High Asynchronous One-time A: Not telehealth B: Telehealth	Referral to hospital A: 26.6% B: 8.1% Unnecessary trips to the hospital A: 13.1% B: 0.4% Missed Fractures (%) A: 9 (13.6) B: 2 (1.7)	NR
Lee 2016[74] United States Veterans Administration 321 Prospective Cohort Moderate Asynchronous One-time A: Not telehealth B: Telehealth	Travel Distance saved assuming that 1 visit was avoided for each veteran 11,917 miles or 69.7 miles per person Quality of care: Patient was ordered prescription of bisphosphonates, % **A: 39.7%** **B: 75.8%, p<0.01** Patients completed testing, %: **A: 37.1%** **B: 63.0%, p<0.01**	NR
Lee, 2014[73] United States 3 VA Medical Centers 3081 Prospective Cohort Moderate Asynchronous One-time A: Not telehealth B: Telehealth	Before-After % change in two facilities, one with telehealth in the after period, the other without 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

Bold=statistically significant; telehealth superior

Dental

Three studies, all conducted in Europe, evaluated the use of telehealth for dental consultations (Table 17). Two focused on specific issues (dental implants[96] and temporomandibular joint [TMJ] disorders[86]), and the third used video to replace in-person visits for restorative dentistry.[128] The results are 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 vs. 2.3).[86] The single cost analysis determined that telehealth visits were less than hospital visits but more than outreach visits (i.e., when dentists venture into communities in need of services).[128]

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**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Nickenig,2008[96] Germany 1 dental clinic 2 external experts 857 Prospective Moderate Real time One time A: No telehealth B: Telehealth	Changes in diagnosis (%) A: 36 (4%) B: 0 (0%) Change in prosthodontic protocol (%) A: 67 (7%) B: 3 (3%) Number and position of implants (%) A: 148 (19%) B: 13 (15%)	NR
Scuffham,2002[128] United Kingdom Comparison: A: Outreach visits B: Hospital visits C: Teledentistry 2 general dental practices 1 hospital 25 Prospective High Real time One time A: No telehealth B: Telehealth	NR	Total variable costs per patient, in £ A: 233.86 B: 1181.52 C: 404.10 Total societal costs, in £ A: 403.11 B: 1181.51 C: 582.69 Outreach visits are least expensive.

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Salazar-Fernandez, 2012[86] Spain, Seville 1 hospital 10 Primary Cares 1052 Prospective cohort Low Asynchronous Continuing A: No telehealth B: Telehealth	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

NR = not reported; NS = not significant
Bold=statistically significant; telehealth superior

Cancer

We identified five articles reporting on four studies about using telehealth in cancer care (Table 18). In all of these studies, telehealth was used to convene virtual tumor boards or cancer care planning meetings. All of the studies used video to communicate, and records were shared electronically. None followed patients over time to assess the impact on patient outcomes. 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 U.S. Veterans Administration, telehealth provided more comprehensive care and avoided travel, but the time from referral to treatment was not significantly different.[42] 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 the face-to-face meeting participants felt a consensus was reached more frequently than did the telehealth participants.[132] Similarly, 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 travel costs[110,117] while a study in Australia reported net savings as the travel avoided exceeded the cost of telehealth equipment.[148]

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**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Kunkler, 2007[132] UK Edinburgh, Scotland 2 general hospitals 1 cancer center 473 RCT: Cluster Moderate Real Time One time A: Not telehealth B: Telehealth	Mean response of MDT members on a 5 point scale with 5 being strongly agree, to the following 3 statements: 1. Consensus was reached by all parties involved **A: 4.20** **B: 4.06, p=0.048** 2. Confident that decision was in the best interests of the patient A: 4.16 B: 4.07, NS 3. Discussion of patient was 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 cheaper than standard meetings: approximately 40 meetings per year.
Salami, 2015[42] United States 1 VA referral institution 9 VA Medical Centers 116 Retrospective cohort Moderate Real Time One Time A: Not telehealth B: Telehealth	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

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Stalfors, 2003[110] Stalfors, 2005[117] Sweden 3 district hospitals 1 Regional Hospital 104 84 answered questionnaire Prospective cohort 2005 Retrospective analysis of the same study High (Stalfors, 2003) Moderate (Stalfors, 2005) Real Time One Time A: Not telehealth B: Telehealth	Mean time spent including travel and waiting time, in hours (95% CI) A: 8.9 (±0.8) B: 3.4 (±0.5) Actual presentation, in min (95% CI) A: 14.2 (±1.4) B: 13.3 (±2.03) Answered questionnaire A: 85% B: 78% Felt meeting went too fast A: 23% B: 42% 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% Rating of satisfaction with information about future treatment**:** Very good: A: 67% B: 56%, NS Good: A: 21% B:38%, NS Insufficient: A: 0% B: 2%, NS Bad: A: 0% B: 0%	Combined cost, in SEK A: 2267 B: 2036, NS Direct medical, in SEK A: 576 B: 1550[a] Direct nonmedical, in SEK A: 886 B: 176 Indirect nonmedical, in SEK A: 805 B: 310

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Intermediate Outcomes**	**Cost/Revenue Outcomes**
Thaker, 2013[148] Australia, Queensland 1 Cancer Center 6 rural centers 147 Retrospective cohort High Real Time Continuing A: Not telehealth B: Telehealth	NR	Net savings: $320,118 Total cost of tele consults: $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: $3600.

CI = confidence interval, MDT = multidisciplinary team, NR = not reported, NS = not significant, RCT = randomized controlled trial, SE = standard error, SEK = Swedish Krona, VA = Veterans Affairs

[a] 1288 is equipment cost

Bold=statistically significant; telehealth superior

Psychiatry

Six articles reported the results of four studies of telehealth programs used to treat depression[70,71,84,85] and posttraumatic stress disorder (PTSD)[69] in adults and attention deficit hyperactivity disorder (ADHD)[55] in children (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 health care in rural areas or to practices with no services. The studies randomized either practices or patients to the telehealth program or usual care. All four programs reported improvement in clinical outcomes such as decreases in symptoms or higher remission rates after 6 months or 1 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, but also an increase in specialty physical care costs attributed to case management referrals for pain management and management of other comorbid chronic conditions.[85] The same study also found that minority patients had a higher rate or response to treatment including telehealth, suggesting that telehealth as part of collaborative care may ameliorate racial disparities in care.[84]

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[70], 2011[85] Davis, 2011[84] United States, south-central 7 Veterans Administration primary care centers n=395 RCT Moderate Both Continuing A: Not Telehealth B: Telehealth	Depression treatment response at specified month A is reference **6 months: OR=1.94, p=0.02** 12months: OR=1.42, p=0.18 Minority vs. Caucasian A: 18% vs 8% NS **B: 42% vs. 19%, p=0.004** **Adjusted OR** **Minority response (Caucasian reference** **OR=6.0, p=0.01** Remission at specified month 6 months: OR=1.79, p=0.14 ***12 months: OR=2.39, p=0.02*** Health status indicators Change in PCS at specified month: group difference 6 months: 0.31, NS 12 months: 1.09, NS Change in MCS at specified month: group difference 6 months: 2.46, NS **12 months: 3.90, p<0.01** Change in QWB at specified month: group difference **6 months: 0.037, p<0.01** 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** 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 health care Encounters; marginal effect 0.42, p=0.001 Costs: marginal effect $490.60 p=0.003
Fortney,2013[71] United States, AR 5 Federally Qualified Health Centers n=364 RCT Moderate Real Time Continuing A: Not Telehealth B: Telehealth	Response to treatment **OR: 7.74, p<0.0001** Remission **OR: 12.69, p<0.0001** Adherence IRR: 1.22, NS[a] Primary Care Visits IRR: 1.16, NS[a] Depression-related primary care visits IRR: 0.99, NS[a] Any specialty mental health visits IRR: 0.56, NS[a]	Satisfaction at specified time period: OR Baseline 1.08: NS[a] **6 months, 2.76: p=0.0012** **12 months, 1.99: p=0.0313** 18 months,1.67: NS Depression severity at specified time period: group difference[a] Baseline: -0.04, NS **6 months:-0.50, p<0.0001** **12 months: -0.49, p<0.0001** **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[69] United States 11 Veterans Administration outpatient clinics n=265 RCT Moderate Real Time Continuing A: Not Telehealth B: Telehealth	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 at least 8 psychotherapy sessions: A: 5.3% B: 27.1% Percent receiving some 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**
Myers, 2015[55] United States, WA and OR 88 primary care providers n=223 children RCT Low Both Continuing Comparison: A: Not Telehealth B: Telehealth	Results at 25 weeks: Inattention **A: 48%** **B: 23%, p<0.001** Hyperactivity **A: 31%** **B: 16%, p=0.02** ADHD combined **A: 26%** **B: 12%, p=0.005** Oppositional defiant disorder **A: 26%** **B: 16%, p=0.04** Models adjusted for baseline differences produced similar results	NR

ADHD = attention deficit hyperactivity disorder; IRR = incidence rate ratio; MCS = Mental Component Summary; NR = not reported; 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

[a] Adjusted

[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

Consultations for Single Conditions Using Diagnostic Technology

In ten studies telehealth was used for consultants for a specific specialty, and the consultation involved guiding the use of diagnostic technology and assessing the transmitted information (Table 20). These studies used fetal echocardiograms,[50,108,131,163] ultrasound,[21,39] endoscopy,[126,152] Doppler,[47] and nasopharyngolaryngoscopy.[51] These studies found telehealth consultations increased 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 20. Single specialties using diagnostic technology: selected outcomes

First Author, Year **Location** ***Specialty And Technology*** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
McCrossan,2012[131] United Kingdom Northern Ireland *Fetal Telecardiology* 2 hospitals 66 Prospective Moderate Real time One time A: No telehealth B: Telehealth	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** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
Sharma,2003[50] United States, NY *Fetal Telecardiology* 2 hospitals; 1 with expertise, 1 without 229 Retrospective cohort High Real time One time A: No telehealth B: Telehealth	Mean number of inadequately identified cardiovascular items, out of 31 A: 2.3 items B: 2.1 items, NS	Patient satisfaction on a 5-point scale, with 5 as highest 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 Overall quality of care and services: A: 4.6 B: 4.5, NS	NR
Bagayoko,2014[163] Mali *OB and Fetal Echo* 8 clinics n=215 Prospective cohort (survey) and Case-Control Before After (consultations, cost) Moderate Real time (presumed, not stated) One time A: No telehealth B: Telehealth	Increase in rate of attendance A: 44.9% B: 79.8%	NR	Average patient savings with telehealth: equivalent to $25

First Author, Year **Location** ***Specialty And Technology*** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
Boman,2014[108] Sweden *Robot Assisted Echo and Cardiology* 1 primary health care center; 1 hospital 38 RCT Moderate Real time echo; separate followup One time A: No telehealth B: Telehealth	NR	Total median process time, in days (IQR) **A: 114 (75-140)** **B: 27 (12-60), p<0.001** Median time from randomization to echocardiography, in days **A: 86 (66-117)** **B: 12 (7-29), p<0.001** Median time from clinical examination to GP signing off the results, in days (IQR) A: 6 (4-25) B: 5 (0-19), NS	NR
Long, 2014[21] United States, AR *Obstetric Ultrasound* NR >90 health unit sites >54 hospitals 25 clinical sites Before-After Moderate Real time One time A: No telehealth B: Telehealth	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

First Author, Year **Location** ***Specialty And Technology*** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
Britt, 2006[39] United States, AR *Obstetric Ultrasound* NR >90 health unit sites >54 hospitals 25 clinical sites Before-After Moderate Real time One time A: No telehealth B: Telehealth	Mean number of maternal transports to UAMS A: 278 B: 237 Mean LOS per maternal transport, in days **A: 8.02** **B: 6.06, p=0.003**	Mean umber of remote consultations **A: 108** **B: 269, p=0.01** Mean umber 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** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
van der Pol,2010[126] UK: Scotland, Shetland Islands, and Aberdeen *Endoscopy for Airway Cancer* 2 rural clinics 1 mainland clinic n=90 Prospective Moderate Real time One time A: No Telehealth B: Telehealth	NR	NR	Total cost per patient, in £ A: 380.52 B: 353.43 Average cost per clinic, in £ 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 £ 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

First Author, Year **Location** ***Specialty And Technology*** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Utilization Outcomes**	**Other Intermediate Outcomes**	**Economic Outcomes**
Xu,2008[152] Australia, Queensland *Pediatric ENT With Endoscopy* 1 hospital; several clinics 265 Retrospective cohort Low Real Time Continuing A: No Telehealth B: Telehealth	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 between conducting 265 consultations A vs. B cost-savings $7,621
Endean,2001[47] United States, KY *Vascular Surgery with Doppler Probe* 1 University hospital; 3 clinics 32 Pre-post Moderate Real Time One Time A: No Telehealth B: Telehealth	NR	Mean evaluation time, in minutes A: 19.0 B: 20.6 Overall concordance (%) 29 of 32 (91%) Mean physician satisfaction score with telemedicine consult on a 7 point scale with 7 as the highest: 5.71 Mean patient satisfaction score when comparing TH to conventional from (-1) to 1 with 1 as better: 0.27	NR

AUD = Australian dollars; Echo = echocardiogram; ENT = ear nose and throat; GP = general practitioner; IQR = interquartile range; LOS = length of stay; NR = not reported; NS = not significant; TH = telehealth; RCT = randomized control trial; UAMS = University of Arkansas for Medical Sciences

[a] Average percentages A: 2001-2003; B: 2004-2007

Bold=statistically significant; telehealth superior

Single Specialty Consultations

An additional 11 studies evaluated the use of teleconsultations with specialists for different conditions (Table 21). These did not include the use of diagnostic tests or technology as part of the consultation. Instead, most involved consultations designed to assist in managing chronic conditions. Two studies facilitated asynchronous, ongoing exchanges of information between primary care physicians and specialists to facilitate management of hypertension[92] and diabetes;[115] in both cases patient outcomes improved. The remaining studies all assessed real time video consultations. Two studies were of diabetes management; one for children in schools[20] and one in remote regions far from medical centers.[113] Other studies were of video consultations for hepatitis C,[43,83] chronic pain,[41] genetic counseling,[149] rheumatology,[158] urology,[48] and end stage renal disease and dialysis.[160] These also reported positive effects of telehealth consultations on clinical outcomes (e.g., similar rates of repose to treatment or lower mortality rates) and more limited effects on intermediate outcomes (e.g., no difference in satisfaction or cost savings being dependent on patient costs).

Table 21. Single specialty by type: selected outcomes

Condition or Specialty	**Author, Year** **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical and Cost Outcomes**	**Intermediate Outcomes**
Hypertension	De Luca 2005[92] Italy, Naples 1 University Clinic 23 hospital based clinics 60 General Practitioners 4024 Prospective Cohort Moderate Asynchronous Continuing A: No Telehealth B: Telehealth	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** **OR[a] 0.838, p<0.05**	NR

Condition or Specialty	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical and Cost Outcomes	Intermediate Outcomes
Diabetes	Carallo,2015[115] Italy, Calabria 33 General Practitioners 312 Prospective High Asynchronous Continuing A: No Telehealth B: Telehealth	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 BMI kg/m2 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
Diabetes	Izquierdo, 2009[20] United States, NY 25 schools Kindergarden-8th grade 41 RCT High Real time Continuing A: No Telehealth B: Telehealth	HbA1c value at 6 months: A: increase **B: decrease, p<0.02** Urgent visits: A: no change B: significant decrease, p-value NR Hospitalizations for diabetic ketoacidosis A: 22.2% B: 4.3%	Pediatric Quality of Life Diabetes module: No difference between groups

Condition or Specialty	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical and Cost Outcomes	Intermediate Outcomes
Diabetes	Nikkanen,2008[113] Finland, Oulu Arc Sub region 3 health centers 101 Pre-post Moderate Real time Continuing A: No Telehealth B: Telehealth	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, mmHg: A: 146 B: 140 Difference:(-6), NS Mean body mass index, kg/m2: 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.	
Chronic Hepatitis C	Rossaro, 2013[43] United States, CA 1 physician 5 telemedicine clinics 1 University Clinic 80 Retrospective Moderate Real time Continuing A: No Telehealth B: Telehealth	Sustained virologic response A: 43% B: 55%, NS	Completion of therapy (%) **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 of therapy** **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

Condition or Specialty	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical and Cost Outcomes	Intermediate Outcomes
Hepatitis C	Arora, 2011[83] United States, NM 1 university clinic; 21 rural clinics 407 Prospective cohort Moderate Real time Continuing A: No telehealth B: Telehealth	Patients with sustained virologic response (%) All genotypes A: 84 (57.5) B: 152 (58.2) difference between ECHO sites and UNM HCV clinic 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 OR[a] 1.10, NS Serious Adverse Events **A: 13.7%** **B: 6.9%, p=0.02**	
Chronic noncancer pain	Frank, 2015[41] United States, Veterans Administrations 47 medical centers 148 community-based outpatient clinics A: 299,981 B: 22,454 Prospective cohort with pre-post elements Moderate Real Time Continuing A: No Telehealth B: Telehealth	NR	Delivery of out-patient care: HR **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: HR **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)

Condition or Specialty	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical and Cost Outcomes	Intermediate Outcomes
Clinical genetics	Gattas, 2001[149] Australia, Queensland 1 hospital 62 A: 23 (8 providers, 8 counselors, 5 patients) B: 44 (16 providers, 16 counselors, 12 patients) RCT High Real Time One Time A: No Telehealth B: Telehealth	NR	Numerical data not reported Patient satisfaction areas measured, no data provided: Communication Ability to maintain eye contact Comfort level of room Satisfaction with clinic format NS for all domains Provider satisfaction comparing A to B: Communication: no difference Ability to maintain eye contact: slightly lower Room comfortability: higher Satisfaction with clinic format: no difference Counselor Satisfaction: Counselors higher satisfaction with face-to-face consultations
End Stage Renal Disease (ESRD)	Bernstein, 2010[160] Canada, Manitoba 1 hospital; 12 local centers 2663 Retrospective Cohort Moderate Real Time Continuing A: No telehealth B^1: Local Community Care (Telehealth) Near Urban Center B^2: Local Community Care (Telehealth) Far from Urban Center	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, $p<0.01$	

Condition or Specialty	Author, Year Location Number of Sites Number of Patients Study Design Risk of Bias Timing Consultation Frequency Comparison	Clinical and Cost Outcomes	Intermediate Outcomes
Rheumatology	Jong, 2004[158] Canada 3 hospitals 6 physicians Prospective High Real time Continuing A[1]: No Telehealth, in person A[2]: No telehealth, email B: Telehealth	Average Cost: A: $975 -travel cost B: NR C: $87.50- half hour of videoconference, an average length of a session	Physician satisfaction: Higher for video than in person or in person with email, values not provided
Urology	Chu, 2015[48] United States, CA 1 Tertiary care clinic 2 outpatient primary clinics 97 Pre Post High Real time One time A: No Telehealth B: Telehealth	Estimated Savings: Expenses: $67 Lost Opportunity Cost: $126 Total patient savings: 5 hours $193 per visit	Estimated savings Mean distance: 277 miles Mean time: 290 minutes

ALT = alanine aminotransferase; APRI = aspartate aminotransferase (AST) platelet ratio index; BMI = body mass index; BP = blood pressure; CI = confidence interval; DBP = diastolic blood pressure; ECHO = Extension for Community Healthcare Outcomes; HbA1c = hemoglobin; HCV = hepatitis C virus; 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; SE = standard error; UNM = University of New Mexico

[a] Adjusted

Bold=statistically significant; telehealth superior

Multiple Specialty Consultations

We identified 10 articles representing eight studies that evaluated telehealth programs facilitating outpatient consultations for multiple specialists (Table 22). These programs mostly create agreements between primary care practices, but also correctional facilities and remote locations, and a hospital or medical center that has multiple specialists available. 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. The clinical outcomes are limited to avoiding inpatient and ED visits, and telehealth consultations did not result in significant changes in the

two studies that measured these.[72,124] Satisfaction was generally high, but the impact on access was not frequently reported, and most studies did not find differences in management. The evaluation of costs was mixed, with the largest study reporting higher costs for telehealth.[134] The higher costs were due to the equipment costs and to the fact that for the telehealth consultation both the primary care physician and the specialist were present. This added physician time was not offset by the cost savings despite a significant reduction in the number of tests and investigations.

Table 22. Multiple specialty 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**	**Economic Outcomes**
Angstman, 2009[56] United States, MN Number of sites unclear; 1 medical organization 728 Retrospective cohort Low Both One-time A: No Telehealth B: Telehealth	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[44] United States, CA 34 primary care and 4 specialty sites 741 Prospective Cohort High Real time Continuing A: No Telehealth B: Telehealth	NR	**Distance to specialist, in km** **A: 195** **B: 27** **Difference: (-168), p<0.05** Travel time, in minutes A: 156 B: 26 Difference: (-130), 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** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical Outcomes**	**Intermediate Outcomes**	**Economic Outcomes**
Fox, 2007[72] United States, TN 4 adolescent correctional facilities n=706 Before-After Moderate Real time Continuous A: Not telemedicine B[1]: Telehealth, after 1 year B[2]: Telehealth, after 2 years	ED visits per center per month expressed as estimate, IDR[A] 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 center per month expressed as estimate, IDR[A] **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	Mean time from referral to psychiatric treatment, in days A: 50.1 days B[1]: 24.86 days B[2]: 21.59 days Time from referral to treatment[a] expressed as HR (% decrease in time to referral) **Facility 1: 4.40, p<0.001, 77.27% reduction** Facility 2: 1.09, p=0.622, 8.26% reduction **Facility 3: 2.29, p=0.0006, 56.33% reduction** Facility 4: 0.74, p=0.1326, 35.14% increase Outpatient visits per center per month expressed as estimate, IDR[A] **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** Effect of telehealth volume usage on access expressed as estimate, IDR **Outpatient visits per center per month: 0.02, 1.0204, p<0.0001** **ED visits per center per month**: **(-0.05), 0.9524, p<0.0001** Inpatient visits per center per month: (-0.04), 0.9615, NS	NR

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation Frequency** **Comparison**	**Clinical Outcomes**	**Intermediate Outcomes**	**Economic Outcomes**
Harno, 2000[99] Finland, Myyrmäki and Tuusula 2 hospitals, 3 health centers n=292 Prospective cohort Moderate Asynchronous One time A: No Telehealth B: Telehealth	NR	Proportion of patients receiving appointments at outpatient clinic: A: 79% B: 43% Percent of consultations with diagnosis changes: A: 25% B: 29% Patient satisfaction: A: 60% B: 80%	Variable cost for outpatient visits, in €: A: 210.81 B: 32.06
Jaatinen, 2002[106] Finland, Satakunta 4 clinics 1 Hospital n=78 Randomized case-control Moderate Asynchronous Continuous A: No Telehealth B: Telehealth	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

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation** **Frequency** **Comparison**	**Clinical Outcomes**	**Intermediate Outcomes**	**Economic Outcomes**
Smith, 2002[151] Australia, Queensland Three hospitals 276 referrals (involving 387 patients) Before-After High Real time One time A: No Telehealth B: Telehealth	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[95] Greece, Lemnos and Skyros n=38 Prospective cohort Low Real Time One time A: No Telehealth B: Telehealth	NR	Average consultation time: A: 30.0 min B: 5.3 min Post-consultation time requirements: A: 10.0 min B: 2.6 min	Total cost per patient: A: 270.061€ B: 203.578€ Savings dependent on distance travelled and number of cases

Author, Year **Location** **Number of Sites** **Number of Patients** **Study Design** **Risk of Bias** **Timing** **Consultation** **Frequency** **Comparison**	**Clinical Outcomes**	**Intermediate Outcomes**	**Economic Outcomes**
Wallace, 2002;[124] Jacklin, 2003;[134] Wallace, 2004[122] United Kingdom 2 hospitals, 29 practices n=2094 RCT Low Real time Continuous A: No Telehealth B: Telehealth	Mean difference in specified variable 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 on a 5-point scale where 1=poor **A: 3.64** **B: 3.97** **Difference: 0.33 (0.23 to 0.43)** Mean patient enablement, higher scores indicate improved enablement: A: 2.4 B: 2.5 Difference: 0.07 (-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: 48.1 47.5 -0.51 (-1.78 to 0.7) Difference between patients offered followup appointments, OR: **11%, 1.53, p<0.0001** Mean difference in # of outpatient visits, (95% CI): 0.04 (-0.10 to 0.18) Mean difference in # of contacts with practice (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 the GP and specialist time

CI = confidence interval; ED = emergency department; GP = general practitioner; IHR = hazard ratio; DR = incidence density ratio; NHS = National Health Service; NR = not reported; NS = not significant; OR = odds ratio; RCT = randomized control trial; SD = standard deviation; SF-12 = Short Form-12

[a] Combined 1+2 years after telehealth

Bold=**statistically significant; telehealth superior.** ***Bold and italicized=statistically significant; telehealth inferior.***

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.

Most 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 methods and results.

The strongest evidence across groups of studies, all moderate SOE ratings, is for five combinations of settings and outcomes. For inpatient care, the evidence supports the positive impact of remote intensive care units (ICUs), showing that they reduce ICU mortality and ICU length of stay (LOS). In emergency care the studies estimate that 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. Telehealth consultations may reduce inpatient LOS and costs; may improve outcomes and reduce costs for emergency care due to fewer transfers; and may reduce outpatient visits and costs due to travel (low strength of evidence in favor of telehealth). Current evidence reports no difference in overall hospital LOS with remote ICUs, no difference in clinical outcomes with inpatient telehealth specialty consultations, no difference in mortality but also no difference in harms with telestroke; 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 telehealth consultations for conclusions to be drawn (insufficient evidence).

The SOE is low or insufficient across all the settings for the impact of telehealth on costs. This is due to several factors. First, only a minority of the studies assessed economic outcomes (43 of 145) so there are not as many studies as there were for clinical and intermediate outcomes in any given setting or clinical area. Perhaps more importantly, those studies that did examine costs or other economic impacts often lacked rigor and detail (e.g., used changes in length of stay and average costs to estimate change or compared costs across time periods without any adjustments) or used different perspectives and units of measurement, making it difficult to draw conclusions across studies. The results of our prototype decision model underscore the importance of both perspective or setting and how outcomes are measured on the conclusions that can be drawn about the economic impact of telehealth from the available evidence.

More details on the results for each setting are provided in the following text and summary tables.

Inpatient Telehealth Consultations

To facilitate summary and synthesis we split the inpatient studies into Remote ICU and specialist consultations for hospitalized patients. Table 23 provides the number of studies reporting each type of outcome, the main finding 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 ICU LOS (moderate strength of evidence). Their impact on hospital mortality and LOS is less clear with some studies reporting lower mortality and some finding no difference (low strength of evidence). A subset of the studies (5) analyzed the costs of remote ICUs or their impact on revenue but their methods and conclusions were inconsistent with half reporting savings or increased revenue and half reporting increased costs (insufficient evidence). The studies of inpatient specialist consultations reported that clinical outcomes, including mortality or serious morbidity (e.g., cardiac arrest, low birthweight, falls, and disability) improve with telehealth but these differences are not always statistically significant (low strength of evidence) while the impact on intermediate outcomes such as hospital LOS or patient satisfaction is also mostly positive, but with differences that are close to significant and estimates that are less precise (low strength of evidence). Costs were compared in only three studies, two of which reported savings (low strength of evidence), and only one study explicitly examined harms (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; while this differed across studies there was no identifiable pattern of association of these characteristics with the results.

Table 23. 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)	10	Lower ICU mortality with telehealth	Moderate
	Hospital Mortality (KQ1)	8	Lower (but not always statistically significant) mortality or no difference with telehealth	Low
	Cost (KQ1)	5	Unable to summarize across studies: different methods and inconsistent results.	Insufficient
	ICU LOS (KQ2)	8	Shorter ICU LOS with telehealth	Moderate
	Hospital LOS (KQ2)	8	No difference in hospital LOS	Low
	Harms (KQ3)	0	None reported in identified articles	Insufficient
Inpatient specialty consultations	Clinical outcome (KQ1)	11	Better clinical outcomes with telehealth but small differences and most not significantly different	Low
	Cost (KQ1)	3	Cost savings due to avoiding transfers or travel when telehealth is used	Low

Topic	Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
	Intermediate outcome (KQ2)	14	Reductions in LOS and waiting time but all not significantly different; satisfaction measures good but not excellent	Low
	Harms (KQ3)	1	One study of teleproctored endoscopic surgery reported no difference in complications or harms compared with standard procedures	Insufficient

ICU = intensive care unit; KQ = Key Question; LOS = length of stay

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 and urgent care (Table 24). Across the telestroke studies there were no differences in mortality or harms, but there was a consistent increase in treatment with tPA (all low strength of evidence). The studies of specialty consultations for emergency patients all reported improvements in clinical outcomes, however, these differences were not always statistically significant, and two of three studies reported lower costs (low strength of evidence). For intermediate outcomes such as transfers, hospital admissions and time spent in an ED, there were more consistent finding of benefits from telehealth consultations (moderate strength of evidence). We did not identify sufficient evidence to reach a conclusion about clinical outcomes or 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) and costs (low strength of evidence).

Table 24. 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 (KQ1)	8	No difference in mortality when telehealth and no telehealth are compared	Low
	tPA administration (KQ2)	7	tPA use increases (significant in 3 studies; not in 3 studies)	Low
	Harms (KQ3)	4	No difference in harms or increase in negative outcomes	Low
Emergency Care: Specialty Consultations	Clinical outcomes (KQ1)	5 (six articles)	Lower mortality or better outcomes with telehealth but not always statistically significant	Low
	Cost (KQ1)	3	2 of 3 studies report lower costs with telehealth	Low
	Intermediate outcomes (KQ2)	12	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

Topic	Outcome (KQ)	Number of Studies (N)	Main Findings	Strength of Evidence (Insufficient, Low, Moderate, High)
Emergency Care: EMS or Urgent Care	Clinical Outcomes (KQ1)	1	Single study of prehospital telehealth triage of patients with cardiogenic shock in Italy (n=121 patients)	Insufficient
	Cost (KQ1)	3	Lower costs due to avoided transfers when telehealth is used	Low
	Intermediate Outcomes (KQ2)	4	Fewer air transfers or referrals to higher level of care with telehealth	Low
	Harms (KQ3)	0	No studies reported data on harms	Insufficient

KQ = Key Question; tPA = tissue plasminogen activator

Outpatient Telehealth Consultations

We grouped the included articles evaluating telehealth consultations in the outpatient setting into 10 clinical topics (Table 25). Seven are specific specialties wherein we identified three or more articles (i.e., dermatology, wound care, ophthalmology, orthopedics, dentistry, cancer and psychiatry). The remaining three topics consist of programs designed to facilitate consultations with multiple specialists and two groups of reports about specialties containing one or two articles each. The first consists of consultations involving the use of diagnostic technology such as echocardiograms, ultrasounds, endoscopies, and Dopplers. The other group includes articles about specific specialty consultations that do not involve diagnostic technology, and these studies evaluated the use of telehealth consultations in the management of chronic conditions including hypertension, diabetes, arthritis and chronic pain.

Clinical outcomes were improved in several clinical areas including wound care, orthopedics, psychiatry, and chronic conditions such as diabetes, and clinical course was found to be similar in dermatology (moderate strength of evidence). For some specialties including ophthalmology, dentistry, cancer, and specialties combined with diagnostic technology, clinical outcomes were not reported, and none of the outpatient studies explicitly addressed harms. Given that all of these studies addressed at least one intermediate outcome, we split them into three categories for the SOE assessment: access, management and utilization, and satisfaction. Access was improved with telehealth consultations particularly in dermatology where time to diagnosis and treatment were reduced or in telehealth consultations using diagnostic technology which 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 impact how a condition was managed and what services were utilized (e.g. a hospitalization or travel to a specialist for an in-person exam). While 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, a minority of studies reported differences in diagnosis, planned management, or treatment (low strength of evidence). 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). Costs were reported as lower in most studies, but the methodologies used varied considerably, and most of the positive

(cost savings) results hinged on patient savings of travel and time rather than cost savings for the health system (low strength of evidence).

Table 25. 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)	21	Improved or similar clinical outcomes with telehealth compared with other modes of consultation	Moderate
Cost (KQ1)	29	Most but not all 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)	10	Access in terms of time to or comprehensiveness of service is improved with telehealth	Moderate
Intermediate Outcomes: Management and Utilization (KQ2)	32	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)	18	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

An 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, comparing (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 health care 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.

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 health care outcomes[164] and reviews on single clinical areas (e.g. dentistry[165] and psychiatry[166]). In total we reviewed 17 systematic reviews that were related to our topic and used these to identify additional studies to include 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 categories. 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 (e.g., to diagnose a condition or to provide direction during a surgery) of the consultation and the types of outcomes. For example, even though the populations are different, remote neurological consultation or an adult with TBI 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 and how they 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 necessary technology may be different from that needed to connect ambulances and first responders to consultants.

Our approach and the issues of applicability for outpatient consultations 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. We divided the 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, satisfaction, or the use of health services. In this case the focus was on differences in outcomes for telehealth on these three types of outcomes.

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 a comparison group and retrospective cohort studies. In some cases, all of the studies for a specific clinical area would be considered weak designs. For example, all of the studies on remote ICU programs compared outcomes prior to the remote ICU program initiation to a period after implementation. Even though some 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 consultant) was being given 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 may be able to conclude that remote ICU reduces mortality and store and forward dermatology reduces time to diagnosis, but it is hard to say which is more effective. 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 disability but not necessarily mortality. However, because disability 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 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, infectious diseases, 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 or 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 telehealth for a specific function, 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. This focused our search on this specific function of telehealth and telehealth in general. 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, related 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 we did not include some existing relevant studies.

As the focus of the 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 did not attempt quantitative synthesis using meta-analysis. Instead we used the strength of evidence framework to examine results across studies that were similar in terms of setting and types of outcomes. 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 come to different conclusions.

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 quality adjusted life years (QALYs) could be used to inform judgements about the value of additional costs given the patient benefits.

Future Research Needs

While we identified over 140 studies 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 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 they were not all rural or under-resourced hospitals as has been suggested might 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 with an appropriate technician and 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. Having 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 measures of access or satisfaction or cost effectiveness assessments that standardize benefits into measures such as quality adjusted life years. While costs are not the only important outcome, collecting more cost and 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 what the most important outcomes for a given condition are. 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. 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.

The need for clarifying objectives is related to the need for the use and study of telehealth consultations to consider different perspectives and different levels of implementation and evaluation. The work on the decision analyses highlighted the importance of clearly specifying the options being compared, or what is "usual care." For example for a decision analysis, it is important to decide if the alternative to a telehealth consultation is a face-to-face consultation or

nonreceipt of a service/no consultation. While both may be possible, this shapes the many factors for consideration. In the studies we evaluated for the systematic review, what the nontelehealth or "usual care" option consisted of was often not specified and was not always clear.

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 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 for money could come from a 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.

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 some data is 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.

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.

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 given 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 mortality and length of stay (LOS); 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 and increase access to care.

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 decisionmaker'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

ADHD	attention deficit hyperactivity disorder
AHRQ	Agency for Healthcare Research and Quality
AOR	adjusted odds ratio
APACHE	Acute Physiology and Chronic Health Evaluation
AV	atrioventricular
BMI	body mass index
BP	blood pressure
CCRCT	Cochrane Central Register of Controlled Trials
CI	confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CMMI	Center for Medicare & Medicaid Innovation
CPT	current procedural terminology
DBP	diastolic blood pressure
DCER	decremental cost-effectiveness ratio
DM	decision model
DNR	do not resuscitate
DRG	diagnostic related group
Echo	Echocardiogram
ED	emergency department
EEG	electroencephalogram
eICU	electronic intensive care unit
ENT	ear, nose, and throat
EMS	emergency medical services
EPC	Evidence-based Practice Center
GBP	British Pound
GOS	Glasgow Outcome Scale
GP	general practitioner
HgbA1C	Hemoglobin A1c
HIPPA	Health Insurance Portability and Accountability Act
HR	hazard ratio
ICER	incremental cost-effectiveness ratio
ICP	intraparenchymal intracranial pressure
ICU	intensive care unit
IQR	interquartile range
ITT	intention to treat
IV tPA	intravenous tissue plasminogen activator
K	Kappa

KQ	Key Question
LDL	low-density lipoprotein cholesterol
LOS	length of stay
MCS	Mental Component Summary
MESH	Medical Subject Heading
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
NR	not reported
NS	not significant
NSI	neurosurgical intervention
OB/GYN	obstetrics/gynecology
OHA	oral hypoglycemic agent
OR	odds ratio
PCS	Physical Component Summary
PICOTS	population, intervention, comparator, outcomes, timing, and setting
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTSD	posttraumatic stress disorder
QALY	quality-adjusted life-years
RCT	randomized controlled trial
RR	risk ratio
RVU	relative value units
SAPS	Simplified Acute Physiology Score
SBP	systolic blood pressure
SD	standard deviation
SE	standard error
SEADs	Supplemental Evidence and Data for systematic reviews
SEK	Swedish Krona
SF-12	Short Form-12
SOE	strength of evidence
SR	systematic review
TBI	traumatic brain injury
TEP	Technical Expert Panel
TM	Telemedicine
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