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Telehealth-guided provider-to-provider communication to improve rural health: A systematic review

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Abstract

Introduction: Telehealth may address healthcare disparities for rural populations. This systematic review assesses the use, effectiveness, and implementation of telehealth-supported provider-to-provider collaboration to improve rural healthcare.

Methods: We searched Ovid MEDLINE®, CINAHL®, EMBASE, and Cochrane CENTRAL from 1 January 2010 to 12 October 2021 for trials and observational studies of rural provider-to-provider telehealth. Abstracts and full text were dual-reviewed. We assessed the risk of bias for individual studies and strength of evidence for studies with similar outcomes.

Results: Seven studies of rural uptake of provider-to-provider telehealth documented increases over time but variability across geographic regions. In 97 effectiveness studies, outcomes were similar with rural provider-to-provider telehealth versus without for inpatient consultations, neonatal care, outpatient depression and diabetes, and emergency care. Better or similar results were reported for changes in rural clinician behavior, knowledge, confidence, and self-efficacy. Evidence was insufficient for other clinical uses and outcomes. Sixty-seven (67) evaluation and qualitative studies identified barriers and facilitators to implementing rural provider-to-provider telehealth. Success was linked to well-functioning technology, sufficient resources, and adequate payment. Barriers included lack of understanding of rural context and resources. Methodologic weaknesses of studies included less rigorous study designs and small samples.

Discussion: Rural provider-to-provider telehealth produces similar or better results versus care without telehealth. Barriers to rural provider-to-provider telehealth implementation are common to practice change but include some specific to rural adaptation and adoption. Evidence gaps are partially due to studies that do not address differences in the groups compared or do not include sufficient sample sizes.

Keywords

Rural health, remote consultations, telehealth, telemedicine, Extension for Community Healthcare Outcomes (ECHO), systematic review, video education

Numerous studies have documented health disparities for people living in rural areas of the United States.[1–4] Rural-urban differences in access and quality of care contribute to higher mortality[4–7] and morbidity from conditions including substance/opioid misuse,[8,9] chronic illnesses,[10–13] and human immunodeficiency virus/human papillomavirus and other infectious diseases.[14,15] Causes of rural-urban differences are varied and related to complex macro and micro sociologic-demographic forces[16] and economic trends;[17,18] nevertheless, the need for solutions is urgent. Both the coronavirus disease 2019 (COVID-19) pandemic and acknowledgement of structural racism have focused attention on broad inequities in healthcare in the United States, disproportionate burden on rural populations, and the resulting harms to underserved populations.

Telehealth utilizes technology to provide health care across time and/or distance[19], encompassing a wide range of interventions, modes, and clinical functions. Telehealth

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is frequently proposed to address limited access and health disparities[20,21] and there is a sizable body of research, including systematic reviews and reviews of reviews,[22–29] suggesting telehealth can be effective. However, implementation and spread have been slow,[30–32] with steady, but small increases in telehealth use before the COVID-19 pandemic.[33] Rapid increases in the use of telehealth to limit the risk of exposure and transmission during the COVID-19 pandemic may continue to fuel wider adoption and more long-term use.[34,35] Growth in telehealth has focused attention on the need to address the digital divide, promote widespread access to telehealth,[36] and assure telehealth promotes equitable healthcare.[37]

Rural provider-to-provider telehealth (RPPT) is a subset of telehealth interventions focused on supporting health care providers that treat rural patients and populations through consultations and collaborative patient care as well as mentoring and education.[38–40] We conducted this systematic review to identify and synthesize the available research on whether telehealth-supported provider-to-provider communication and collaboration can contribute to improving the health and well-being of rural residents and communities. This review was conducted to inform a National Institutes of Health (NIH) Office of Disease Prevention (ODP) Pathways to Prevention (P2P) workshop, *Improving Rural Health through Telehealth-Guided Provider-to-Provider Communication,* held on October 12–14, 2021). The panel report and recommendations from this workshop are also published in this journal.[41]

Methods

We conducted this review using methods outlined in the Agency for Healthcare Research and Quality (AHRQ) Methods Guide for Effectiveness and Comparative Effectiveness Reviews (hereafter "AHRQ Methods Guide").[42] Our protocol is available on the AHRQ website (https://effectivehealthcare.ahrq.gov/products/rural-telehealth/protocol) and registered with PROSPERO (registration no. CRD42021233545). Detailed methods and additional information in the full report are available at https://effectivehealthcare.ahrq.gov/products/rural-telehealth/research.

Key questions

This review was designed to answer the following four questions:

Key Question 1:

What is the uptake of different types of provider-to-provider telehealth in rural areas?

Key Question 2:

What is the effectiveness of provider-to-provider telehealth for rural patients?

Key Question 3:

What strategies are effective and what are the barriers and facilitators to implementation and sustainability of provider-to-provider telehealth in rural areas?

Key Question 4:

What are the methodological weaknesses of the included studies of provider-to-provider telehealth for rural patients and what improvements in study design (e.g. focus on relevant comparisons and outcomes) might increase the impact of future research?

Data sources and searches

We developed strategies with an expert librarian, had these peer-reviewed by a second librarian, and searched Ovid MEDLINE®, CINAHL®, EMBASE, and Cochrane CENTRAL for studies published between 1 January 2010 and 13 October 2021 (Search strategies included in online Supplement 1). Studies on telehealth have been published before January 2010. However, this start date was selected in consultation with the key informants and NIH ODP stakeholders and corresponded to their request to focus the review on studies using current technology that would be most relevant to future policy and decision-making.

Study selection

Two team members reviewed abstracts and full-text articles to identify studies that met our inclusion criteria (Supplemental Table 1), and any disagreements were resolved through discussion and consensus. To be included, studies had to be of rural patients or populations, or report results separately for rural patients or populations. Trials and observational studies that provided data on use, effectiveness, and facilitators or barriers to implementation of RPPT for inpatient, outpatient, or emergency care and studies of telehealth used for training health care providers who care for rural populations were included. Descriptive articles and studies that reported only data after telehealth implementation (no comparison group) were excluded. Studies had to be conducted in the United States or countries identified as having very high or high human development levels by the United Nations Human Development Report.[43]

We defined RPPT as any form of interactive support using telecommunications technology provided to health care professionals who care for rural patients and populations. This included: video, audio, or digital remote consultations across space (e.g. video) or time (e.g. store and forward) as well as remote mentoring or education including rounds or case reviews. We excluded (a) telehealth for patient encounters, (b) remote patient monitoring if the data were transmitted only from a patient to a single provider and were not used as part of provider-to-provider

consultations, and (c) communications that were limited to referring a patient to another provider for care and with no other interaction.

To assess use of RPPT we included studies with indicators or measures of uptake such as rates of use as outcomes. For effectiveness we included studies reporting clinical outcomes (e.g. mortality and morbidity) and intermediate outcomes (e.g. treatment, satisfaction, health care services utilization, and economic outcomes) We excluded studies if the outcomes were projections or the results of simulations.

Data extraction and risk of bias assessment

One person extracted data on the study design, setting, patient population, telehealth intervention, participating providers, and outcomes from the included studies. If a study was reported in multiple publications, the study was included once in our counts, but information about the study and data on outcomes were abstracted from all available publications. When extracting data from effectiveness studies, we also extracted methodological weaknesses listed by the study authors. Extracted data were verified for completeness and accuracy by a second person. Two team members independently assessed the risk of bias for individual studies using criteria appropriate for the study design and consistent with the approach in the AHRQ Methods Guide.[42] Studies were rated as low, moderate, or high risk of bias.

Data synthesis and analysis

We summarized surveys and analyses that provided counts or estimates to assess use of RPPT. To address the effectiveness of RPPT, we grouped studies by health care setting, then clinical indication, and summarized findings based on the direction and magnitude of effect. We also assessed the strength of evidence (SOE) for outcomes prioritized by the ODP working group, following the approach described in the AHRQ Methods Guide.[42] Our assessment of implementation summarized the few identified studies that compared approaches, then summarized barriers and facilitators cited in included studies. We classified barriers and facilitators using an existing framework, the Consolidated Framework for Implementation Research (CFIR).[44] We then summarized how frequently barriers and facilitators were reported across all identified studies. Our synthesis of the methodologic weaknesses of the effectiveness studies consisted of summarizing the weaknesses identified by the study authors as well as those identified by the review team.

Results

Our search produced 6329 citations, after triage of abstracts we reviewed 1024 full-text articles and included 166 studies reported in 179 publications (Figure 1). Seven studies met the inclusion criterial for Key Question 1 and provided data on use of provider-to-provider telehealth is rural areas (Key Question 1), 97 studies in 106 publications provided data on effectiveness of RPPT(Key Question 2) and were also used to identify methodological weaknesses in the body of evidence (Key Question 4), and 67 studies in 71 publications were used to summarize barriers and facilitators to implementation of RPPT (Key Question 3). Detailed descriptions of the included studies, as well as the data extracted, are included in the appendix to the full report at https://effectivehealthcare.ahrq.gov/products/rural-telehealth/research.

Use of provider-to-provider telehealth for rural populations

We did not identify comprehensive data on the use of RPPT in the United States. However, we identified seven studies that reported on national or regional use of provider-to-provider telehealth for emergency or inpatient care and included data specific to rural areas.[45–51] These studies were published since 2015 but included data collected prior to the COVID-19 pandemic.

Most studies reported lower use in rural than in urban areas, but studies that examined changes over time reported increases in both rural and urban hospitals. A study conducted in 2018 found that urban hospitals were twice as likely as rural hospitals to use telehealth for intensive care unit (ICU) and stroke care.[46] A study of telehealth use for heart attack and stroke assessment reported that rural hospital use increased from 6% in 2012 to 16% in 2017, though this was still lower than urban hospitals.[45] One study that reported higher use in rural than in urban areas focused on rates of telestroke use (8.6 vs. 2.3 per 1000), using Medicare fee-for-service claims to compare rates at the patient, rather than hospital, level.[51] Two studies of telehealth use for any reason by emergency departments (EDs) in New England in 2014[50] and nationwide in 2016[49] reported use by 49% and 54% of rural EDs, though this differed by region, with less use in the southern United States. Additionally, studies of telepsychiatry use in rural EDs in 2016[47] and by rural mental health facilities from 2010 to 2107[48] reported less than 30% of those surveyed used telehealth.

Effectiveness of provider-to-provider telehealth for rural patients

We assessed effectiveness and SOE after grouping studies by setting and clinical topic. Table 1 presents outcomes for patients, providers, and payers. Findings are summarized in the text below by setting and in terms of SOE by outcome in Supplemental Table 2.

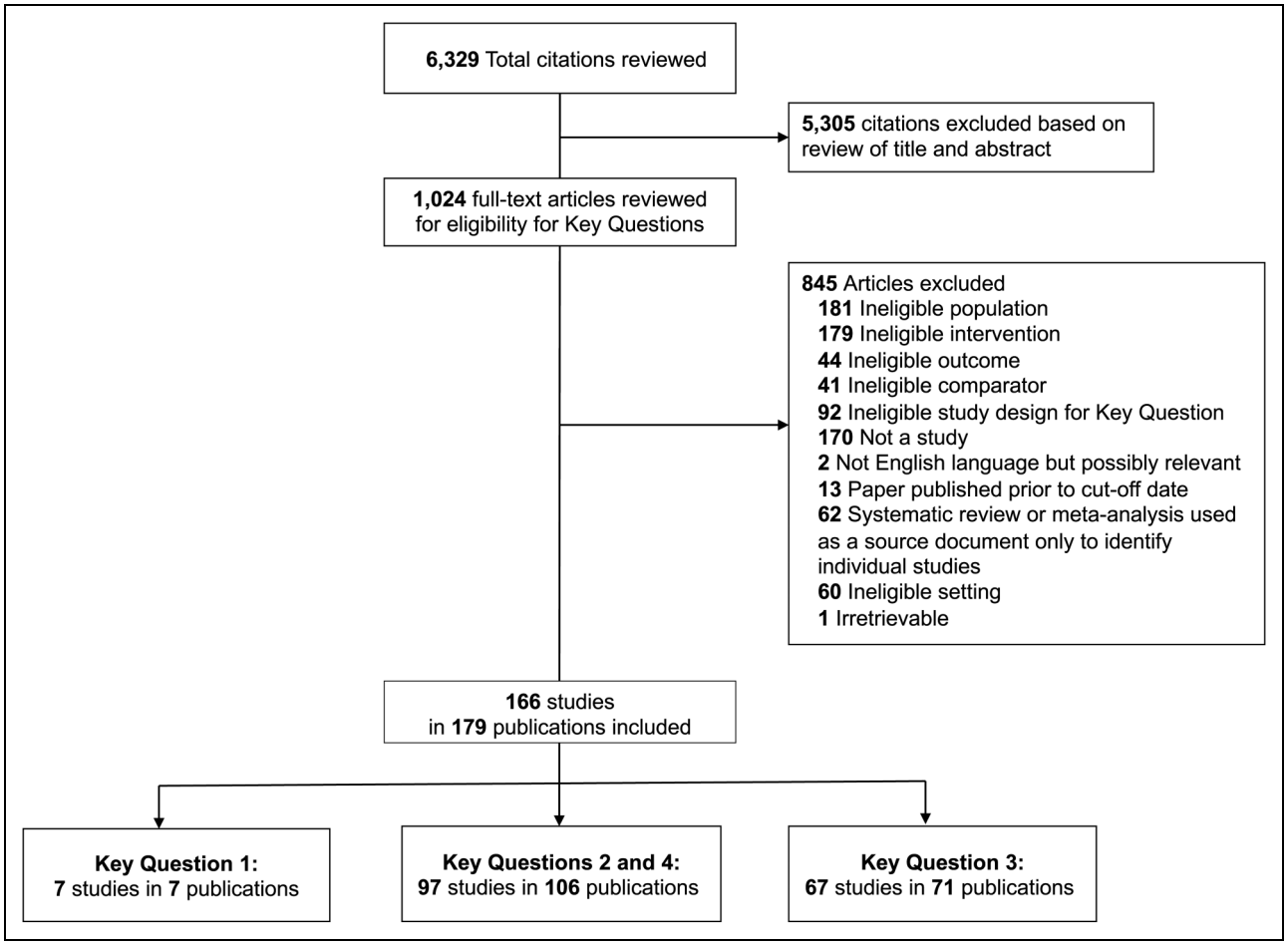

Figure 1. Literature flow diagram. Key Question 1: What is the uptake of different types of provider-to-provider telehealth in rural areas? Key Question 2: What is the effectiveness of provider-to-provider telehealth for rural patients? How does provider-to-provider telehealth affect outcomes for patients and populations? How does provider-to-provider telehealth affect outcomes for healthcare providers? How does provider-to-provider telehealth affect outcomes for private and public payers? Key Question 3: What strategies are effective and what are the barriers and facilitators to implementation and sustainability of provider-to-provider telehealth in rural areas? Key Question 4: What are the methodological weaknesses of the included studies of provider-to-provider telehealth for rural patients and what improvements in study design (e.g. focus on relevant comparisons and outcomes) might increase the impact of future research

Effectiveness for inpatient care. Seventeen studies, reported in 18 articles, evaluated RPPT for inpatient care (Table 1). The majority ($n = 12$) were studies that compared outcomes before and after the implementation of telehealth,[52,54–62,66,67] two (reported in three articles) were prospective cohort studies,[63,64,131] and three were retrospective cohort studies.[53,65,68] Eleven were conducted in the United States,[52,53,55,56,58,62–66,68] five in Australia,[54,57,60,61,67] and one in Scotland.[59] Risk of bias was rated as high for six studies[52,57,58,60,62,66] and medium for 11 studies.[53–56,59,61,63–65,67,68]

Summarizing these studies, we found evidence that telehealth consultations in rural hospitals resulted in no difference in length of hospital stay (six studies; low SOE) or transfers (three studies; low SOE) compared with usual care, which was in-person or phone consultations. Additionally, telehealth-supported care for neonates at rural hospitals resulted in no difference in clinical outcomes when compared to transfer and care at a hospital with a Level 4 neonatal intensive care unit (two studies; Low SOE). Also, mortality rates were not different when patients were treated in rural hospitals with remote ICUs rather than transported to more distant hospitals (two studies; low SOE).

Effectiveness for outpatient care. Thirty-two studies (in 35 publications) evaluated the use of RPPT interventions to support outpatient care.[69–74,76–82,84–103,155] Sixteen studies (reported in 17 publications) were randomized controlled trials (RCTs),[69–73,76–79,81,86,89,95,98–100,102] six were prospective cohort studies,[74,83,85,92,96,155] six were retrospective cohort studies,[80,84,87,88,91,101] four were pre-post study designs (same group measured before and after implementation),[82,90,94,97] and two were before-after

Table 1. Effectiveness in inpatient, outpatient and emergency care.

Clinical topic (number of studies)	Patient outcomes (reference)[a]	Provider outcomes[a]	Payer outcomes[a]
Inpatient care			
Multiple conditions (4)	~ Mortality in hospital [52,53] ~ Transfers [52] ~ Length of stay [52,53] ~ Readmission [53]	~ Drug prescribing [54] + Communication ratings [52]	+ Hospital revenue [55] + Professional billing revenue [55]
Infectious disease (3)	+ Mortality [56] ~ Transfers [56] – Length of stay [56b] ~ Length of stay [57] ~ 30-day readmission [56]	+ Provider satisfaction [56] + Improved antimicrobial use or infection rate [57,58] ~ Antibiotic use [57] + Appropriate prescribing and adherence to guidelines [57]	None reported
Stroke (1)	~ Length of stay [59]	None reported	+ Cost [59]
Spinal fracture (1)	+ Length of stay [60]	+ Knowledge, skills, confidence [60]	None reported
Mental and behavioral disorders (1)	+ Transfers [61]	None reported	None reported
Neonates (5)	+ Transfers [62,63] ~ Length of stay [64,65] ~ Enteral feeding [64,65] ~ Ventilation/oxygen [64,65] ~ Proportion of deliveries at community hospitals [66] + Statewide infant mortality to 1 year and telehealth hospital death before discharge [62] ~ Morbidity [62]	None reported	None reported
ICU (2)	~ Mortality in high dependency unit [67] ~ Mortality in hospital [67] ~ Mortality total [67] + Mortality 90-day [68] + Transfers [67]	None reported	None reported
Outpatient Care			
Depression (3)	**M** Response (varies by time point [6, 12, 18 months]) [69–75] **M** Remission (varies by time point [6, 12, 18 months]) [69–75] ~ Depression-free days [69–75] ~ Depression symptom score (BDI) 3 and 6 months [69–75] **M** Quality of Life (varies by time point [6, 12, 18 months] and scale [Quality of Well-being Scale and SF-36 Mental]) [69–75] ~ Treatment adherence 3 months,+ 6 months [69–75] + Medication adherence 6 and 12 months [69–75]	None reported	~ Utilization: overall,+ outpatient only[69,70,73,74] ~ Total costs [70,73] – Adjusted total cost [72] + Incremental cost/ depression-free days [72] – Depression-related primary and mental health costs [70,73]
PTSD (1)	+ Prescribed any medication for PTSD [76]	None reported	– Total outpatient costs [76,77]

(continued)

Table 1. Continued

Clinical topic (number of studies)	Patient outcomes (reference)[a]	Provider outcomes[a]	Payer outcomes[a]
	~ Adherence to medication regimen >80% [76] ~ Any psychiatric encounter at 12 months [76] + Mean number of CPT sessions at 12 months [76] **M** Quality of Life (varies by scale [Quality of Well-being Scale and SF-36 Mental and Physical scales]) [76]		
ADHD (1)	~ Teacher ratings (VADRS) [78] ~ Caregiver ratings (VADRS-role performance and CIS-P scale) [78]	None reported	None reported
Diabetes (4)	+ A1c [79–82] and self-monitoring of blood glucose [82] + Diabetes Self-Management Education score [79,82] ~ Total cholesterol [79,82] and systolic blood pressure [81]	None reported	None reported
Diabetic neuropathy (1)	+ Screening rate [83]	+ Screening referral or reminder [83]	None reported
Hepatitis C (1)	~ Sustained virologic response [84] + Completion of therapy [84] ~ Mean weeks of therapy [84] + Mean face-to-face visits [84] + Anemia and withdrawal due to adverse events [84]	None reported	None reported
Rheumatology (2)	+ Distance to visit [85] ~ Quality of life, disease-related function and visit satisfaction [86]	None reported	+ Cost of visit [85]
Oncology (2)	~ Receipt of radiotherapy [87]	None reported	+ Total costs [88]
Echocardiography (1)	+ Total process time [89] + Time to specialist consultation [89]	None reported	None reported
Hemodialysis (1)	+ Amount of urea removed [90] ~ Other clinical measures [90]	None reported	None reported
Fracture clinic (1)	None reported	None reported	+ Cost compared to transfer or sending a specialist [91]
Dementia care (1)	~ Yearly change in MMSE: all patients [92] + Yearly change in MMSE: patients with baseline MMSE 15–30 [92]	None reported	None reported
Ulcer care (1)	+ Time from referral to appointment [93] + Leg ulcer healing time [93]	None reported	~ Cost per patient [93]
Pharmacy (2)	~ A1c and systolic BP: patients with diabetes or HTN [94] + A1c and systolic BP: patients with diabetes and HTN [94]	+ Guideline adherence [95]	None reported
Remote consultation (3)	+ Hospital visits [96] + Patient function + Medication adherence [97] + Health-related quality of life [97]	~ Overall referrals or to eConsult specialties [98]	None reported
Dermatology (2)	~ Clinical course [99]	None reported	**M** Cost per participant [100]
Endoscopy (1)	None reported	None reported	~ Costs [101]
Blood pressure (1)		None reported	None reported

(continued)

Table 1. Continued

Clinical topic (number of studies)	Patient outcomes (reference)[a]	Provider outcomes[a]	Payer outcomes[a]
	+ Blood pressure [102] + Stroke recurrence [102]		
Palliative care (1)	~ Patient symptoms and function + Nurse or general practitioner visits, hospital admissions	None reported	None reported
Ultrasound for pregnancy (1)	+ Increase in comprehensive ultrasound for all and high-risk pregnancies [103]	None reported	None reported
Emergency care			
Stroke (10) TeleED Video-conference	~ In-hospital, 30-day and 90-day mortality [51,104–107] + 30-day all-cause mortality, super rural patients [51] ~ Symptom onset to tPA time [51,104–111] + tPA within 3 h of symptom onset [51,104–106,108–111] ~ 90-day modified Rankin Scale [104,106] ~ Post-tPA intracranial hemorrhage [104,106,107] **M** tPA use [51,104–106,108–111] ~ Length of stay, overall and rural patients [51,104–106,108–111] + Length of stay, super rural patients [51] + Appropriate transfer to high-volume center or higher level of care [109] + Discharge to home or rehab [107,112]	+ Correctness of decision-making/ accurate triage [104,112]	– Total medical expenditures per event [51]
Heart attack/STEMI (2) TeleECG	+ On time and time to treatment [113,114]	None reported	None reported
Heart attack/STEMI (1) Text triage	+ Time to hospital arrival [115] **M** Arrival-to-balloon time [115] ~ False-positive STEMI [115]	None reported	None reported
Chest pain/ MI (2) TeleED videoconference	**M** Time from ED arrival to ECG [108,116] ~ Time from ED arrival to fibrinolytic [108,116] + Likelihood of receiving fibrinolytic when eligible [116]	None reported	None reported
Multiple (1) TeleED robot	+ Transfer [117] + Length of stay (robot/transfer vs. no robot/no transfer) [117]	None reported	None reported
Multiple (4) TeleED video-conference	~ Patient deaths in ER [118] **M** Transfer to another facility [118,119] + Admit to provider time [120] – ED length of stay, non-transferred patients [120] + ED length of stay, transferred patients [120] – Likelihood of discharge from ED [118]	None reported	~ Total ED patient volume [118] + Lower ED costs and operating expenses [121]

(continued)

Table 1. Continued

Clinical topic (number of studies)	Patient outcomes (reference)[a]	Provider outcomes[a]	Payer outcomes[a]
	– Rural hospital admission [118]		
	– Discharged AMA from ED [118]		
Critical care	+ Transfer avoided [122]	+ Physician-related ED medication errors [124]	None reported
(3)	+ Transfer to lower level of care [122]		
TeleED video-conference	+ Parent/guardian satisfaction [123]	+ Quality of care scores [123]	
	+ Accuracy of clinical picture prior to arrival [122]	+ Referring physician satisfaction [123]	
Trauma	~ Mortality	None reported	None reported
(1)	+ Chest tube, intubation [125]		
TeleED video-conference	+ ED length of stay [125]		
	M Increased diagnostic imaging [125]		
	+ Time to arrival at final hospital [125]		
	~ Transfer [125]		
Hand trauma	~ Length of stay at first hospital [126]	None reported	~ Transport cost
(1)	~ Type of transfer, air or ground [126]		
TeleED video-conference	+ Admitted from ED [126]		
Sepsis/septic shock	None reported	+ Adherence to sepsis treatment bundle [127]	None reported
(1)			
TeleED video-conference			
Behavioral health; suicidal ideation or attempt	+ ED wait time [128]	None reported	None reported
	– ED length of stay [128b]		
(2)	+ Hospital admission [129]		
TeleED video-conference	+ Involuntary hold placement [129]		
	~ 30-day readmission [129]		
Sexual abuse	None reported	+ Quality, completeness, accuracy of abuse examination forms[130]	None reported
(1)			
TeleED video-conference			

AMA: against medical advice; BP: blood pressure; CIS-P: Columbia impairment scale-parent version; ECG: electrocardiogram; ED: emergency department; HTN: hypertension; ICER: incremental cost-effectiveness ratio; ICU: intensive care unit; MMSE: mini-mental state examination; PTSD: post-traumatic stress disorder; SF-36: 36 item short form survey; STEMI: ST-elevated myocardial infarction; tPA: tissue plasminogen activator; VADRS: Vanderbilt Attention-Deficit/Hyperactivity Disorder Rating Scale.

[a]Symbol meaning: +: Improved outcome with telehealth; ~: Similar outcome with telehealth; –: Worse outcome with telehealth; M: Outcomes were not consistent across studies.

[b]Length of stay was longer with telehealth, and longer stays are usually considered a negative outcome. However mortality decreased which may indicate that more care was appropriate. The authors note that the consultations tended to occur later in the hospital stay in this study and a study in which the consultation happened sooner would provide clearer evidence about the impact on length of stay.

studies (different groups/systems measured before and after implementation).[93,103] Eleven of the studies were conducted in the United States;[69–71,76,78,82,84,85,94,95,99,100,103] the remainder were conducted in Canada,[86,90,98] Australia,[83,88,91,155] Korea,[79,92,97] China,[102] Denmark,[80] New Zealand,[87] Spain,[96] United Kingdom,[93,101] Chile,[74] Taiwan,[81] and Sweden.[89] Risk of bias was rated as high for eight studies,[80,82,89,91,93,97,101,103] medium for 21 studies,[71,74,76,78,79,81,83–88,90,92,94–96,99,100,155,156] and low for two studies.[98,102]

RPPT for outpatient care varied widely across interventions and outcomes (Table 1). Outpatient telehealth consultations with specialists in various clinical specialties (e.g. diabetes, depression, outpatient medication management) resulted in improvements in clinical outcomes compared with care without specialist involvement. For patients with diabetes, RPPT resulted in improvements in A1c and self-management in patients with diabetes but had no effect on blood pressure or cholesterol levels (4 studies; Low SOE). In patients with depression, RPPT was associated with some improvement in treatment response, medication adherence, and satisfaction (three studies; Low SOE), and higher utilization and corresponding costs for outpatient consultations due to increased access, resulting in overall benefit based on cost-effectiveness analyses (two studies; Low SOE). Studies found that outpatient telepharmacy consultations improved guideline adherence and patient outcomes but only for patients with both diabetes and hypertension (two studies; Low SOE).

Effectiveness for emergency care. We included 28 studies of RPPT for emergency care, either by emergency medical services (EMS) or EDs.[51,104–130] Two of these studies were RCTs,[104,112] 10 were prospective cohort studies,[106,108,110,111,113–117,127] eight were retrospective cohort studies,[51,121–125,129,130] and eight were studies that compared outcomes before and after telehealth initiation.[105,107,109,118–120,126,128] Eighteen of these studies were conducted in the United States,[51,104,108,111,116,118–130] two were conducted in Italy,[113,114] two in Australia,[105,107] and one each in Canada,[117] Spain,[110] Finland,[106] Turkey,[115] and Japan.[109] Risk of bias was rated as high for one study,[108] medium for 26 studies,[51,105–107,109–130] and low for one RCT.[104]

Telehealth consultations for emergency assessment and initial care of stroke, heart attack, or chest pain at rural hospitals resulted in similar rates of mortality (five studies; Low SOE) and similar time to treatment when patients were treated locally as opposed to transferred, suggesting telehealth did not cause delays (eight studies; Low SOE). Telehealth consultations by specialists for critical care and trauma patients in rural EDs had a generally positive impact on transfers, with results reporting fewer unnecessary transfers, more appropriate transfers, or similar rates compared with care without RPPT (five studies; Low SOE).

Effectiveness for education and mentoring. Twenty-three studies evaluated RPPT for education and mentoring (Table 2),[132–153,157] including three RCTs[144,151,153] and 20 observational studies. Observational study designs included pre-post,[132–136,138,139,141–143,146,148,150,152] prospective cohort,[137,149] and retrospective cohort studies.[140,156] All studies were conducted across multiple clinical sites or health care organizations. Sixteen studies were performed in the United States,[132,134–141,143–146,149,150,157] four in Australia,[147,148,151,152] one in Canada,[142] and one in Vietnam.[153] One study was rated low risk of bias,[142] 11 were rated medium risk of bias,[132,133,137,138,140,144,145,149,151,153,157] and 11 were rated high risk of bias.[134–136,139,141,143,146–148,150,152]

Extension for Community Healthcare Outcomes (ECHO) programs is a model that uses video for remote instruction and case-based learning and was designed to promote best practices in rural healthcare[158,159] and has been use to expand access to specialty care.[160] ECHO programs were associated with better or equivalent patient outcomes (two studies; Low SOE), including reduction in A1c in patients of trainees after ECHO compared with before participation (one study), and similar Hepatitis C viral response and serious adverse events rates at the "spoke" site with ECHO participation to those at an academic medical center (one study). ECHO and non-ECHO video training programs (a) resulted in desired changes in provider behavior (e.g. increased appropriate prescribing practices, screening, and patient counseling) (eight studies; Low SOE) and (b) were associated with increased provider confidence, efficacy, and scores on knowledge tests (ten studies; Low SOE).

Implementation of provider-to-provider telehealth for rural patients

Sixty-seven studies in 71 publications addressed the implementation of RPPT.[49,59,118,161–227] Most of these studies were program evaluations that combined data from several sources, such as site visits, observations, surveys, and interviews. A smaller number were qualitative research studies that analyzed interviews, focus groups, or documents and then categorized or cataloged specific barriers and facilitators to initial implementation, ongoing operations, longer-term sustainment, or spread of the use of telehealth.

Information on the barriers and facilitators was first recorded as described by the study authors. Then, because studies used different terms, we mapped these using CFIR constructs (mapping tables are provided in the full report) to standardize our description and allow us to summarize and compare these across studies. Identified barriers and facilitators mapped to 19 of the 39 constructs that make up CFIR.

Figure 2 illustrates how the 219 facilitators and 192 barriers we identified map to the CFIR constructs. Each

Table 2. Summary of evidence of effectiveness for provider education and mentoring.

Modality	Clinical topic (number of studies)	Patient outcomes[a]	Provider outcomes[a]
ECHO video-conference	Antibiotic therapy (1)	~ In-hospital mortality and length of stay [132]	+ Antibiotic prescribing [132]
	COVID-19 in long-term care (1)	None reported	+ Self-efficacy and satisfaction [133]
	Dementia (1)	None reported	+ Comfort with assessment and treatment[134]
	Diabetes (2)	+ A1c [135]	+ Self-efficacy in patient coaching/education; identification of psychosocial treatment barriers [136]
	Liver disease (3)	~ Sustained viral response [137] ~ Serious adverse events [137] ~ Access to direct acting antiviral treatment in rural areas [138]	+ Hepatitis C virus awareness, knowledge, abilities, and intention to screen at-risk patients [139]
	Mental health (5)	None reported	+ Opioid use disorder diagnosis/prescribing [140] + Reduction in patients prescribed ≥3 psychotropic medications [141] + Provider knowledge and self-efficacy [142] + General development and Autism-specific screening [143] + Pediatric behavioral health knowledge and patient management [141] + Satisfaction with sessions [141,142,144]
Non-ECHO video-conference	Childhood obesity (1)	~ Child nutrition and physical activity [145]	+ Documentation and counseling [145] ~ Family centered care [145]
	Dermatology (1)	None reported	+ Knowledge of and ability to provide dermatology procedures [146] ~ Ability to provide liquid nitrogen [146]
	Mental health (1)	None reported	+ Confidence in managing behavioral and psychological symptoms of dementia [147] + Satisfaction with educational program [147]
	Pediatric burns (1)	None reported	+ Knowledge of burn prevention, first aid, airway/inhalation injury, and circulation and fluid resuscitation [148] M Chemical and electrical burns, burn wound, pain and itch management [148]
	Perioperative care (1)	None reported	~ Perioperative training scores [149] ~ Rating program as a success [149]
Online education course	Mental health (3)	None reported	+ Role adequacy, legitimacy, and support [150] **M** Role motivation, work satisfaction, and task-specific self-esteem [150] + Education completion [151] + Knowledge, skills, confidence, and utilization of CBT [151] + Computer and internet-related skills [152] + Knowledge about mental health service, confidence in responding to mental health problems [152]
	Low vision screening (1)	None reported	+ Knowledge of low vision screening and treatment [138]
Short messaging service	Multiple conditions (1)	None reported	~ Medical knowledge [153] + Satisfaction with intervention [153]

A1c: glycated hemoglobin; CBT: cognitive-behavioral therapy; ECHO: Extension for Community Healthcare Outcomes.[44,154]
[a]Symbol meaning: +: Improved outcome with telehealth; ~: Similar outcome with telehealth; –: Worse outcome with telehealth; **M**: Outcomes were not consistent across studies.

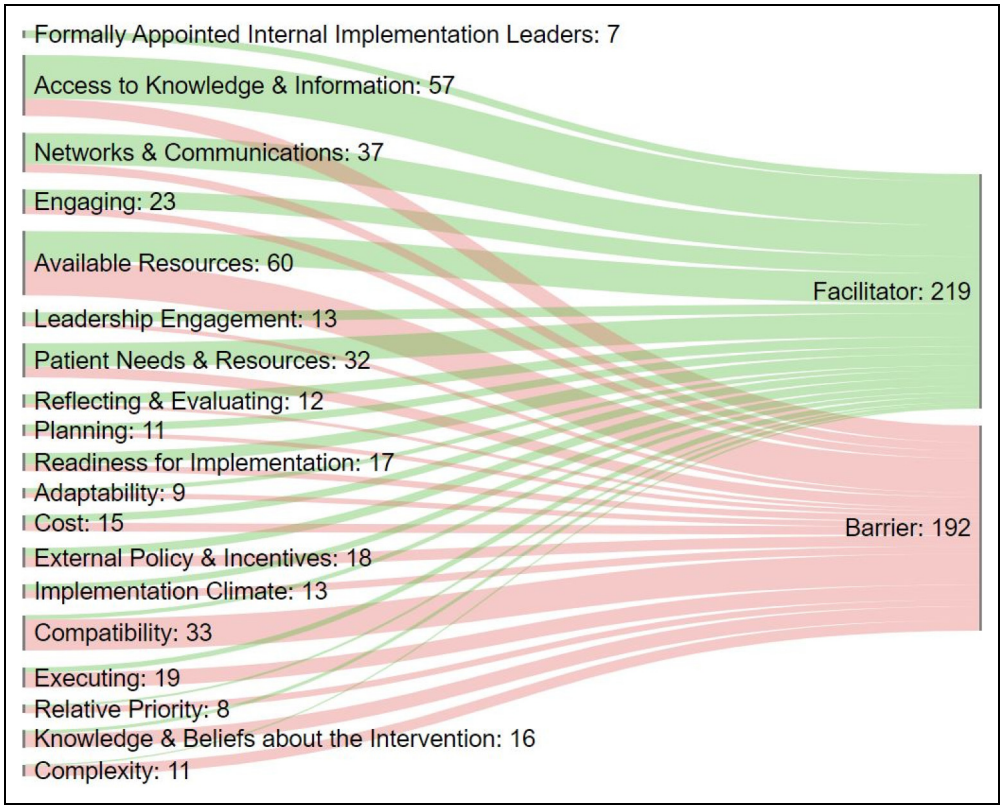

Figure 2. Facilitators and barriers to implementation*.
*Definitions: Access to Knowledge & Information: Access to digestible information and knowledge about the innovation and how to incorporate it into work tasks; Formally Appointed Internal Implementation Leaders: Individuals from within the organization who have been formally appointed with responsibility for implementing an innovation as coordinator, project manager, team leader, or other similar role; Planning: Degree to which a scheme or method of behavior and tasks for implementing an innovation are developed in advance, and the quality of those schemes or methods; Leadership Engagement: Commitment, involvement, and accountability of leaders and managers with the implementation of the innovation; Engaging: Attracting and involving appropriate individuals in the implementation and use of the innovation through a combined strategy of social marketing, education, role modeling, training, and other similar activities; Available Resources: Level of resources organizational dedicated for implementation and on-going operations including physical space and time; Networks & Communications: Nature and quality of webs of social networks, and the nature and quality of formal and informal communications within an organization; Reflecting & Evaluating: Quantitative and qualitative feedback about the progress and quality of implementation accompanied with regular personal and team debriefing about progress and experience; Cost: Costs of the innovation and costs associated with implementing the innovation including investment, supply, and opportunity costs; External Policy & Incentives: External strategies to spread innovations including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting; Relative Priority: Individuals' shared perception of the importance of the implementation within the organization; Implementation Climate: Absorptive capacity for change, shared receptivity of involved individuals to an innovation, and the extent to which use of that innovation will be rewarded, supported, and expected within their organization; Readiness for Implementation: Tangible and immediate indicators of organizational commitment to its decision to implement an innovation; Adaptability: Degree to which an innovation can be adapted, tailored, refined, or reinvented to meet local needs; Needs & Resources of Those Served by the Organization: Extent to which the needs of those served by the organization (e.g. patients), as well as barriers and facilitators to meet those needs, are accurately known and prioritized by the organization; Compatibility: Degree of tangible fit between meaning and values attached to the innovation by involved individuals, how those align with individuals' own norms, values, and perceived risks and needs, and how the innovation fits with existing workflows and systems; Knowledge & Beliefs about the Innovation: Individuals' attitudes toward and value placed on the innovation, as well as familiarity with facts, truths, and principles related to the innovation; Complexity: Perceived difficulty of the innovation, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement; Executing: Carrying out or accomplishing the implementation according to plan.
CFIR: Consolidated Framework for Implementation Research.[44,154]

construct and the number of times it occurred in our data is included in the label, and the width of the line represents the relative frequency. Short definitions of each construct are included as notes to the figure; comprehensive descriptions are available in CFIR articles and tools.[44,154] The figure illustrates the point that most constructs can either

facilitate or impede implementation, depending both on context and their presence or absence. The two most frequently cited constructs in our analysis were *Available Resources* and *Access to Knowledge & Information. Available Resources* is a broad concept including the wide range of investments an organization dedicates to implementing or sustaining an innovation or program. This was cited 60 times, and almost equally split between mention as a facilitator and as a barrier. *Access to Knowledge & Information* was cited 57 times, most frequently, though not exclusively, as a facilitator. We repeated the analysis by health care setting (available in the full report). Barriers and facilitators were similar across different settings. Assessed and summarized using CFIR constructs, the included implementation studies and program evaluations provided information about what is needed to translate knowledge about effectiveness of RPPT into actual practice.

Many facilitators and barriers were not specific to rural settings. The studies highlight that telehealth needs to alleviate burden on providers, the technology needs to work, staff resources and reimbursement need to be allocated to provide both start-up infrastructure and ongoing support, and training of both support staff and clinicians is needed. Engagement from a range of stakeholders from patients to health system leadership and governments was cited in studies as essential. Some issues were raised in identified studies that are specific to rural programs. In the United States, insufficient internet in rural areas remains a persistent barrier. Lack of understanding of the rural environment by urban-based consultants and educators risks reducing the utility of teleconsultations and remote training programs. Remote consultants for the care of rural patients can be used for either frequent events or serve as a resource for rare events in rural healthcare, but needed technology and procedures are different in these two cases and technology and operations needed to be tailored to frequency of use. Most RPPT programs are local or in a single health system, yet sustainment requires long-term commitment and resources, on a scale that may not be feasible for smaller rural organizations.

Methodologic challenges in studying provider-to-provider telehealth for rural patients

We abstracted limitations cited by the authors and combined these with our risk of bias and applicability assessments to identify and categorize the methodological weaknesses of the available evidence. Studies did not routinely control for confounders related to patients, providers, facilities, and differences in telehealth implementation across study sites, and have been hampered by data limitations, such as missing data or inaccuracies in data collected for reasons other than research. In our assessment, it is often difficult to attribute impact to telehealth because less rigorous study designs, rather than RCTs or prospective, well-designed observational studies, were used in more than two-thirds of the included studies (Table 3).

Discussion

The research on RPPT for collaboration in the delivery of rural health care provided an evidence base that addressed questions about use, effectiveness, implementation, and methodological weaknesses, but the evidence was uneven and could not support definitive, universally applicable conclusions.

To answer Key Question 1, we identified seven studies that reported national or regional trends of increasing telehealth use, with differences across specialties and geographic locations. Increasing use was evident even before the onset of the COVID-19 pandemic. For effectiveness (Key Question 2), we identified and synthesized studies that assessed the impact of RPPT and found evidence that outcomes were better or similar with RPPT for applications in inpatient, outpatient, and emergency care. We also summarized studies demonstrating that telehealth for rural provider education and mentoring, including ECHO programs, may improve patient outcomes, change provider behavior, and increase provider knowledge and confidence in treating specific conditions. To address Key Question 3, we categorized barriers and facilitators, finding most were common to practice change initiatives, though some were specific to the rural context. We identified important methodological weaknesses (Key Question 4) in the RPPT effectiveness studies, including less rigorous study designs and small sample sizes.

Our synthesis of the available evidence was qualitative because the modes, functions, and outcomes studied and how they are measured were heterogeneous. We grouped studies of similar topics that assessed similar outcomes allowing these conclusions. However, there were several instances where only one study was identified, or two or more studies reported conflicting results leading to an assessment of "unclear effect" or "insufficient evidence." Classification of barriers and facilitators to implementation in 67 studies confirmed that common barriers for change in practice, including inadequate provider time, technology, and other resources, are limiting the spread of RPPT. However, there are also specific barriers, such as incomplete understanding of rural context and lack of long-term commitments to maintaining the infrastructure and staffing needed. Our assessment of the methodological weaknesses of the effectiveness studies found these frequently employed less rigorous designs, had small sample sizes, and often did not minimize possible bias through design or analytic approach.

Table 3. Study designs and number of sites by setting for effectiveness studies.

	Inpatient	Outpatient	EMS/ED	Education/Mentoring	Total
Study design					
RCT	0	15	2	3	20
Prospective cohort	2	6	10	2	20
Retrospective cohort	3	6	8	2	19
Pre/Post[a]	0	4	0	14	18
Before/after[b]	13	3	8	2	26
Number of sites					
Multisite	13	27	22	23	85
Single center	5	7	6	0	18
Total	18	34	28	23	103

ED: emergency department; EMS: emergency medical services; RCT: randomized controlled trial.
[a]Same patients or providers evaluated pre and post-intervention.
[b]Do not have the same patients or providers in both time points.

Our review had limitations associated with our methods. We only included studies published in English about research conducted in developed countries. Searching for studies of RPPT was challenging as telehealth is a broad term and studies do not consistently include "rural" in titles or abstracts. We were unable to conduct quantitative synthesis (i.e. meta-analyses) and our qualitative synthesis combined studies with similar, but not identical, outcomes.

There were also limitations due to the nature of the evidence base. Research on telehealth in general is often not based on a clear model of how telehealth is expected to affect outcomes and whether telehealth needs to produce outcomes that are better than standard care or if equivalence with in-person alternatives is sufficient. It is often unclear if the goal of telehealth is to provide care that is as good as care provided without telehealth or if the investment in telehealth requires outcomes to be better. While telehealth should increase patient and provider satisfaction, there is no agreement on how to prioritize clinical outcomes, resource use, costs, and potential harms.

Our assessment of the methodological weaknesses of the included studies suggests directions for future research. Additional research is needed to measure outcomes at multiple time points or over longer periods of time, as short-term outcomes may differ from longer-term outcomes (e.g. provider retention of knowledge acquired through remote education and mentoring). Additional trials would strengthen the evidence base, as would observational studies that include contemporaneous comparison groups and multiple sites. The former would allow the impact of telehealth to be separated from historical change or the potentially unique characteristics of specific sites or providers/consultants. More complete descriptions are needed of both telehealth interventions and comparators. Clear statements of the intended impact of telehealth would help inform assessments of fit and help clarify whether telehealth was designed to replace in-person services or add additional services.

The existing evidence base was insufficient to allow us to unequivocally endorse all potential uses of RPPT as tools for improving health care for rural patients. Nevertheless, the studies we identified and summarized do not report harm or negative consequences. More importantly, they suggest it is likely that the application of telehealth can improve patient outcomes such as access to and quality of care, provider outcomes such as knowledge and self-efficacy, and payer outcomes such as reduced costs or maintenance of payments to rural providers.

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Supplemental material

Supplemental material for this article is available online.

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