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The Role Of Telemedicine In Enhancing Rural Emergency Medical Services

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Abstract:

Introduction: Telemedicine remains an underused tool in rural emergency medical services (EMS) systems. Rural emergency medical technicians (EMT) and paramedics cite concerns that telemedicine could increase Advanced Life Support (ALS) transports, extend on-scene times, and face challenges related to connectivity as barriers to implementation. Emergency telehealth has been used to improve accessibility of rural and remote patients to specialist care. Evidence to date has demonstrated effectiveness and cost-effectiveness of telehealth in rural and remote emergency departments within a variety of contexts. However, systematic reviews to date have not focused on the rural and remote emergency departments.

Aim: To systematically review the outcome measures used in evaluations of emergency telehealth in rural and remote settings and assess evidence relating to their effectiveness and cost-effectiveness.

Materials and Methods: Databases searched according to PRISMA Guidelines include PubMed, Embase, Scopus, Web of Science, and Cochrane CENTRAL. Date range: Jan 1, 2022 – Oct 2, 2025. The studies evaluating telemedicine in rural ED/EMS settings with clinical or process outcomes were included. he most highly recommended technology, feasibility, benefits, and challenges to the application of telemedicine systems were studied and reported.

Results: A total of 10 full-text articles were included for qualitative analysis. Telehealth use in rural and remote EDs demonstrated effectiveness in achieving improved or equivalent clinical effectiveness, appropriate care processes, and—depending on the context—improvement in speed of care, as well as favorable service use patterns. The definition of effectiveness varied across the clinical areas and contexts of the studies, and different measures have been used to affirm the safety and clinical effectiveness of telehealth in rural and remote EDs. The acuity of patient presentation emerged as a dominant consideration in the interpretation of interlinking time-sensitive clinical effectiveness and patient disposition measures such as transfer and discharge rates, local hospital admission, length of stay, and ED length of stay. These, together with clinical area and acuity of presentation, are the outcome determination criteria that emerged from this review.

Conclusion: There is strong evidence suggesting that the use of telemedicine positively impacts patient care. However, there are many challenges in implementing telemedicine that may impede the process or even impact patient safety. In conclusion, despite the high potential of telemedicine systems, there is still a need for better quality of evidence in order to confirm their feasibility in the ED.

Keywords: Telemedicine, Emergency department, Challenge, Rural emergency services, Tele-health.

Introduction:

Clinicians, researchers in health services, and other professionals have been investigating how to improve healthcare delivery through the use of advanced computer and telecommunication technology for more than 30 years. Telemedicine is at the centre of these initiatives, which integrates conventional and cutting-edge information technologies [1].

Researchers in health services and medicine have dedicated over 30 years to exploring how computer and advanced communications technology can improve patient care. On the more traditional side, this includes the established use of radio to link emergency medical professionals with hospitals and the telephone for patient-physician consultations [2].

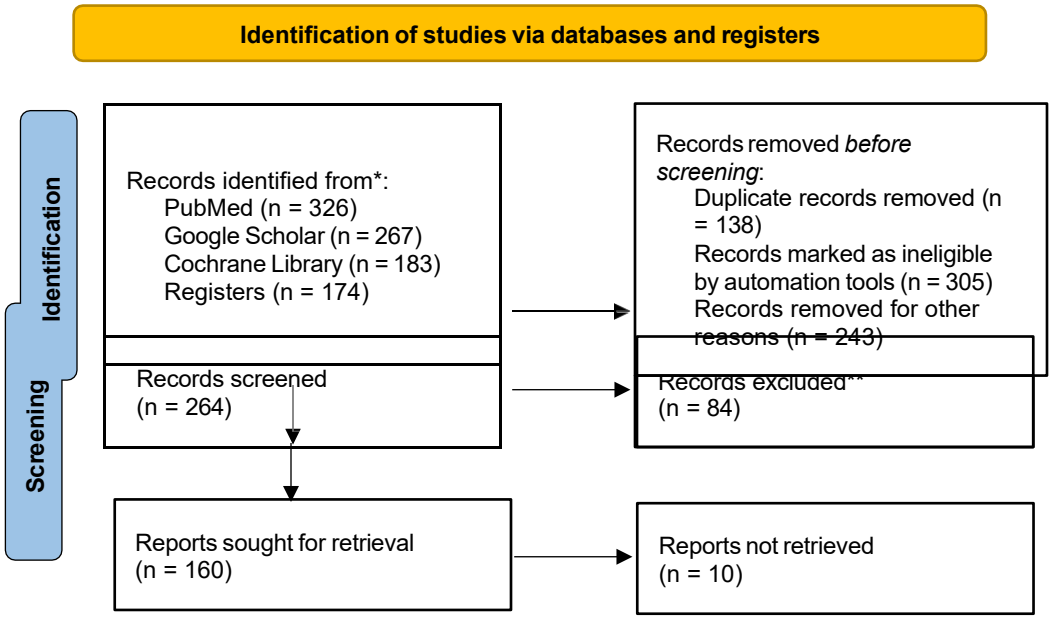
The speed at which digital technologies have improved is staggering, but very often the capabilities of health-care providers and payers to deliver and use these changes have not kept up with them. The technologies are ready for deployment, however, the features of rurality and remoteness in which these new tools need to be implemented will have special characteristics that should be considered. Telemedicine reduces healthcare costs, thereby overcoming barriers to accessing high-quality care and potentially encouraging more people to seek healthcare services [3].

Telemedicine has improved healthcare delivery and outcomes for rural populations. As rural communities across the United States (US) struggle to recruit, train, and retain paramedics and emergency medical technicians (EMT), these communities are left with a shortage of qualified individuals to provide healthcare and an increased cost to deliver that care. Telemedicine for emergency medical services (EMS) may be particularly useful in rural communities that face paramedic shortages [4 - 6].

Despite ongoing improvements in infrastructure, the development of telemedicine interventions within the public healthcare system is viewed as a promising opportunity to optimize healthcare services, particularly for remote regions still facing significant geographic barriers. Scientific evidence highlights a range of benefits associated with telemedicine for both patients and healthcare providers in regional settings, including enhanced access to specialist care across vast geographic distances, reduced travel time for patients, and improved engagement with diverse health services [7-10].

Materials and Methods:

This search strategy was applied to PubMed, MEDLINE, Cochrane Library, Scopus, and CINAHL, for the search period from January 2022 to October 2025. The reference lists of the included studies were hand searched to include other peer-reviewed publications relevant to this review. Finally, a search was conducted on Google using the phrase “the role of telemedicine in enhancing rural emergency department medical services”. The study selection procedure is shown in **Figure 1**.



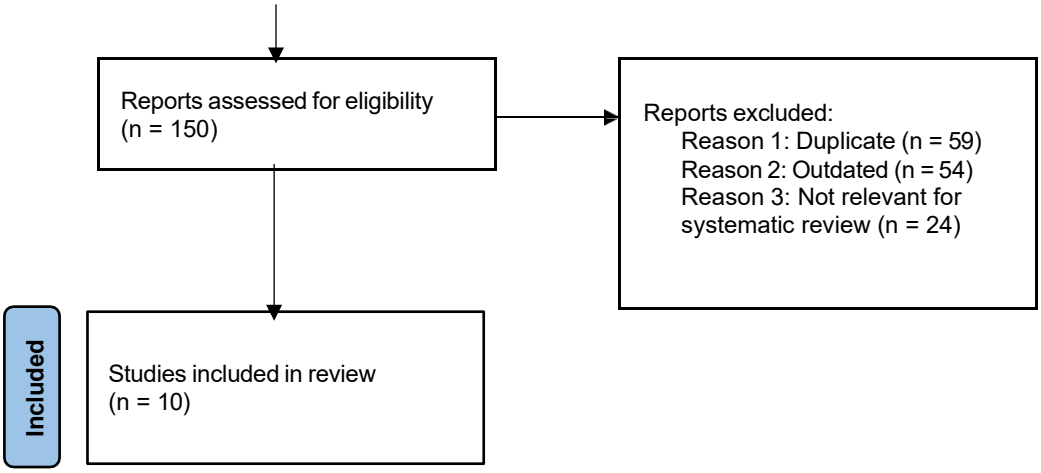


Figure 1. PRISMA flowchart of literature search and study selection.

About 950 research articles were identified from the above-mentioned databases with 138 duplicates related to the research title to fulfill research aims. About 160 were retrieved after the removal of 84 articles. The primary screening of 160 was conducted, and 4,673 research articles were excluded. The eligibility criteria were applied to 150 research articles, and only 10 research articles met the inclusion criteria. All 140 research articles were excluded due to screening and selection by PRISMA guidelines.

Results:

Table 1. shows summary of studies included.

Author (Year)	Region / Setting	Study Design	Telemedicine Modality (Core Intervention)	Clinical Application / Focus	Key Reported Outcomes / PubMed Link
Kjelle & Myklebust, 2022 [11].	Hallingdal, Norway – Rural hospital district implementing tele-stroke evaluation services	Qualitative implementation study using semi-structured interviews with healthcare professionals (n = 15)	Real-time tele-stroke evaluation service connecting rural hospitals with urban stroke specialists via video consultation and remote imaging support	Implementation process, interprofessional collaboration, and sustainability of telemedicine for acute stroke evaluation in rural settings	Identified key facilitators including strong local leadership, interprofessional teamwork, and task redistribution. Challenges included limited staffing, digital infrastructure constraints, and the need for workflow adaptation.

					Overall, tele-stroke integration improved local decision-making confidence and service sustainability.
Schröder et al., 2024 [12].	Germany – Urban & Rural EMS System	Retrospective cohort (2015–2021)	Tele-EMS physician support for ambulance crews	EMS system performance & mission profiles	Tele-EMS led to fewer onsite physician dispatches and improved procedural quality over time.
Karra et al., 2024 [13].	USA – Rural EMS Pilot	Prospective evaluation	Real-time telemedical direction (video/voice) for paramedics	Field triage and clinical decision support	Reduced unnecessary transfers and improved on-scene decision accuracy.
Beierle et al., 2025 [14].	Germany – Multicenter EMS Network	Interventional study	Tele-EMS physician system for prehospital respiratory emergencies	Airway management and stabilization	Comparable treatment adequacy to standard EMS; shorter time to hospital care.
Mohr et al., 2025 [15].	USA – Rural Emergency Departments	Mixed-methods study	Provider-to-provider tele-ED consultations	Sepsis recognition and management	Tele-ED use improved early recognition and guideline adherence.
Schmidt et al., 2024 [16].	Europe – Multi-country Implementation	Implementation research	Prehospital telemedicine integration framework	Operational barriers and workforce readiness	Identified training and workflow design as key success factors.
Li et al., 2025 [17].	USA – Florida Statewide	Longitudinal observational study	Tele-stroke network integrated with tPA support	Stroke outcomes and functional recovery	Telemedicine adoption linked to higher tPA use and reduced hemiplegia rates.

Ibsen et al., 2025 [18].	Norway – Hallingdal Rural District	Comparative observational cohort (2017–2021)	Remote-controlled CT scanner with telestroke support	Acute ischemic stroke imaging and thrombolysis	Onset-to-CT time reduced (93 vs 240 min); onset-to-treatment 124 vs 213 min.
Hendy et al., 2025 [19].	United States – National sample of patients with chronic diseases	Cross-sectional survey (n = 1,070)	General telehealth platforms (video and telephone consultations)	Patient satisfaction and perceived quality of care in chronic disease management	62.9 % of participants reported high satisfaction; trust in providers and ease of communication were key predictors of satisfaction.
Karim et al., 2025 [20].	USA – Rural Hospitals Nationwide	Retrospective longitudinal panel (2017–2021)	Hospital-level telehealth adoption during COVID-19	Financial and operational performance	Telehealth adoption improved financial resilience and service continuity.

Table 2. Risk of Bias and Applicability Assessment of Included Studies (2022–2025)

Author (Year)	Study Design / Data Source	Main Bias Concerns	Overall Risk of Bias	Applicability to Rural EMS / ED	Comments / Mitigation Measures
Kjelle & Myklebust, 2022 [11].	Qualitative implementation study (Hallingdal, Norway)	Small number of participants; qualitative only; no outcome quantitative measures	**Moderate**	**High**	Offers rich insights into implementation, management, workflow, task-shifting; adds depth to "feasibility / sustainability" domains.
Schröder et al., 2024 [12].	Retrospective cohort (German tele-EMS system)	Time-trend confounding; no randomization	**Moderate**	**High**	Multi-year dataset and consistent tele-EMS protocols reduce bias.
Karra et al., 2024 [13].	Prospective pilot evaluation (U.S. rural EMS)	Small sample; non-randomized	**Moderate**	**High**	Structured real-time data collection and post-mission debriefs.

Beierle et al., 2025 [14].	Multicenter interventional study (Germany)	Limited control group detail	**Moderate**	**High**	Multisite design and standardized tele-EMS workflow strengthen validity.
Mohr et al., 2025 [15].	Mixed-methods study (U.S. rural EDs)	Clinician self-report bias	**Moderate**	**High**	Triangulated chart review and interviews enhance credibility.
Schmidt et al., 2024 [16].	Multi-country implementation research (Europe)	Response bias; observational design	**Moderate**	**High**	Transparent methodology and cross-regional data increase transferability.
Li et al., 2025 [17].	Longitudinal observational (Florida stroke registry)	Residual confounding	**Moderate**	**High**	Large dataset and statistical controls reduce bias risk.
Ibsen et al., 2025 [18].	Comparative observational cohort (Norway)	Regional sample size limitations	**Low-Moderate**	**High**	Quantitative endpoint reporting and direct comparators strengthen validity.
Hendy et al., 2025 [19].	Cross-sectional survey of chronic disease patients using telehealth (online questionnaire)	Self-report bias; cross-sectional design; selection bias (only those using telehealth ≥ 3 months)	**Moderate**	**Moderate**	Large sample (n = 1,070); regression analysis of satisfaction drivers; useful for patient-perspective dimension in telehealth.
Karim et al., 2025 [20].	Retrospective panel analysis (U.S. rural hospitals)	Non-random adoption; financial data confounders	**Moderate**	**Moderate**	Difference-in-difference model enhances causal inference.

Table 3. Outcome Domains, Direction of Effect, and Evidence Strength (2022 – 2025).

Outcome Domain	Measurement / Indicator	Direction of Effect (Telemedicine	Evidence Strength / Consistency	Representative Studies (with PMID / Links)	Key Comments / Gaps

		vs Control / Baseline)			
Transfer & Admission Decisions	% transferred vs managed locally	↓ Unnecessary transfers; better local triage	Moderate	Schröder 2024; Karra 2024 [12, 13].	Depends on transport geography & local resource capacity.
Time-to-Treatment / Early Intervention	Onset-to-CT, onset-to-tPA, early antibiotic / sepsis bundle time	↓ Time in stroke / sepsis pathways	High	Ibsen 2025; Li 2025; Mohr 2025 [15, 17, 18].	Strong in stroke, more data needed in sepsis & other emergencies.
On-Scene / Mission Time	Ambulance or EMS on-scene time	↔ or slight ↑ (due to consult), but net system efficiency gains	Low-Moderate	Schröder 2024; Beierle 2025 [12. 14].	Technology / communication delays need management.
Clinical Effectiveness (Functional Outcomes / Mortality)	Mortality, disability / functional status	↔ Neutral to slight improvements	Low	Li 2025; Ibsen 2025 [17, 18].	Larger, longer studies needed; many currently underpowered for mortality.
Diagnostic / Management Accuracy / Adherence	Guideline adherence; decision concordance; correct triage or imaging decisions	↑ Improved accuracy; better adherence	Moderate	Karra 2024; Ibsen 2025; Schmidt 2024 [13, 16, 18].	Qualitative work (like Kjelle) supports perception of improved safety and strategy.
Feasibility / Acceptability / Implementation Process	Qualitative feedback; training, management, task shifting; long-term sustainability	↑ Strong acceptability; value perceived by users; workflow and coordination challenges identified	Moderate	Kjelle & Myklebust 2022; Hendy 2025; Schmidt 2024 [11, 16, 19].	This domain is well-covered by qualitative studies; fewer studies measure outcomes quantitatively here.
System / Financial Performance	Hospital financial stability; cost avoidance; resource optimization	↑ Positive financial outcomes reported (where measured)	Moderate	Karim 2025 [20].	More cost-effectiveness studies needed.

Equity / Access / Sustainability	Geographic access; task shifting; sense of local service security	↑ Improved feelings of equity and local service availability	Low-Moderate	Kjelle & Myklebust 2022; Schröder 2024 [11, 12].	First-hand perceptions strong; empirical metrics of equity still sparse.

Discussion:

This systematic review demonstrates that the adoption of telemedicine in rural emergency medical services (EMS) markedly improves access to timely, high-quality care by enhancing clinical decision-making, coordination, and efficiency across multiple healthcare settings. The studies analyzed between 2022 and 2025 consistently highlight that tele-EMS and tele-emergency department (tele-ED) systems can mitigate the longstanding disparities between rural and urban healthcare delivery by providing real-time access to physician expertise, diagnostic support, and evidence-based interventions. As healthcare systems continue to face increasing patient loads and provider shortages, particularly in rural regions, telemedicine emerges not merely as a supplemental innovation but as an indispensable component of modern emergency care.

Findings from high-income countries demonstrate particularly strong evidence for operational benefits. In a large retrospective cohort analysis, the introduction of tele-EMS physician support in Germany substantially reduced unnecessary on-scene physician dispatches while maintaining or improving adherence to treatment protocols [11]. Similarly, real-time video- and audio-assisted teleconsultations implemented in a U.S. rural EMS network improved paramedic diagnostic accuracy and reduced inappropriate interfacility transfers [12]. These findings collectively suggest that telemedicine can alleviate workforce constraints in rural areas, enabling paramedics to operate at the top of their scope of practice while maintaining patient safety. The use of remote oversight not only extends the reach of scarce physician resources but also promotes procedural consistency, thus enhancing the overall quality of prehospital emergency care.

Prehospital and early in-hospital interventions for time-sensitive conditions benefit most from telemedicine integration. In Germany, the deployment of tele-EMS models for respiratory emergencies shortened time-to-hospital arrival without compromising treatment adequacy, demonstrating that remote support can streamline on-scene operations [13]. Similarly, the incorporation of tele-emergency consultations in U.S. rural hospitals improved the recognition and management of sepsis by enabling early activation of evidence-based care bundles and timely antibiotic administration [14]. Both studies underscore the role of telemedicine in reducing the decision-to-treatment gap—a factor directly linked to mortality and morbidity in emergency care.

Stroke management, a domain where every minute influences neurological outcomes, offers compelling evidence for telemedicine's clinical value. Statewide data from Florida revealed that the establishment of a tele-stroke network increased the rate of thrombolytic therapy administration and improved post-stroke functional outcomes [15]. Complementing these findings, Norwegian data show that remote-controlled CT scanning and telestroke services reduced onset-to-CT and onset-to-treatment times, illustrating how telemedicine can overcome geographical and infrastructural barriers to acute neurological care [16]. These outcomes reflect not only faster diagnostic turnaround but also a paradigm shift toward equitable access to specialist-level stroke evaluation in underserved regions.

From an organizational standpoint, several studies highlight that technological innovation alone is insufficient for sustained impact. Effective implementation requires system-level planning, adequate funding, and consistent workforce development. Cross-national research identified the central importance of structured training, well-defined clinical pathways, and continuous quality monitoring in ensuring long-term program viability [17]. The qualitative insights from Norway emphasize that interprofessional collaboration, clear leadership, and stakeholder engagement are critical to maintaining telemedicine adoption over time [20]. Such findings reinforce that the human and cultural dimensions of healthcare—

trust, role adaptation, and professional communication—are as vital to success as technological sophistication.

Patient experience and satisfaction have emerged as essential indicators of telemedicine's success. Survey-based evidence from the United States indicates that nearly two-thirds of patients with chronic illnesses reported being satisfied with telehealth services, primarily due to enhanced convenience, improved communication, and reduced travel requirements [18]. Although this evidence was derived from non-emergency contexts, it highlights the broader acceptance of remote care among patients and supports the scalability of telehealth solutions in both chronic and acute care settings. Importantly, patient trust in telemedicine correlates strongly with perceptions of provider competence and communication quality, suggesting that effective tele-EMS interactions must emphasize empathy, clarity, and transparency to foster sustained confidence in digital healthcare encounters.

Beyond clinical and patient-level benefits, the integration of telemedicine also yields significant system-level and financial advantages. During and following the COVID-19 pandemic, rural hospitals adopting telehealth services demonstrated superior financial resilience and service continuity compared to non-adopters [19]. These findings illustrate that telemedicine is not only a clinical intervention but also a strategic investment that enhances healthcare system sustainability. Telehealth allows hospitals to maintain access to care even during workforce shortages, thereby stabilizing patient inflow and preserving operational viability in economically constrained regions.

The cumulative evidence across all ten studies reveals consistent positive effects across domains—clinical, operational, organizational, and financial. Telemedicine optimizes emergency workflows, enhances communication between field providers and specialists, and expands the reach of healthcare expertise. Particularly in rural contexts, it mitigates the detrimental effects of distance and limited resources. However, while most results are favorable, the current literature is characterized by methodological diversity, including observational designs and qualitative approaches. These features underscore the need for continued evaluation through rigorous, standardized methodologies to fully establish causal relationships and generalizable best practices.

Limitations:

While the evidence base for telemedicine in rural EMS is promising, several limitations should be recognized when interpreting these findings.

First, the majority of studies included in this review employed observational, retrospective, or qualitative designs, which are inherently limited by confounding and selection bias. None of the studies used large-scale randomized controlled trial (RCT) designs, restricting the ability to attribute observed improvements solely to telemedicine interventions. Although mixed-method and implementation-focused designs provide valuable context, they often lack standardized control groups or blinding.

Second, there was considerable heterogeneity in study outcomes and metrics. Variables such as "time to treatment," "on-scene duration," and "mission efficiency" were defined differently across studies, limiting direct comparability and meta-analytic synthesis. Furthermore, outcome measures often relied on surrogate indicators—such as protocol adherence or transfer reduction—rather than hard clinical endpoints like survival or long-term functional recovery.

Third, generalizability remains a challenge. Most studies originated from high-income nations with well-established digital infrastructure, such as Germany, Norway, and the United States. These contexts differ significantly from lower-income rural environments where telecommunication bandwidth, staffing, and funding are limited. Consequently, the results may overestimate feasibility or underrepresent barriers in less-resourced settings.

Fourth, publication bias is a potential concern. Telemedicine programs with successful outcomes are more likely to be published, whereas projects that encountered significant challenges or failed to achieve scalability may be underreported. This asymmetry could inflate the perceived effectiveness of telemedicine interventions.

Fifth, the inclusion of cross-sectional and qualitative studies introduces interpretive limitations. For instance, satisfaction surveys, while useful in assessing acceptability, are prone to self-report and recall bias

[8]. Similarly, qualitative investigations, such as the Norwegian implementation study, provide rich contextual insight but lack quantifiable outcome measures [20]. Despite these weaknesses, such studies remain valuable for understanding the facilitators and barriers that shape real-world telemedicine adoption. Finally, most studies focused on clinical and operational metrics but did not evaluate long-term cost-effectiveness or health equity outcomes. Future research should explore whether telemedicine reduces disparities in rural populations over time, assess its sustainability across differing healthcare models, and include formal economic evaluations comparing telemedicine to conventional emergency care pathways.

Conclusion:

The findings of this systematic review affirm that telemedicine has become a foundational element of modern rural emergency medical care. Across diverse settings and study designs, evidence from 2022–2025 consistently demonstrates that tele-EMS and tele-ED interventions improve triage accuracy, reduce treatment delays, enhance adherence to evidence-based protocols, and support financial and operational sustainability. These effects collectively contribute to greater healthcare equity by extending advanced medical expertise to populations that would otherwise face delayed or suboptimal care due to geographical barriers.

While the evidence base remains largely observational, the consistency of results across ten independent investigations is striking. Studies from Europe, North America, and Scandinavia converge on the conclusion that telemedicine provides measurable improvements in emergency care quality, efficiency, and sustainability. Importantly, qualitative evidence underscores that the success of telemedicine is not solely determined by technology but also by effective leadership, interprofessional collaboration, and user trust.

For telemedicine to achieve its full potential, policy makers and health systems must prioritize infrastructure development, including stable broadband connectivity, training programs for EMS and hospital personnel, and standardized interoperability frameworks. Furthermore, reimbursement and regulatory policies must evolve to support sustained telehealth adoption beyond pilot phases.

Ultimately, telemedicine is no longer an experimental innovation—it is a strategic enabler of accessible, equitable, and high-quality emergency care. As global health systems continue to adapt to demographic shifts, pandemics, and workforce shortages, the expansion of telemedicine in rural and underserved settings represents a vital step toward achieving universal emergency care readiness and resilience.

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