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The Role of Telemedicine in Supporting Paramedic Clinical Decision-Making in Remote and Rural Areas: A Systematic Review

دور الطب الاتصالي في دعم اتخاذ القرارات السريرية لدى المسعفين في المناطق النائية والريفية: مراجعة منهجية

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Abstract:

Introduction

Background: Paramedics working in remote and rural areas often make time-critical decisions while access to on-scene physicians, specialist services and advanced diagnostic facilities is limited. Real-time telephone, video and physiological-data transmission may help bridge this gap; however, clinical benefits, safety and implementation requirements vary across systems.

Objective: To evaluate published evidence from 2019–2025 on whether telemedicine supports paramedic assessment, treatment and disposition decisions, with particular attention to rural or geographically isolated services.

Methods: A structured, source-verified evidence synthesis identified 12 original research reports published within the specified period using PubMed-indexed records, journal full texts and linked citations. Studies involving on-scene paramedics or emergency medical technicians receiving remote clinical advice were eligible; relevant implementation and qualitative studies were also considered. Outcomes were synthesized narratively because interventions, designs and populations differed substantially. Design-matched JBI and RoB 2 domains informed a transparent appraisal of reported methodological limitations. A complete database-export and full-text screening audit was not provided, so a numerical PRISMA flow or pooled effect was not constructed.

Results: Evidence from rural studies showed that mandatory medical consultation could increase the likelihood of leaving low-acuity patients on scene, but video offered no consistent advantage over telephone and repeat-call safety requires attention. A rural United States pilot reported no statistically significant change in advanced-life-support transport (42% before versus 45% after implementation). A rural paramedic-led primary-response study found that teleconsultation altered the intended care plan in 56.16% of responding supported cases. Wider EMS evidence suggested tele-physician support can be integrated into acute-care workflows and may preserve access to physician expertise; robust mortality and long-term outcome evidence remained limited.

Conclusion: Telemedicine is a useful support to—not a substitute for—paramedic assessment, standard operating procedures and escalation pathways. Rural services should prioritize reliable connectivity, clinician availability, clinical governance, training, documentation and prospective measurement of patient safety.

Keywords: telemedicine; paramedics; emergency medical services; rural health; prehospital care; clinical decision-making; teleconsultation; remote medical direction.

الملخص

الخلفية :غالباً ما يتخذ المسعفون العاملون في المناطق النائية والريفية قرارات سريرية تتطلب تدخلاً سريعاً، في ظل محدودية إمكانية الوصول إلى الأطباء في موقع الحادث، والخدمات الطبية التخصصية، ومرافق التشخيص المتقدمة. وقد يسهم التواصل الفوري عبر الهاتف أو الفيديو، ونقل البيانات الفسيولوجية للمرضى، في سد هذه الفجوة؛ إلا أن الفوائد السريرية، ومتطلبات السلامة والتنفيذ، تختلف باختلاف الأنظمة الصحية.

الهدف :تقييم الأدلة العلمية المنشورة خلال الفترة من 2019 إلى 2025 بشأن مدى إسهام الطب الاتصالي في دعم عمليات التقييم والعلاج واتخاذ قرارات تحديد مسار الرعاية لدى المسعفين، مع التركيز بصورة خاصة على الخدمات الإسعافية في المناطق الريفية أو المعزولة جغرافياً.

المنهجية :أُعدّ توليف منظم للأدلة العلمية، جرى التحقق من مصادرها، وشمل تحديد 12 تقريراً بحثياً أصلياً منشوراً خلال الفترة المحددة، بالاعتماد على السجلات المفهرسة في قاعدة بياناتPubMed ، والنصوص الكاملة للمقالات المنشورة في المجلات العلمية، والاستشهادات المرجعية المرتبطة بها. وشملت معايير الإدراج الدراسات التي تناولت المسعفين أو فنيي الطوارئ الطبية العاملين في مواقع الحوادث، ممن يتلقون استشارات طبية عن بُعد، كما أُخذت دراسات التنفيذ والتطبيق والدراسات النوعية ذات الصلة في الاعتبار. وتم توليف النتائج سردياً نظراً للاختلافات الكبيرة بين التدخلات والتصاميم البحثية والمجموعات السكانية. واستُخدمت مجالات التقييم الملائمة لكل تصميم من إرشادات معهد جوانا بريغز (JBI) وأداة تقييم مخاطر التحيز (RoB 2) لإجراء تقييم شفاف للقيود المنهجية الواردة في الدراسات. ونظراً لعدم توفر تدقيق كامل لصادرات قواعد البيانات وعمليات فحص النصوص الكاملة، لم يُعدّ مخطط التدفق العددي وفق معاييرPRISMA ، كما لم يُحسب تأثير إجمالي مجمّع للدراسات.

النتائج :أظهرت الأدلة المستمدة من الدراسات الريفية أن الاستشارة الطبية الإلزامية قد تزيد من احتمالية إبقاء المرضى ذوي الحالات منخفضة الحدة في موقع الحادث دون نقلهم إلى المستشفى، إلا أن استخدام الفيديو لم يُظهر تفوقاً ثابتاً على الاستشارات الهاتفية، كما أكدت النتائج ضرورة الاهتمام بسلامة المرضى الذين قد يحتاجون إلى إعادة الاتصال بالخدمات الإسعافية. وأفادت دراسة تجريبية أولية أُجريت في منطقة ريفية بالولايات المتحدة بعدم وجود تغير ذي دلالة إحصائية في معدلات نقل المرضى بواسطة خدمات الإسعاف المتقدمة لدعم الحياة، إذ بلغت النسبة 42% قبل تطبيق التدخل مقابل 45% بعده. كما أظهرت دراسة للرعاية الأولية بقيادة المسعفين في منطقة ريفية أن الاستشارات الطبية عن بُعد أدت إلى تغيير خطة الرعاية العلاجية المقترحة في 56.16% من الحالات التي تلقت الدعم. وأشارت الأدلة الأوسع نطاقاً في خدمات الطوارئ الطبية إلى إمكانية دمج دعم الأطباء عن بُعد ضمن مسارات تقديم الرعاية الحادة، بما قد يحافظ على إمكانية الاستفادة من الخبرات الطبية المتخصصة، في حين ظلت الأدلة القوية المتعلقة بمعدلات الوفيات والنتائج الصحية طويلة الأمد محدودة.

الاستنتاج :يمثل الطب الاتصالي وسيلة داعمة لعمل المسعفين، وليس بديلاً عن التقييم السريري الذي يجرونه، أو إجراءات التشغيل القياسية، أو مسارات التصعيد والإحالة الطبية. وينبغي للخدمات الإسعافية في المناطق الريفية إعطاء الأولوية لتوفير اتصال تقني موثوق، وضمان توافر الأطباء للاستشارات، وتعزيز الحوكمة السريرية، وتوفير التدريب المناسب، وتوثيق الاستشارات والتدخلات، إلى جانب القياس المستقبلي المنهجي لمؤشرات سلامة المرضى.

الكلمات المفتاحية :الطب الاتصالي؛ المسعفون؛ خدمات الطوارئ الطبية؛ الصحة الريفية؛ الرعاية قبل الوصول إلى المستشفى؛ اتخاذ القرارات السريرية؛ الاستشارات الطبية عن بُعد؛ التوجيه الطبي عن بُعد.

1. Introduction

Emergency medical services (EMS) depend on paramedics and emergency medical technicians (EMTs) who must assess patients, establish clinical priorities, initiate treatment and determine the most appropriate transport destination before hospital evaluation. In remote and rural regions, these decisions may be made far from comprehensive hospitals and without immediate access to an emergency physician. Geographic distance, small and dispersed populations, limited specialist availability and variable mobile-network coverage can make both under-triage and unnecessary conveyance consequential.

Telemedicine refers in this review to real-time or near-real-time communication between a field clinician and a remote medical professional using telephone calls, video links or transmitted clinical data. This is narrower than consumer telehealth, electronic recordkeeping or standalone automated decision support. In the prehospital setting, a remote physician may interpret observations, help establish a differential diagnosis, advise on medication or procedural decisions, select a destination hospital, or support a decision to treat a patient on scene. The potential advantage is access to expertise without requiring a physician to travel to every event. The possible disadvantage is an additional communication step that can increase workload, introduce technical delays, or create uncertainty over accountability.

A 2020 systematic review of prehospital decision-support telemedicine concluded that studies often described feasibility and perceived benefit but had heterogeneous outcomes and considerable confounding, limiting causal interpretation [2]. More recent controlled trials, rural pilot projects and service evaluations provide valuable additional evidence, although the settings and goals differ. In particular, research must distinguish whether remote consultation improves the clinical decision itself from whether a new communication system merely increases access to advice.

The topic is of practical relevance to the Saudi Red Crescent Authority and other EMS organizations serving large territories, where telemedical contact may augment structured paramedic care. Evidence developed in Germany, Norway, the Czech Republic, Canada and the United States cannot be transferred automatically to Saudi Arabia because scope of practice, transport geography, health-system organization and telecommunication infrastructure may differ.

1.1. Problem statement

Rural paramedics may face clinical uncertainty when a patient has symptoms that could indicate either a benign condition or time-sensitive deterioration, when decisions about non-conveyance require medical oversight, or when specialized services are geographically distant. Although telemedicine can connect personnel to remote experts, it is not clear which communication modes provide incremental clinical value or whether improvements in processes translate into safer patient outcomes.

1.2. Research gap

The literature includes randomized comparisons of telephone, video and routine care, but these usually involve selected low-acuity cohorts or specific regional systems. Other studies use before–after designs, service data or participant interviews. Outcomes vary from changed management plans and transport rates to consultation duration, vital-sign improvement and perceived usability. Direct rural studies remain few, with limited follow-up on subsequent deterioration, re-contact, mortality, patient experience and cost-effectiveness. Some publications also analyze overlapping datasets and therefore should not be counted as independent patient samples.

1.3. Objectives and review question

Primary question: Among paramedics or EMTs caring for patients in remote, rural or otherwise resource-constrained prehospital settings, how does real-time telemedicine support influence assessment, treatment and disposition decisions compared with usual care or telephone-only support?

Examine evidence of changes in clinical management, conveyance, destination selection and adherence to medical direction.

Summarize patient-safety outcomes, including adverse events, repeat EMS contact and diagnostic concordance.

Identify operational requirements and barriers: connectivity, training, usability, teamwork, workload and clinical governance.

Differentiate direct rural evidence from wider prehospital evidence and highlight research priorities for the Saudi EMS context.

2. Literature Review

2.1. Mechanisms of telemedical decision support

Telemedical advice can affect three connected decision levels. First, it can support diagnostic interpretation by enabling remote inspection of clinical symptoms, ECGs, images or physiological measurements. Second, it can guide immediate treatment, such as analgesia, cardiopulmonary resuscitation support or responses to abnormal vital signs. Third, it can influence disposition through recommendations for non-conveyance, patient monitoring, transport priority or appropriate hospital selection. The ability to connect does not necessarily establish that a more accurate decision was made; valid assessment requires clinical comparators and safety follow-up.

Telephone consultation is technically simple and already embedded in many EMS systems. Video can expose additional visual information but requires more bandwidth, patient privacy protections and interface usability. In a randomized rural low-urgency study, video did not improve the proportion of patients treated on scene relative to mandatory telephone calls [3]. A nonrandomized community paramedicine study likewise found that video was perceived to enhance medical assessment without materially changing ED transport probability [4]. These findings challenge the assumption that higher-bandwidth technology is always clinically superior.

2.2. Rural service delivery and workforce integration

Rural telemedicine is strongly shaped by geography and workforce design. Kjelle and Myklebust described an out-of-hours rural stroke pathway in which local paramedics participated in neurological examination and CT positioning while imaging staff and physicians worked remotely [6]. Their related implementation study emphasized manager engagement, interdepartmental coordination and recurrent training [7]. Overheu and colleagues later described a rural paramedic-led primary-response model that integrated standard operating procedures with remote physician backup; the physician's input altered many documented treatment plans [14].

In contrast, the Arizona rural EMS chest-pain pilot showed feasibility but no significant change in advanced-life-support transport rates [10]. A telemedicine service can therefore be operationally acceptable even when a selected clinical performance measure does not improve. Understanding why, how frequently and for which patient groups consultation is activated is as important as installing the technology.

2.3. Safety and systems-level evidence

The TEMS randomized non-inferiority trial from Germany evaluated severe prehospital emergencies and reported non-inferiority in intervention-related adverse events within the prespecified margin [8]. An associated diagnostic concordance analysis later compared tele-EMS and on-scene physician diagnoses and found no statistically significant difference for its reported comparisons [13]. These two papers, however, draw on the same parent trial; they provide different outcomes, not two independent replications.

Longitudinal service studies suggest that experienced tele-EMS systems may shorten consultation duration and support paramedics across many case types [9]. Nonetheless, service maturity, protocol changes and secular trends can explain part of these associations. Finally, surveys demonstrate the significance of acceptance and usability: the German implementation study of 91 participants reported a System Usability Scale result of 68.68 and identified usability as a major correlate of acceptance [11].

3. Methodology

3.1. Review design and reporting approach

This manuscript is a structured review of original research published from 1 January 2019 through 31 December 2025. The aim was to use a transparent, PRISMA 2020-informed structure for question framing, eligibility, study description and synthesis [1]. Relevant publications were checked directly through PubMed-indexed bibliographic records, full-text publisher pages and their reference links on 3 November 2026. Because no exported multi-database searches, deduplication file, independent reviewer decisions or complete exclusion register accompanied the supplied Group F title-and-author page, the review does not claim a reconstructed comprehensive PRISMA screening process or a registered protocol. The 12 reports in the evidence table are verifiable publications reviewed for this manuscript, not an assertion that only 12 eligible studies exist worldwide.

3.2. Eligibility criteria

Table 1. Eligibility framework (PICOS)

Element	Criteria applied
Population	Practicing paramedics, EMTs or field EMS teams delivering patient care; multidisciplinary rural programs included when paramedics performed a documented clinical role.
Intervention	Real-time physician/specialist consultation by telephone, video, remote imaging support or transmitted physiological information that informs field decisions.
Comparison	Usual field care, optional consultation, telephone-only support, conventional on-scene physician care, or no comparator in a clearly described implementation study.
Outcomes	Clinical decisions, management plan changes, transportation/conveyance, diagnostic concordance, safety or repeat-contact outcomes; implementation and usability as secondary outcomes.
Study types	Original randomized trials, cohorts, quasi-experimental studies, observational service evaluations and relevant qualitative/mixed-methods investigations.
Time/language	Publication date 2019–2025; English-language evidence accessible for source verification.
Exclusions	Hospital-only telemedicine; dispatch video without a field paramedic decision component; automated software without remote clinician input; reviews, opinion pieces and unverified references as primary outcome evidence.

3.3. Information sources and search approach

Evidence identification focused on PubMed, PubMed Central, peer-reviewed journal websites and citation links. Search concepts combined paramedic/EMT/EMS, prehospital, telemedicine/teleconsultation/tele-emergency physician, remote medical direction, rural/remote and clinical decision, non-conveyance, transport or safety. The reproducible PubMed example in Appendix A identifies the target scope, while the original publication links for each evidence-table entry are provided in the references. The search was intentionally supplemented with seminal prehospital controlled studies from non-rural systems for contextual comparison, and these are clearly identified as indirect evidence.

A multi-database search covering PubMed, Scopus, Web of Science, CINAHL and Embase was not performed or documented as part of this manuscript. No retrieval totals, duplicate counts, full-text exclusions or researcher-specific screening decisions are inferred from the targeted evidence-identification process. Consistent with the request to avoid an unsupported diagram, no PRISMA flow figure is presented.

3.4. Selection and data extraction

Reports were retained in the evidence map when their available published abstract or full text demonstrated direct involvement of paramedics/EMTs and a relevant remotely supported decision, or when implementation outcomes explained such use. Information summarized for each report included year, geography, clinical setting, design, sample or service volume, telemedicine modality, principal outcome, limitations and relevance to rural practice. Separate publications from overlapping projects were identified to avoid inadvertent aggregation. No primary data were requested from investigators, and the narrative does not report unverified adverse-event or patient-level data.

3.5. Quality appraisal and certainty considerations

A design-matched critical-appraisal framework was applied to the information verified in the accessible records: JBI domains were used to identify likely limitations of observational, quasi-experimental and qualitative designs, and RoB 2 domains were considered for randomized studies [15,16]. The critical-appraisal table therefore reports design, available strengths and specific threats to causal interpretation. It does not assign invented item-level checklist responses or overall risk-of-bias percentages, which would require full study-specific assessment records and independent reviewer reconciliation. Evidence strength is discussed by outcome domain rather than transformed into a numerical quality score.

3.6. Synthesis methods

A narrative synthesis was chosen a priori for this evidence map because patient acuity, telemedicine modalities, comparator groups, follow-up intervals and reported endpoints were incompatible with a common pooled effect. Results were organized into: (i) treatment and clinical-plan decisions; (ii) transport and disposition; (iii) patient safety and diagnosis; and (iv) implementation and workforce effects. Effect sizes and confidence intervals are reproduced only when explicitly reported by the source study. Findings from indirect non-rural studies were not presented as estimates of effectiveness in rural Saudi Arabia.

4. Results

4.1. Study identification and characteristics

Twelve relevant original reports published between 2020 and 2025 were verified and mapped. Direct rural or remote-care evidence was found in the Czech rural randomized study, two reports on the Norwegian rural stroke pathway, the Arizona rural EMS pilot and the German rural paramedic-led response model. Additional European and North American reports supplied comparisons involving telemedical physician support, user implementation, video versus telephone communication and diagnostic agreement. The studies span randomized clinical trials, retrospective comparisons, long-term service evaluations, qualitative interviews and cross-sectional surveys. Their clinical populations and denominators are not interchangeable, and two pairs of reports concern related local programs or shared patient datasets [3–14].

Table 2. Characteristics of the 12 verified original research reports

ID / Study	Setting, design and scale	Decision-support findings	Interpretation / limitations
S1 Sykora et al. (2020) [3]	Czech Republic; rural low-urgency EMS; randomized 3-arm trial; 791 assigned events	Mandatory PHONE or VIDEO vs usual optional consultation; both increased on-scene management vs control (PPA OR 2.07 and 2.01).	Direct rural evidence; safety events infrequent, 48-hour re-contact concerning in VIDEO group.
S2 Abrashkin et al. (2021) [4]	USA; community paramedicine, 1,707 responses; retrospective natural experiment	Video vs phone: adjusted ED transport OR 0.80 (95% CI 0.62–1.03), not statistically significant.	Indirect non-rural advanced illness setting; selection/confounding and connection failure.
S3 Schröder et al. (2021) [5]	Germany; 10,362 tele-EMS consultations (2015–2018); observational service analysis	Of 2,234 life-threatening vital-sign findings in analyzed records, 65.6% were remedied during consultation.	No suitable concurrent comparator; improvement not necessarily caused by telemedicine.
S4 Kjelle & Myklebust (2021) [6]	Norway; rural remotely guided CT/stroke pathway; 6 interviews	Teamwork and quality were positive; communication, image reading, training and safety routines required attention.	Direct rural qualitative evidence; small sample, no comparative patient outcomes.
S5 Kjelle & Myklebust (2022) [7]	Norway; same regional rural stroke project; 15 participants in interviews/focus group	Task-shifting viewed as valuable; management, coordination, sustainable training central.	Related implementation study, not independent clinical-outcome replication.

ID / Study	Setting, design and scale	Decision-support findings	Interpretation / limitations
S6 Kowark et al. (2023) [8]	Germany; open-label randomized non-inferiority TEMS trial; 3,220 primary analysis	Tele-EMS support non-inferior to conventional physician EMS for intervention-related adverse events.	Broader EMS rather than rural-only; very low event frequency and open-label design.
S7 Schröder et al. (2024) [9]	Germany; 229,384 EMS missions 2015–2021; longitudinal observational study	Tele-EMS physician consulted in 23,172 missions (10.1%); teleconsult duration 12.07 to 9.42 min.	Process and resource metrics, with secular trends and regional-system effects.
S8 Karra et al. (2024) [10]	USA; rural Arizona; 38 pre and 38 post chest-pain/ECG patients	ALS transport 42% pre vs 45% post (OR 1.11, 95% CI 0.45–2.76); no significant shift.	Direct rural evidence, small QI sample; no robust clinical endpoint.
S9 O'Sullivan et al. (2024) [11]	Germany; prehospital implementation survey; 91 users	Positive attitudes; System Usability Scale 68.68; usability associated with acceptance.	Implementation evidence; cross-sectional self-report, not patient benefit.
S10 Guo et al. (2025) [12]	Canada; 220 recorded paramedic calls; before–after with concurrent control	Centralized consultation implementation; no statistically significant difference in call duration or selected protocol measures.	Indirect non-rural process study; limited sample and low event rates.
S11 Hess et al. (2025) [13]	Germany; TEMS-trial diagnostic subanalysis	No significant difference in diagnostic concordance for tele-EMS versus on-scene physicians (reported p=0.877).	Shares TEMS trial population with S6; outcome-specific available diagnosis data.
S12 Overheu et al. (2025) [14]	Germany; rural paramedic-led on-call response, 2,165 evaluated surveys; retrospective	367 teleconsult-supported missions (16.95%); plan changed in 114/203 responses (56.16%).	Direct rural evidence; changes in plans are not proven patient-benefit outcomes.

4.2. Telemedicine and clinical management decisions

The clearest direct evidence of telemedicine changing a paramedic's intended course of action comes from Overheu et al. [14]. Within a rural paramedic-led physician on-call service, 367 of 2,165 recorded survey cases received telemedical support (16.95%). Among the 203 relevant supported cases with a response to the management-change question, 114 (56.16%) involved an altered planned management course; 89 (43.84%) confirmed the initial plan. This illustrates potential clinical influence but does not

establish whether a changed plan was more accurate or improved health outcomes. The service used SOPs, dedicated training and remote physician availability, indicating that its effectiveness depends on organizational design as well as communication equipment.

In the broader German EMS context, Schröder et al. reviewed 10,362 teleconsultations from 2015–2018. Among selected analyzed records with initially life-threatening vital-sign findings, 1,465 of 2,234 findings (65.6%) were corrected during consultation [5]. The observation supports clinical plausibility of field stabilization with remote expertise; it does not justify attributing improvement to telemedicine alone because medications, paramedic actions and natural changes may also contribute. Large-scale randomized evidence on specific intervention choices, medication errors and avoidable adverse events remains limited.

4.3. Non-conveyance, transport and resource utilization

Sykora et al. assigned 791 low-urgency rural EMS events to mandatory telephone consultation, mandatory audiovisual consultation or routine care with optional consultation. In per-protocol analyses, leaving patients on scene after treatment was more likely with mandatory PHONE (OR 2.07; 95% CI 1.19–3.58) and VIDEO (OR 2.01; 95% CI 1.15–3.49) than with control [3]. Because both modes performed similarly, the evidence favors a structured consultation process over a conclusion that video is inherently better. Importantly, repeat ambulance visits within 48 hours among patients left on scene occurred in 3/35 phone cases and 8/34 video cases. These small denominators should not be interpreted as a definitive causal increase, but they emphasize the need for safe discharge instructions, clinical red flags and follow-up.

In a separate 1,707-response community paramedicine evaluation, Abrashkin et al. found that video connection did not significantly reduce ED transport compared with telephone communication (adjusted OR 0.80; 95% CI 0.62–1.03) even though physicians reported that video enhanced assessment in 85% of video responses [4]. This non-rural result helps separate perceived informational value from an actual change in conveyance.

The Arizona rural telemedicine pilot documented 58 successful telemedicine encounters and compared 38 patients before with 38 after implementation in its specified chest-pain/ECG analysis. ALS transport was 42% before versus 45% after (OR 1.11; 95% CI 0.45–2.76). No significant difference was demonstrated, while median out-of-service time was 47 minutes before and 33 minutes after (p=0.07) [10]. The study supports feasibility in a sparsely served setting but is underpowered to exclude important differences in clinical events.

4.4. Diagnostic accuracy and patient safety

Kowark et al. randomized 3,531 severe emergency patients to a tele-emergency physician service or conventional physician-based EMS; 3,220 were included in the primary analysis. The telemedical service met its prespecified non-inferiority criterion for the primary endpoint of intervention-related adverse events, with only one observed primary event in the telemedical group [8]. Although clinically relevant, an extremely low event rate makes the trial less informative for uncommon harms or specific high-risk diagnoses. Non-inferiority in this service configuration should not be read as universal proof of telemedicine equivalence in every rural ambulance system.

Hess et al. analyzed diagnostic concordance using information from the TEMS parent trial. They reported no statistically significant difference between tele-EMS and on-scene physician diagnoses when compared with admission diagnoses (p=0.877), with available admission-diagnosis information

in 447 tele-EMS and 977 on-scene physician missions [13]. This offers an additional diagnostic endpoint but should not be counted as a second randomized trial or an independent cohort. Some hospital diagnoses were unavailable, and subgroup conclusions are more uncertain.

Rural Norwegian stroke-pathway publications [6,7] describe the practical value of remote specialist guidance when patients face lengthy interhospital journeys, but neither supplies comparative patient-level estimates of functional recovery, mortality or treatment delays attributable to the program. Thus, the clearest evidence for rural decision support concerns feasibility, clinical workflow and selected disposition decisions; direct evidence for long-term patient safety remains thinner.

4.5. Operational feasibility, acceptability and workforce outcomes

Longitudinal observations from Aachen showed that tele-EMS physicians were consulted during 23,172 of 229,384 EMS missions (10.1%) from 2015 to 2021 and that average teleconsultation duration decreased from 12.07 to 9.42 minutes [9]. The pattern is consistent with a maturing service but may reflect selection and workflow changes, rather than a direct intervention effect. Guo et al. compared 220 paramedic telephone consultations around implementation of centralized medical advice and found no statistically significant differences in consultation duration or selected protocol measures [12]. Service centralization can therefore change where responsibility sits without guaranteeing measurable short-term time savings.

The qualitative Norwegian studies reinforce that remote expertise is only effective when clinicians trust the system, understand their new responsibilities and have supervised simulation or refresher training [6,7]. The survey study by O'Sullivan et al. [11] found generally positive expectations, although usability and acceptance were not synonymous with clinical effectiveness. Across studies, barriers include limited network availability, additional communication steps, heterogeneous patient presentations, privacy safeguards, remote physicians' familiarity with field constraints and uncertainty about medico-legal responsibilities.

4.6. Summary of outcome directions

Table 3. Cross-study interpretation by outcome domain

Outcome domain	What the studies support	What remains uncertain
Clinical plan changes	Remote consultation can confirm or alter care decisions; a rural service recorded changes in 56.16% of evaluable supported cases [14].	Whether altered decisions improved outcomes or avoided diagnostic error.
Conveyance	Structured teleconsultation increased on-scene treatment in a rural trial vs usual care [3].	Best eligibility criteria for safely avoiding transport; video superiority not demonstrated [3,4].
Safety	A large German RCT found tele-EMS non-inferior for a rare intervention-related adverse-event endpoint [8].	Rural-specific mortality, deterioration, re-contact and longer-term adverse events.
Diagnosis	TEMS subanalysis reported similar diagnostic concordance [13].	Reliable validation against a uniform clinical reference standard across regions.

Outcome domain	What the studies support	What remains uncertain
Operational efficiency	Service implementation and shorter consultation times observed in mature systems [9].	Cost-effectiveness, network downtime, time-to-treatment and impact in low-volume rural areas.
Implementation	Training, SOPs, interdisciplinary coordination and usability repeatedly emerged as central [6,7,11,14].	Generalizability to EMS systems with different regulation, clinician scope and infrastructure.

5. Critical Appraisal and Risk-of-Bias Considerations

Table 4 is an evidence-grounded methodological assessment using the appropriate JBI design domains for nonrandomized and qualitative papers, and key RoB 2 domains for trials [15,16]. These observations highlight specific caution points rather than providing an unsupported numerical score. Where the same study platform underlies multiple reports, selective duplication of populations is marked. The review's central confidence judgment is that some process and disposition effects are supported by controlled studies, while rural-specific patient-centered outcomes are less certain.

Table 4. Design-matched critical-appraisal matrix (report-based)

Study	Applicable assessment	Study feature supporting credibility	Important uncertainty / bias domain
S1 [3]	Randomized / RoB 2	Randomized rural three-arm comparison and reported ITT/PPA analyses.	Open-label consultation; 48-hour events sparse; missing/per-protocol selection may affect safety inference.
S2 [4]	Observational / JBI	Large analytic sample and adjusted comparison.	Nonrandom video success; unmeasured confounding; non-rural advanced illness population.
S3 [5]	Observational / JBI	Large teleconsultation archive with clinical physiological outcomes.	Uncontrolled vital-sign improvements and record selection; attribution of cause not established.
S4 [6]	Qualitative / JBI	Interviews describe actual rural workflow and team experiences.	Six interviews; local transferability; no patient outcome comparator.
S5 [7]	Qualitative / JBI	Multi-professional managers and frontline workers included.	Voluntary recruitment and same service as S4; subjective reports may favor implementation.

Study	Applicable assessment	Study feature supporting credibility	Important uncertainty / bias domain
S6 [8]	Randomized / RoB 2	Large pragmatic trial with prespecified non-inferiority outcome.	Open-label allocation; very rare adverse-event endpoint; generalization to rural conditions uncertain.
S7 [9]	Observational / JBI	Large consecutive service volume over seven years.	Time trends and case-mix changes; process outcomes rather than validated patient benefit.
S8 [10]	Quasi-experimental / JBI	Direct rural implementation with before–after comparison.	38 participants in each period; no randomization; broad confidence interval.
S9 [11]	Cross-sectional / JBI	Published survey instrument and factor analysis.	Self-reported attitudes; recruitment and perception bias; no clinical endpoints.
S10 [12]	Quasi-experimental / JBI	Audio review and concurrent comparison group.	Only 220 calls; low frequency of errors; temporal confounding.
S11 [13]	Secondary RCT analysis / RoB 2 domains	Prespecified source trial provides comparison of diagnostic categories.	Selective availability of diagnoses; overlapping participant set with S6; not an independent RCT.
S12 [14]	Observational / JBI	Rural paramedic program with documented management decisions.	Only subset answered management-change item; no counterfactual or direct health outcomes.

6. Discussion

6.1. Interpretation of the main findings

Across diverse EMS models, telemedicine appears most defensible as a means of improving access to clinical oversight rather than as a stand-alone treatment. The rural randomized evidence from Sykora et al. suggests that mandatory consultation can support treatment on scene, but it does not show that audiovisual communication is superior to telephone [3]. The rural Arizona project similarly demonstrates that a functioning physician link need not alter transport patterns [10]. Overheu et al. identify a different potential mechanism: consultation frequently changed the paramedic's original plan [14]. These studies describe different effects—disposition, transport modality and decision revision—and should not be collapsed into a single effectiveness claim.

One possible interpretation is that the principal benefit arises when clinicians obtain timely input at points of genuine diagnostic or disposition uncertainty. When established protocols already indicate the

appropriate course, adding a video call may increase complexity without improving the result. Conversely, in high-stakes situations or geographically distant services, the ability to discuss an ECG, visual finding or treatment risk with a physician may support a safer decision. The current literature does not establish optimal activation thresholds or which patients are most likely to benefit.

A second important distinction is between technological feasibility and patient benefit. Improved call quality, favorable usability surveys and shorter consultation duration are useful implementation measures. They are not substitutes for appropriate clinical treatment, patient deterioration or mortality outcomes. The mixed pattern across controlled, before–after and qualitative studies suggests that future evaluations should embed digital systems within a standardized clinical governance model and evaluate both decision quality and downstream effects.

6.2. Comparison with previous research

The findings are aligned with Kim et al.'s earlier systematic review, which identified descriptive support for telemedical decision assistance but insufficient standardized and controlled outcome evidence [2]. Controlled research published subsequently provides stronger findings for specific questions, particularly low-acuity disposition and the primary safety endpoint of the TEMS trial [3,8]. It has not eliminated the evidence gap for remote areas, since the largest randomized trial was not confined to rural EMS and the most directly rural studies remain relatively small or descriptive.

Similar caution arises from the video comparison. Even if a remote clinician feels more informed by video, the measured decision or transport rate may be unchanged [4]. Health service leaders should therefore choose the simplest modality capable of meeting the clinical purpose and maintain telephone as a resilience option when video connections fail.

6.3. Implications for Saudi Red Crescent Authority practice

The Saudi Red Crescent Authority operates across urban centers, long-distance road networks and geographically dispersed communities; therefore, telemedical support may be particularly relevant for crews facing long transport intervals or lack of immediate specialist access. An implementation model should start with clinical scenarios rather than equipment purchase. Potential pilot scenarios include uncertain non-conveyance, complex medication decisions, triage to specialty-capable facilities and selected high-risk presentations requiring prompt physician guidance. Decisions must remain consistent with approved Saudi clinical scope, governance and emergency transport protocols.

A practical pathway would define: an activation trigger; a minimum assessment data set; physician contact and callback standards; identification of the clinician providing advice; read-back of verbal orders; a documented final decision; transport/escalation criteria; and a contingency plan when connectivity fails. Simulation-based multidisciplinary training should cover communication, remote ECG or image interpretation, unclear findings, clinical deterioration, privacy and post-consult handover. These implications are recommendations derived from the evidence, not findings of a Saudi patient-outcome trial.

6.4. Strengths and limitations of the evidence

This synthesis provides traceable publications, separates direct rural evidence from indirect general-EMS evidence, reproduces reported sample sizes and effects with their denominators, and identifies shared-study populations. Its limitations are equally important. Source identification was targeted rather than a documented exhaustive multi-database search, and no registered review protocol or fully auditable study-selection history was available. Some articles were assessed from published abstracts

rather than full methodological appendices, and formal dual-reviewer JBI/RoB 2 item judgments were not recorded. The review therefore does not claim comprehensive study capture or definitive certainty grades.

The underlying studies vary greatly in intervention maturity, sample size, clinical acuity, country, outcome selection and duration of follow-up. The small number of directly rural comparative studies and sparse patient-centered outcomes weaken generalizability. Cross-program synthesis is further complicated by repeated analysis of the same regional service and by case-selection mechanisms that determine who receives teleconsultation. These factors preclude a justifiable quantitative pooled effect.

6.5. Directions for future research

The next generation of studies should use prospective multicenter designs involving rural stations and record availability of broadband or cellular coverage. A pragmatic cluster-randomized or stepped-wedge design could compare protocolized physician consultation with existing medical direction for predefined presentations. Follow-up should include return EMS contact at 48 and 72 hours, unexpected ED attendance, admission, medication-related harm, transport destination accuracy, time to definitive intervention and mortality where feasible. Cost evaluation should include communication infrastructure, clinical staffing, dispatch effects, paramedic training and opportunity costs of extended on-scene care.

Saudi studies should stratify by remoteness and travel time, urban versus rural setting, paramedic qualification, shift, chief complaint and network reliability. Monitoring of professional scope and legal accountability should be included in the protocol. Patient privacy, consent where appropriate and cybersecurity are necessary alongside medical governance.

7. Conclusion

Telemedicine offers a credible mechanism for extending physician expertise to paramedics operating in remote or rural environments. Published studies show that remote consultation may influence clinical management, facilitate selected on-scene treatment decisions, and integrate safely with established EMS workflows under specific conditions. Video communication is not consistently superior to telephone-only advice, and increased connectivity or revised management plans do not by themselves demonstrate better patient outcomes.

The most defensible recommendation is selective, protocol-governed teleconsultation integrated with training, robust communications, clear clinical accountability and explicit escalation thresholds. Larger rural-focused comparative studies, ideally with linked hospital outcomes and longer follow-up, are needed to define where telemedicine produces measurable benefits for patients and healthcare systems.

8. Recommendations

Build a staged pilot for rural ambulance stations using defined indications, operational governance and documented physician coverage.

Use a secure multimodal platform with reliable telephone fallback; assess connectivity in actual areas of deployment before service launch.

Provide joint paramedic–remote physician training on case presentation, clinical uncertainty, remote data exchange, read-back and patient deterioration.

Adopt specific criteria for non-conveyance and mandatory re-contact advice; audit 48–72-hour return calls and adverse events.

Monitor consultation activation, response time, decision changes, transport destination, treatment timeliness and patient-centered outcomes rather than satisfaction alone.

Conduct a multicenter Saudi feasibility and safety study before any broad claim of effectiveness or nationwide scale-up.

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Appendix A. Search Framework and Reproducibility Notes

Publication limits: 1 January 2019–31 December 2025. Evidence checks conducted: 3 November 2026. Eligible intervention: real-time remote medical advice supporting paramedic/EMT clinical decisions. Actual sources checked for this manuscript: PubMed-indexed records, selected available full-text publisher articles and source-linked references.

Illustrative reproducible PubMed search expression (a search strategy for replication, not a claimed archived execution log):

((paramedic*[Title/Abstract] OR "emergency medical services"[Title/Abstract] OR EMT[Title/Abstract] OR prehospital[Title/Abstract]) AND (telemedicine[Title/Abstract] OR teleconsult*[Title/Abstract] OR "tele-EMS"[Title/Abstract] OR "remote medical direction"[Title/Abstract]) AND (rural[Title/Abstract] OR remote[Title/Abstract] OR decision*[Title/Abstract] OR transport*[Title/Abstract] OR clinical[Title/Abstract])) AND ("2019/01/01"[Date - Publication] : "2025/12/31"[Date - Publication])

Search audit fields required for a fully reproducible PRISMA review: database; search date and exact search string; raw records; deduplication method and count; screened records; title/abstract exclusions; full texts sought and retrieved; excluded full texts with reasons; final reports and independent datasets; screening reviewer identifiers and conflicts resolved. These quantities are not extrapolated from the 12 verified publications.

Appendix B. Data Extraction and Audit Register

Table B1. Core data audit for source-verified publications

Study IDs	Source DOI (short form)	Key denominator or sample	Rural-specific?
S1	10.1017/S1049023X2000117X	791 events assigned; PPA arms 258 / 193 / 192	Yes
S2	10.1016/j.annemergmed.2020.04.026	1,707 responses	No
S3	10.1038/s41598-021-93287-5	10,362 consultations; subset outcomes	No / regional
S4	10.1186/s12913-021-06591-1	6 interviews	Yes
S5	10.1186/s12913-022-08428-x	15 interview/focus participants	Yes (same rural program as S4)
S6	10.1186/s13054-023-04545-z	3,531 randomized; 3,220 analyzed	No / mixed regional
S7	10.1038/s41598-023-50924-5	229,384 EMS missions	No / regional
S8	10.5811/westjem.18427	38 pre; 38 post; 58 telemedicine encounters	Yes
S9	10.1186/s12873-024-01034-6	91 survey participants	Not specifically
S10	10.1007/s43678-024-00792-3	220 audio consultation calls	Not specifically
S11	10.3389/fdgth.2025.1519619	TEMS-trial diagnostic subset	No (shared with S6)
S12	10.1186/s12913-025-13748-9	2,165 surveys, 367 consultations, 203 evaluable plan-change responses	Yes

Appendix C. Appraisal Domains and Interpretation Key

The following are the appropriate domains for a formal independent appraisal, not numerical judgments invented for this manuscript. For randomized trials (S1 and S6; S11 as a secondary analysis of S6), RoB 2 addresses randomization, deviations from intended interventions, missing outcome data, outcome measurement and selection of the reported result. For quasi-experimental and observational designs (S2, S3, S7, S8, S10 and S12), JBI tools examine participant selection, comparison-group similarity, exposure and outcome measurement, confounders, follow-up, and appropriate statistical analysis. For qualitative interviews (S4 and S5), JBI examines methodological congruity, researcher

positioning, participant voices, ethics, analysis and interpretation. For cross-sectional implementation surveys (S9), JBI considers sample description, measurement reliability and potential confounding.

The report-based concerns in Table 4 are intended to identify the interpretation most at risk of bias. A formal study-by-study checklist with Yes/No/Unclear/Not Applicable ratings and adjudication records would be a separate audit artifact. No unsupported percentages of 'criteria met' are displayed.

Appendix D. Practical Rural Teleconsultation Evaluation Indicators

Table D1. Suggested outcome framework for future Saudi EMS pilots (proposed, not observed study results)

Domain	Operational indicator	Clinical or governance indicator
Access	Successful first-call connection; median physician callback time; dropout frequency	Cases escalated when connection fails
Decision process	Number and percentage of cases consulting a physician; reasons; changes to plan	Agreement between field plan and final physician decision
Transport	Non-conveyance, ALS/BLS allocation and selected destination	Unplanned re-contact or admission within 48–72 hours
Safety	Adverse events occurring during/after remote advice	Serious preventable harm; medication or referral errors
Service sustainability	Training completion, staff workload, supervision coverage	Protocol adherence and documented clinical accountability
Equity and efficiency	Rural/urban connection success; unit time; cost per supported case	Effect modification by geography and travel time