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Synergy of Digital Technology Based on Miller's Pyramid in Emergency Medical Education: A Literature Review

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Abstract
Purpose: This study aims to examine the role of digital technology in emergency medical education as an effort to strengthen the Integrated Emergency Management System (SPGDT) and to enhance the clinical competence of healthcare professionals.
Research Methodology: This study employs a literature review approach by analyzing various scientific articles obtained from electronic databases, including Google Scholar, PubMed, and ScienceDirect. The review focuses on the utilization of digital technologies such as educational videos, Realistic Immersive Learning Environments (RILE), and telemedicine in emergency medical education, as well as the implementation of digital technologies within SPGDT.
Results: The findings indicate that the use of digital technology improves the effectiveness of the learning process, situational awareness, and decision-making skills in emergency situations. Furthermore, the digitalization of SPGDT through the use of videos, Artificial Intelligence (AI), Global Positioning Systems (GPS), and integrated systems contributes to faster response times and improved accuracy in emergency care delivery.
Conclusions: The integration of digital technology in emergency medical education and emergency response systems has the potential to enhance clinical competence and support more effective and efficient healthcare services.
Limitations: This study is inherently limited to the analysis of existing literature and lacks empirical data to validate the actual effectiveness of these digital technologies in real-world emergency settings.
Contributions: This study provides a conceptual overview of the use of digital technology in emergency medical education and its contribution to strengthening SPGDT for healthcare professionals.

Keywords: *Digital Technology, Emergency Medical Education, Miller's Pyramid, SPGDT, Telemedicine*

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1. Introduction

Rapid response during the golden hour period is a universally recognized determining factor for survival in medical emergencies. Globally, the World Health Organization (WHO) and international health frameworks have increasingly emphasized the critical need for robust, digitally integrated Emergency Medical Services (EMS) to reduce preventable mortality. This global challenge is now being addressed at the national level through the digital transformation of the Integrated Emergency Management System (SPGDT) in accordance with the guidelines of the Ministry of Health of the Republic of Indonesia (Kemenkes, 2024). This system integrates the chain of command from the national to regional levels and utilizes the location-based "Sigap 24/7" application to ensure accuracy and speed of medical

response in real-time (Maheswara, Jaya, Haptono, Mukhlis, & Ananto, 2025; Sarbadhikari & Sarbadhikari, 2023). By aligning with global digital health initiatives, this national system aims to optimize dispatch and triage protocols. However, although digital infrastructure is already available, there are still limitations in the success of studies integrating the effectiveness of digital technology in healthcare services and emergency medical education comprehensively. In addition, its success still fully depends on the competence of healthcare workers, which is often difficult to achieve through conventional education models alone.

To bridge the gap between theory and high-risk practice, the use of educational videos and Realistic Immersive Learning Environment (RILE) emerges as a vital method to train psychomotor skills in a safe simulation setting (Castillo-Rodríguez, Gómez-Urquiza, García-Oliva, & Suleiman-Martos, 2025; Humaryanto, Miftahurrahma, & Justisia, 2022). This approach accelerates the improvement of clinical competence toward real-world application stages in accordance with Miller's Pyramid, which is further strengthened by telemedicine to expand the reach of consultation. Miller's Pyramid is a hierarchical framework for assessing the clinical competence of medical students, which divides competency development into four levels: knows, knows how, shows how, and does (Witheridge, Ferns, & Scott-Smith, 2019).

Based on studies by Humaryanto et al. (2022) and de Sena et al. (2019), the use of video media is effective in building theoretical understanding as well as structured procedural knowledge, supported by Spence et al. (2016), who positioned it as a superior instrument for skill evaluation compared to verbal feedback as a solution to bridge the limitations of the shows how level in Miller's Pyramid. In addition to medical students, animated videos also serve as an inclusive medium for information and education for the general public, as shown in the study by Aprillyani et al. (2024). Complementing this visual aspect, RILE technology enhances clinical competence through simulation that provides psychological safety and emotional engagement, as emphasized by Castillo-Rodríguez et al. (2025). Building on this perspective, Leder et al. (2019) further added that this immersive experience builds mental preparedness by transforming how learners perceive risk, so that the combination of these two technologies creates a holistic learning ecosystem encompassing comprehensive knowledge, motor precision, and strong mental resilience. Based on this premise, this literature review analyzes the strategic synergy between emergency education technologies as a reinforcement of a digital integrated emergency management system to create precise, responsive, and inclusive national healthcare services.

2. Literature Review

The use of video and RILE is effective in supporting the achievement of clinical competencies based on Miller's Pyramid, particularly at the knows and knows how levels through visualization, as well as the shows level through simulation. This technological integration strengthens the crucial foundation before reaching the highest level, does, which is real clinical practice in emergency systems (Bapatla, Fine, & Rajput, 2021; Witheridge et al., 2019). Furthermore, evidence from international studies demonstrates that the successful integration of digital emergency education and telemedicine is a global phenomenon. For instance, studies from Taiwan by Chen et al. (2025) and Japan by Inokuchi et al. (2025) highlight how mobile-based platforms and online medical consultations significantly optimize resource allocation and triage efficiency in both urban and rural settings. Comparing these international benchmarks with Indonesia's local initiatives provides a strong justification for the ongoing digital transformation of SPGDT.

To reach the highest level, "does," in Miller's Pyramid, systematic real-world clinical practice is required so that learners can apply their knowledge effectively (Witheridge et al., 2019). Applications like "Sigap 24/7" and telemedicine serve as digital technology implementations that support this goal for the development of emergency response systems (Bapatla et al., 2021). The digital transformation of the Integrated Emergency Medical Services System (SPGDT) in Indonesia is now a regulatory obligation through the 2024 Technical Guidelines of the Indonesian Ministry of Health to ensure a rapid national medical response. This system integrates the command structure from the National Command Center (NCC) and Province Command Center (PCC) to the Public Safety Center (PSC) 119 through a digital monitoring dashboard that tracks ambulance distribution and handling durations in real-time.

This integration includes calculating dispatch and response times as a foundation for data-driven decision-making to reduce mortality and disability rates. The implementation of this policy is technically strengthened by mobile applications like "Sigap 24/7," which eliminate conventional communication barriers by uniting various rescue agencies into a single, integrated platform (Ditjen & Kemenkes, 2025; Maheswara et al., 2025).

3. Methodology

This study employed a Systematic Literature Review (SLR) to examine the integration of digital technology in emergency medical education and emergency response systems. A qualitative approach with narrative synthesis was used to analyze and interpret findings from relevant previous studies. The literature search was conducted through the Google Scholar, PubMed, and ScienceDirect databases using the PEOS framework (Population, Exposure, Outcome, Study) to formulate the search strategy. In this review, the population included medical students, healthcare professionals, or emergency learners, while the exposure referred to the use of digital technology in emergency education and response systems. The outcomes focused on clinical competence and emergency system efficiency, and the study component was limited to original empirical research articles. The keywords used in both Indonesian and English included “digital technology,” “emergency education,” “virtual reality,” “telemedicine,” “simulation-based learning,” and “emergency medical systems”.

The literature selection process was conducted through three stages consisting of identification, screening, and inclusion. At the identification stage, articles obtained from the databases were compiled and duplicates were removed. During the screening stage, titles and abstracts were reviewed to determine their relevance to the study objectives. Full-text assessment was then performed for potentially eligible articles based on predefined inclusion and exclusion criteria. The inclusion criteria consisted of original or experimental research articles published between 2016 and 2026, studies discussing digital technology in emergency contexts in either educational or emergency system settings, articles relevant to the research objectives, full-text availability, and publication in either Indonesian or English. Studies were excluded if they discussed emergency medicine without a digital technology component, were review articles or conference abstracts, or focused on technologies outside the scope of video media, Realistic Immersive Learning Environment (RILE), emergency applications, and telemedicine.

To ensure methodological rigor, the quality of each included study was assessed using the Critical Appraisal Skills Programmed (CASP) checklist adapted according to the design of each article. The assessment examined the clarity of research objectives, the appropriateness of the study design, sampling adequacy, validity of data collection methods, transparency of data analysis, and the consistency between findings and conclusions. Each criterion was rated as yes, partially, or no, corresponding to scores of 1, 0.5, and 0, respectively. The total quality score for each study was then calculated, with studies categorized as high, moderate, or low quality. Only studies categorized as moderate to high quality were included in the final narrative synthesis to strengthen the reliability and validity of the review findings.

4. Results and Discussion

Based on the results of the literature review, the use of digital technology is closely related to improving the quality of emergency education and emergency response systems. The quality of emergency education can be optimized through the synergy of digital technologies such as video and RILE to strengthen learners’ cognitive and psychomotor aspects (Alhur, 2024). The integration of these technologies becomes a crucial foundation in supporting the development of emergency response systems through SPGDT with the utilization of the “Sigap 24/7” application and telemedicine (Atmaja et al., 2024; Kemenkes, 2024; Maheswara et al., 2025).

Table 1. Literature review of the use of video and rile in emergency medical education

No.	Method and Sample	Results	Conclusion
1.	A descriptive Research and Development study using a trauma emergency triage simulation video with questionnaire data analysis through SPSS. A total of 74 medical professional students after surgical rotation.	The educational video received the highest ratings in duration effectiveness (77%), visual quality (74.3%), and learning strategy (71.6%) which facilitated understanding (71.6%). The most preferred type of simulation video was emergency simulation and emergency department management.	The trauma emergency triage simulation video is effective in improving students' learning understanding (Humaryanto et al., 2022).
2	A Randomized Controlled Trial comparing two CPR training methods using video and games. Respondents underwent theoretical & practical pre-test and post-test after a 20-minute learning intervention. A total of 45 first-year medical students aged ≥18 years from PUCRS School of Medicine, Brazil.	The video group showed better results in the theory test and most of the practical checklist, with significant differences in one theory item ($p=0.002$) and one practical item ($p<0.001$). Video was more effective due to its structured flow and beginning with diagnosis, whereas the game relied on trial and error, resulting in lower focus on instructions.	Self-directed learning with video resulted in superior theoretical & practical CPR performance compared to the game method (de Sena, Fabrício, da Silva, Bodanese, & Franco, 2019).
3	A prospective experimental study with randomized crossover comparing the effectiveness of video feedback and verbal feedback on CPR performance using a high-fidelity manikin, preceded by an initial simulation assessment. Evaluation was based on a structured checklist assessment tool, with verbal feedback delivered orally and video feedback using StudioCode. A total of 138 final-year medical students from Queen's University of Belfast, Northern Ireland.	The average improvement score in the video group was higher (12/90) compared to the verbal group (4/90). The video group showed significant improvement ($p=0.006$), especially in ventilation quality and global score ($p=0.002$ and $p<0.001$). Although the total scores between groups were not significantly different ($p=0.194$), further analysis showed that the video group still demonstrated better ventilation and auscultation quality ($p=0.06$ and $p=0.028$).	The video feedback method has significant advantages compared to verbal feedback in CPR simulation, thereby improving specific Advanced Life Support skills, especially ventilation quality and global score (Spence, Derbyshire, Walsh, & Murray, 2016).
4	A pre-experimental one group pretest–posttest design with measurement of knowledge before and after SPGDT education based on animated video. Data were analyzed using a paired t-test.	A total of 75 respondents were selected purposively from 212 residents of Lubuk Lingkuk Village. The mean knowledge score increased from 52.33 to 77.53 after the education ($p<0.05$).	SPGDT education through animated video has been proven to have a significant effect on increasing respondents' knowledge (Aprillyani, Agustina, Ilmi, Rosidawati, & Ariyani, 2026).

5	A Randomized Controlled Trial comparing the intervention group (VR) with the control group (traditional). Participants were learners/professionals in the field of emergency healthcare with a focus on CPR procedures and myocardial infarction management.	The VR group showed an increase in learning effectiveness compared to traditional methods. VR creates a safe "trial and error" environment and can be conducted virtually without risk to patients.	VR is a method for the early stage of motor skill training because it provides psychological and physical safety for learners (Castillo-Rodríguez et al., 2025).
6	A comparative analysis (effectiveness of VR and traditional methods on technical aspects). Medical training participants with a focus on surgery, radiology, and equipment handling.	VR overcomes ethical barriers and cadaver availability. VR is superior in training equipment handling, patient positioning, and radiographic techniques.	VR is highly effective for mastering techniques through repetition and increasing confidence. However, it still requires continuous practice to maintain long-term retention (Altalhi et al., 2024).
7	A randomized manikin simulation study on four types of laryngoscopes (Macintosh, McGrath, Pentax AWS, and A-LRYNGO with AI) under conditions where participants wore Level D PPE. Evaluation was conducted in two stages (post-theory and post-workshop). A total of 30 final-year medical students (novices).	The use of A-LRYNGO showed a very high initial success rate (89.7%) compared to the manual Macintosh (51.7%). This was supported by the accuracy of the AI system in automatically detecting the glottis (93.1%). In addition, this technology significantly accelerated intubation time through short training, making it more efficient for beginners compared to conventional methods.	AI-assisted devices are the most effective solution for beginners in high-risk situations, accelerating the learning curve despite the limitations of PPE (Choi et al., 2022).
8	A comprehensive review analyzing the spectrum of Extended Reality technologies as well as biometric sensors and haptic devices in training. Operational technologies in fire and rescue services.	The use of haptic feedback has been proven effective in training muscle memory through real physical sensations (heat and resistance). Psychologically, biometric sensors in VR enable real-time monitoring and training of stress management in high-risk scenarios. AR/MR technologies also enhance situational awareness by displaying digital data directly in the field without diverting the user's attention.	XR systems transform training into active simulation without physical risk. Crucial for sharpening tactical decision-making. Hancko, D., et al. (2025).
9	Experimental Study & Prototyping. The researchers developed a Mixed Reality system (specifically Augmented Virtuality) that maps a real physical manikin into a	The integration of real and virtual worlds in this study was highly precise (error ~1 cm), allowing participants to feel the physical manikin while observing realistic injury visualizations (tactile feedback). The use of Leap	Mixed Reality is the best solution for first aid training because it combines tactile (touch) and visual feedback, increasing emotional and motor engagement. In

	virtual environment using HTC Vive and Leap Motion hand sensors. Effectiveness was tested through measurements of technical accuracy and user experience questionnaires. A total of 27 participants, 13 laypersons (control) and 14 medical students with clinical training experience.	Motion enhanced the sense of presence and facilitated fine motor movements as users could see their real hands without controllers.	addition, this system is safe for long-duration training as it records very low cybersickness scores (Girau et al., 2019).
10	An experimental study consisting of two separate studies compared the effectiveness of safety training using Immersive VR (with a Head-Mounted Display) against a PowerPoint presentation (the standard passive method). The sample included 53 industrial trainees (Study 1) and 68 university students (Study 2), totaling more than 100 participants to ensure reliable statistical results.	The VR group showed a significant change in how they perceived risk (rating the likelihood of accidents higher and more realistically) compared to the PowerPoint group. They also tended to make safer, less risky decisions in simulations after the training. However, there was no significant difference in learning facts; both methods were equally effective at teaching theoretical information.	VR has a unique advantage over traditional methods because it does not just share information; it actually changes behaviors and ways of thinking. VR is better at influencing emotional responses (feeling alert to risks) and actions. This makes it an ideal tool for building a "Safety/Disaster Mindset" for mental readiness, rather than just helping people memorize theories (Leder, Horlitz, Puschmann, Wittstock, & Schütz, 2019).
11	A web-based, cross-sectional survey compared a mobile-based emergency residency training program with traditional paper-based and web-based approaches. The sample included 74 valid respondents from 28 emergency residency training sites in Taiwan. This group consisted of 49 educators or trainers, 16 residents, and 9 Residency Review Committee (RRC) hosts.	The group using the mobile-based program experienced a lower rate of missed assessments compared to those using the paper-based and web-based programs. The mobile program also provided greater ease in identifying performance trends and required clinical scenarios. Additionally, the mobile platform allowed for the real-time visualization of performance trends, which facilitated more individualized training for the residents.	The mobile-based interface significantly improved emergency residency training by providing rapid and customizable updates. It also played a crucial role in advancing Competency-Based Medical Education (CBME) (Chen, Lee, Chang, Chiu, & Hung, 2025).
12	A Randomized Controlled Trial comparing an intervention group (Virtual Reality/VR) with a comparator group (High-Fidelity Simulation/HFS). The participants were 164 medical interns from a teaching hospital. The	Both VR and HFS groups demonstrated a significant improvement in self-reported confidence for managing oxygen desaturation, with no significant difference between the two modalities. Overall satisfaction was high in both groups, although the HFS group reported	VR is an effective and scalable educational modality that can complement HFS in emergency response training. Both methods are associated with improvements in novice physicians' self-reported

	simulation training focused on emergency response skills, specifically managing patients with acute oxygen desaturation.	significantly greater satisfaction regarding tutor guidance and authenticity. Qualitatively, VR was valued for its immersive environment and focused repetition , whereas HFS was praised for its hands-on realism and immediate feedback.	confidence and perceived preparedness for clinical emergencies (Huh et al., 2026).
13	An observational study evaluating the performance of four Large Language Models (LLMs): ChatGPT-4o, Gemini 2.0, Claude 3.5, and DeepSeek R1. The sample consisted of 60 multiple-choice questions from the Emergency Medicine Fellowship Examination (YDUS) in Türkiye. The questions were categorized into knowledge-based (n=26), visual content (n=2), and case-based (n=32) questions. Each question was presented to the models three times to assess both accuracy and response consistency.	ChatGPT-4o achieved the highest overall accuracy at 90.0%. It performed best in both knowledge-based (92.3%) and case-based (90.6%) questions. Claude 3.5 demonstrated the highest response consistency. Conversely, Gemini 2.0 and DeepSeek R1 had lower consistency and a higher frequency of inconsistent hallucinations. Notably, all models struggled with visual-content questions, with DeepSeek R1 failing them completely.	LLMs demonstrate high accuracy for medical knowledge and clinical reasoning in emergency medicine, showing significant potential for use in medical education and clinical decision support systems. However, differences in response consistency, tendencies to hallucinate, and limitations in interpreting visual data indicate that further development is needed for reliable application (Şan et al., 2025).
14	A Randomized Controlled Trial comparing a Virtual Reality-based station (VRS) with a traditional physical station (PHS). Participants were 123 fifth-year medical students undergoing an Objective Structured Clinical Examination (OSCE) focused on emergency medicine scenarios involving septic and anaphylactic shock.	The implementation of VRS was feasible, with 93% of students using the VR technology without major issues. While the difficulty levels were comparable between modalities , the VRS demonstrated superior item discrimination power. Students praised the VRS for its realistic portrayal of emergencies and fair assessment conditions, despite some hesitancy regarding its broader application in future practical exams. Additionally, initial development costs of VRS can be offset by long-term savings on standardized patients and consumables.	Integrating VR-based assessments into established OSCE frameworks is technically and organizationally feasible. VR serves as a well-accepted, realistic, and highly discriminatory tool for assessing clinical competencies in emergency scenarios, accommodating students regardless of prior VR experience (Mühling, Schreiner, Appel, Leutritz, & König, 2025).

Table 1 shows how the integration of digital technology in emergency education creates a framework that combines cognitive aspects with psychomotor skills. Based on studies by Humaryanto et al. (2022) and de Sena et al. (2019), the use of video media is effective in building theoretical understanding and structured procedures. This is supported by Spence et al. (2016), who positioned video as a superior skill evaluation tool compared to verbal feedback, acting as a solution to bridge the limitations of the "shows how" level in Miller's Pyramid. Beyond medical students, animated videos also serve as an inclusive educational and informational medium for the general public, as demonstrated in the research

by Aprillyani et al. (2024). Complementing these visual aspects, RILE technology enhances clinical competence through simulations that provide psychological safety and emotional engagement, as emphasized by Castillo-Rodríguez et al. (2025). Leder et al. (2019) added that this immersive experience builds mental preparedness by changing how learners perceive risk. Consequently, the combination of both technologies creates a holistic learning ecosystem that encompasses comprehensive knowledge, motor precision, and mental resilience.

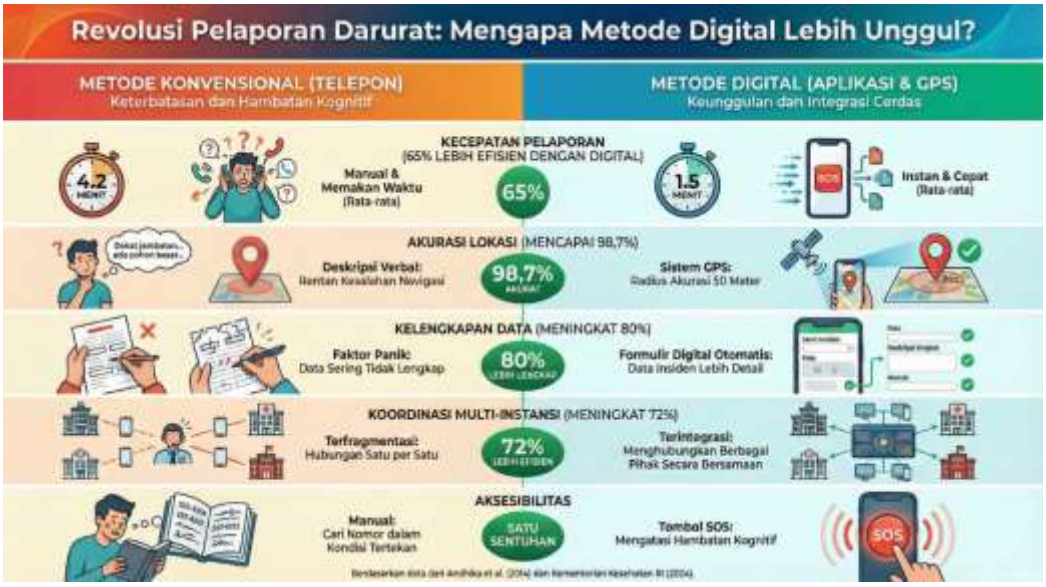

Figure 1. Analysis of the advantages of digital transformation in emergency reporting systems.

On the operational side, modern command platforms utilize Geographic Information System (GIS) and Extended Reality (XR) technologies to visualize crew positions with precision. This is supported by the use of the Global Positioning System (GPS), which is capable of eliminating location ambiguity with an accuracy of up to 98.7% to optimize the golden hour. Beyond technical efficiency, this transformation encourages the active participation of the community as first responders through improved digital literacy. In this context, video-based education has proven to be more effective in increasing the knowledge and calmness of patients' families compared to conventional methods. The synergy between modern central policies and the adoption of GPS-based technology transforms the public from passive reporters into an active part of a disaster mitigation ecosystem that is responsive to future health challenges (Khorram-Manesh et al., 2025; Maheswara et al., 2025).

Table 2. Literature review of the use of telemedicine in emergency response systems

No.	Method and Sample	Results	Conclusion
1.	A qualitative approach with a case study design (qualitative case study) was employed. A total of 15 participants were selected purposively, consisting of 5 healthcare workers, 5 patients using emergency telemedicine services, and 5 community leaders from three remote villages on Lombok Island, West Nusa Tenggara.	Telemedicine increased emergency consultations from 15 to 30 per month, reduced response time from 45 to 25 minutes, and strengthened coordination as well as service quality through more effective communication among healthcare providers.	Telemedicine serves as a cost-effective solution for equalizing emergency service delivery and reducing disparities in healthcare access between urban and remote rural areas (Atmaja et al., 2024).
2	This study compares video and telephone consultations in critically ill pediatric patients	Telemedicine consultations via video and telephone both demonstrated safety in	Telemedicine via video and telephone has been proven to be effective and

	through a cluster randomized trial with an unbalanced crossover design in several emergency departments (EDs). A total of 696 children aged less than 15 years who were critically ill in 15 community and rural emergency departments in Northern California.	medication administration for critically ill children without differences.	safe for use in pediatric emergency consultations in reducing medication errors (Marcin et al., 2023).
3	Comparison of pediatric consultations through telemedicine (audio-video) with telephone consultations in 15 small or rural hospitals to examine its effect on transferring children to other hospitals. A total of 696 children aged ≤14 years (537 children received consultations via telemedicine (audio-video) and 159 children via telephone).	The study results showed that the use of telemedicine in the form of direct audio-video consultations for pediatric patients in hospital and community emergency departments significantly reduced referral rates to pediatric referral hospitals compared to consultations conducted only via telephone.	Telemedicine (audio-video) helps small hospitals manage more pediatric patients and reduces transfers to other hospitals (Marcin et al., 2024).
4	An observational study conducted over one year using telemedicine to assess non-emergency patients who called emergency services. A total of 8,680 patients, with an average age of 63 years, mostly elderly.	A total of 72% of patients could be managed at home without visiting the emergency department, some through telemedicine and home visits by medical teams, with high patient satisfaction (9/10).	Telemedicine enables remote care, reduces emergency department visits, and is safer for elderly patients or those with mild conditions (Cortellaro et al., 2025).
5	A retrospective observational cohort study evaluating the integration of conventional emergency care with telemedicine in rural areas. The sample included 136 patients with mild COVID-19 recovering at home who called an ambulance in Asahikawa, Japan. When an emergency call was received, the fire department control center initiated an online medical consultation to ascertain the necessity of ambulance transport while conventionally dispatching an ambulance.	Out of the 136 patients, 73 (53.7%) were transferred to a hospital via ambulance, while 63 (46.3%) were not. The transferred patients had a significantly higher median age (83 years vs. 37 years) and a higher incidence of hypoxemia (23.3% vs. 3.2%). Furthermore, 44.4% of the patients who were not transferred were successfully prescribed medication through the online medical service.	Integrating private online medical services with the conventional public emergency care system can optimize medical resource allocation and enhance care resource availability in rural areas (Inokuchi, Sakamoto, Sun, Iwagami, & Tamiya, 2025).
6	An observational cohort study evaluating patient-scheduled primary care telemedicine and office visits for acute, high-risk conditions including cardiac,	Telemedicine accounted for 57.7% of all primary care visits. Rates of 7-day Emergency Department (ED) utilization were low	Downstream ED and hospital use are uncommon following primary care for potentially high-risk,

	gastrointestinal, neurologic, musculoskeletal, and head and neck issues. The sample consisted of 258,958 primary care visits by 239,240 adult patients, comparing telemedicine modalities (video and telephone) with in-person office visits.	overall, with cardiac visits having the highest rate at 4.8% and musculoskeletal having the lowest at 0.8%. There was less than a 1% absolute difference in ED use by visit modality for all condition types. Telephone visits were associated with slightly higher ED rates than video visits, but they were the timeliest option. The 7-day hospitalization rate was less than 1%.	time-sensitive conditions across office, telephone, and video visits. Telemedicine, particularly telephone visits, offers a highly timely, safe, and accessible option for acute care without substantially increasing ED utilization (Sax, Kene, Huang, Gopalan, & Reed, 2024).

Table 2 demonstrates that telemedicine plays a highly strategic and essential role in improving both access to and the quality of emergency healthcare services, particularly in regions with limited healthcare resources and infrastructure (Mulyadita, Sutanto, Fiqri, Setiawan, & Pattaik, 2025). A study by Atmaja et al. (2024) shows that the implementation of telemedicine in remote areas can significantly increase the number of emergency consultations, accelerate response times, and strengthen coordination between healthcare providers in the field and referral facilities. Through telemedicine, medical personnel are able to conduct remote clinical assessments accurately and in a timely manner, allowing patients to receive appropriate care without always needing to travel long distances to hospitals (Cortellaro et al., 2025), which further highlights its role in reducing disparities in healthcare access. Additionally, telemedicine video and tele-emergency consultation have proven effective in pediatric care, particularly in medication administration, while also helping to reduce the burden on referral hospitals and improve patient comfort (Marcin et al., 2024; Marcin et al., 2023). Overall, telemedicine functions as a vital communication and service tool that enhances the efficiency, safety, and sustainability of modern healthcare systems, and when synergized with immersive educational technologies and digital emergency systems such as video, Realistic Immersive Learning Environment (RILE), and SPGDT, it contributes to the development of a cohesive healthcare ecosystem by strengthening human resource capacity and improving operational efficiency toward more comprehensive and responsive national emergency healthcare services.

Despite the significant advantages highlighted in the literature, the widespread adoption of these digital technologies in emergency medical education and response systems faces substantial challenges, primarily concerning infrastructure. In many developing regions and rural areas, uneven internet connectivity, low bandwidth, and unstable power supplies severely hinder the real-time functionality required for telemedicine (audio-video) and GPS-integrated applications like "Sigap 24/7." Furthermore, the high initial capital required to procure advanced hardware, such as Virtual Reality headsets, haptic sensors, and high-fidelity manikins for RILE, poses a financial barrier for smaller educational institutions and local hospitals. Beyond technical and financial constraints, the transition to a fully digital ecosystem demands high digital literacy. Older generations of healthcare professionals may experience a steep learning curve or resistance to adopting new digital workflows, necessitating comprehensive and ongoing training. Finally, the integration of cloud-based data, AI, and continuous GPS tracking raises critical concerns regarding patient data privacy and cybersecurity, requiring robust regulatory frameworks to ensure that the digitalization of emergency systems remains both safe and equitable.

5. Conclusions

5.1. Conclusion

Based on the literature review, it can be concluded that the digital transformation of SPGDT initiated by the Ministry of Health of the Republic of Indonesia requires synergy between the improvement of human resource competencies and operational infrastructure in order to maximize the golden hour response. The skill gap in conventional emergency education can now be addressed through the

integration of educational videos and RILE such as VR, which enhance cognitive aspects as well as the psychomotor readiness of medical personnel through safe and repeated simulations. These competencies are then supported by a precise operational ecosystem that utilizes the "Sigap 24/7" application, GPS/GIS-based Command Center integration for real-time tracking, and telemedicine (audio-video) that expands access reach to remote areas. Thus, the strategic collaboration between educational technology and digital service systems creates a more inclusive, efficient, and responsive national healthcare service to ensure overall public safety.

5.2. Research Limitations

This study has limitations in the number of articles analyzed, so the results and discussion presented have not yet been able to fully represent real conditions comprehensively. Therefore, broader data coverage is needed.

5.3 Suggestions and Directions for Future Research

Future research is recommended to use experimental methods with a significant sample size while examining the impact of digital technology on clinical aspects in real settings. Furthermore, future studies must explore the integration of emerging technologies that will shape the next generation of emergency response. This includes the application of Artificial Intelligence (AI) and machine learning for predictive triage and automated dispatch decision-making. The potential of the Internet of Medical Things (IoMT), such as advanced wearable biometric sensors combined with 5G connectivity, should also be investigated to seamlessly transmit continuous, real-time patient data to the Command Center before an ambulance even arrives. Lastly, transitioning from simulation-based VR to the use of Augmented Reality (AR) in live clinical settings where paramedics can see digital overlays of critical patient data or remote specialist guidance directly in their field of vision during a rescue represents a crucial frontier for future exploration.

Author Contributions

All authors contributed to the preparation of this literature review. NMA, ANK, CNS played a central role in all stages of this study, including the conceptualization of the research, comprehensive literature analysis, and the drafting of the initial manuscript. In addition, RFT was responsible for refining the arguments, revising the content critically, and ensuring the overall coherence and quality of the final.

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