p-ISSN 2086-6380
e-ISSN 2548-7949

Jurnal Ilmu Kesehatan Masyarakat, Jul2022, 13(2):127-144
DOI: https://doi.org/10.26553/jikm.2022.13.2.127-144
Available online at http://ejournal.fkm.unsri.ac.id/index.php/jikm

TELEMEDICINE FOR EMERGENCY PATIENTS IN PRE-HOSPITAL CARE: A SCOPING REVIEW

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ABSTRACT

Pre-hospital care is the initial phase of emergency management for patients with acute conditions. Emergency patients' mortality rates can be lowered with appropriate pre-hospital care. The utilization of telemedicine has been increasing rapidly, and one of its applications is the provision of pre-hospital care. This study aimed to identify and evaluate published research on the use of telemedicine to facilitate emergency patient management in pre-hospital care. ProQuest, Scopus, EMBASE, and EBSCOhost databases were used for article search and PRISMA flow diagram was used to perform the articles selection. The search results obtained 443 articles. Title and abstract screening removed 347 articles, leaving 41 to be assessed for eligibility. Articles relevant to the study question and meet the criteria were 14 articles. Most of the studies were conducted in developed countries. The use of telemedicine has a significant potential to improve the quality of pre-hospital care provided to emergency patients, by aiding in diagnosis and treatment selection for patient's better outcomes. However, to establish this system, a well-organized Engine Management System (EMS) system is required. Nevertheless, the use of this technology requires more development, and additional study is required in the future.

Keywords: *emergency patients, pre-hospital care, telemedicine*

ABSTRAK

Perawatan pra-rumah sakit adalah fase awal manajemen emergensi untuk pasien dengan kondisi akut. Angka kematian pasien emergensi dapat diturunkan dengan perawatan pra-rumah sakit yang tepat. Pemanfaatan telemedisin telah meningkat pesat, dan salah satu penerapannya adalah penyediaan perawatan pra-rumah sakit. Studi ini bertujuan untuk mengidentifikasi dan mengevaluasi penelitian yang dipublikasikan tentang penggunaan telemedisin untuk memfasilitasi manajemen pasien emergensi dalam perawatan pra-rumah sakit. ProQuest, Scopus, EMBASE, dan EBSCOhost digunakan untuk pencarian artikel dan diagram alur PRISMA digunakan untuk melakukan pemilihan artikel. Hasil pencarian didapatkan 443 artikel. Penyaringan judul dan abstrak menyingkirkan 347 artikel, menyisakan 41 untuk dinilai kelayakannya. Artikel yang relevan dengan pertanyaan penelitian dan memenuhi kriteria sebanyak 14 artikel. Sebagian besar penelitian dilakukan di negara maju. Penggunaan telemedisin memiliki potensi yang signifikan untuk meningkatkan kualitas perawatan pra-rumah sakit yang diberikan kepada pasien emergensi, dengan membantu dalam diagnosis dan pemilihan pengobatan untuk keluaran pasien yang lebih baik. Namun, untuk membangun sistem ini, diperlukan Engine Management System (EMS) yang terorganisir dengan baik. Meskipun demikian, penggunaan teknologi ini membutuhkan lebih banyak pengembangan, dan studi tambahan diperlukan di masa depan.

Kata kunci: pasien emergensi, perawatan pra-rumah sakit, telemedisin

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Received : June 17, 2022 Accepted : August 2, 2022 Published: September 1, 2022

Introduction

Pre-hospital care is emergency medical care provided to patients prior to their arrival at a hospital after activation of emergency medical services, which includes not only clinical care but also planning, rescue competencies, and scene management skills.[1] Pre-hospital care refers to the treatment provided by first responders, such as community members, emergency physicians, emergency medical technicians, nurses, or paramedics, at the scene of an accident, at home, at school, or elsewhere before the patient is transported to a hospital.[2,3] Pre-hospital care patients are planned to be transferred to a hospital for further treatment, but "out-of-hospital" emergency care patients may not be.[4] In the last few decades, pre-hospital care has evolved considerably. This kind of care has evolved from an organization that primarily served the function of transporting patients to the closest emergency department (ED) to one that performs more in-depth examinations and judgments at an earlier stage in the delivery of medical assistance.[5] Emergency medical services (EMS), which provide pre-hospital care systems, are critical in improving the outcomes of acute conditions or acute exacerbations of chronic diseases. To provide pre-hospital care, a well-coordinated and integrated pre-hospital care system with people who are well-equipped and trained at dispatch centers, ambulance companies, hospitals, and specialty care facilities is needed.[6] The physical environments, mobility requirements, work processes, and types of patients treated in pre-hospital settings are vastly different from those in hospital settings.[7]

A lack of pre-hospital care, transportation, or both is responsible for the majority of early deaths from time-sensitive conditions such as cardiac arrest, stroke, sepsis, obstetric and pediatric emergencies. Trauma-related deaths may be reduced by 25% with pre-hospital care, and this reduction is amplified when it is paired with rapid in-hospital care.[4] EMS clinicians must perform more advanced patient assessments and interventions, as well as make decisions about the patient's level of care, including options such as staying at home with instructions on self-care, transferring to a primary care facility, or bypassing the ED for direct transport to a specialist assessment or treatment center. Pre-hospital care can also be provided in challenging locations, in all types of weather, 24 hours a day, and far from medical assistance.[7]

Telemedicine is becoming more popular, particularly in the wake of the COVID-19 pandemic. The World Health Organization (WHO) on March 11, 2020, declared the COVID-19 outbreak as a global pandemic. COVID-19 has posed a serious threat to the health-care system and society.[8] Some people have trouble accessing health treatments because of the government's social restrictions and the public's fear of catching COVID-19. As though in response to these problems, telemedicine is beginning to emerge as a viable option for certain patients.

Telemedicine is defined as the use of telecommunications technology to give health care services to a patient using videos, photos, radiology examination, physiological findings, or pathology reports which these patients are usually far away from the provider.[9] Mechanic *et al.*[10] defined telemedicine, telehealth's largest segment, as the practice of medicine via a remote electronic interface. According to WHO[11], telemedicine is the delivery of health care services by all health care professionals using information and communication technologies for the exchange of valid information for the diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and continuing education of health care providers, all to improve the health of individuals and communities. Providing clinical support, surmounting obstacles caused by geography, connecting remote users, involving various information and communications technology use, and improving health outcomes are four aspects of telemedicine that are important to consider.[11] Telemedicine has been utilized to minimize gaps in health-care services for many years.[9] Patient and practitioner reactions to enhanced telemedicine during the COVID-19 pandemic have been mostly positive.[12]

Telemedicine has increased health-care providers' ability to care for many individuals while not physically present. Telemedicine is expanding and becoming more valuable for the health-care system as information and technology advance. Telemedicine is a multidimensional approach to emergency care that may be used in both critical and non-critical conditions.[13,14] As emergency patients require a faster response to treatment to reduce morbidity or mortality, telemedicine might be an alternate option or even a solution for providing first care or treatment to emergency patients before their admission to the hospital. This scoping review aimed to identify and evaluate published research on the use of telemedicine for emergency patients in pre-hospital care.

Method

We conducted the scoping review using Arksey and O'Malley's methodological framework: (i) identifying the research question; (ii) identifying relevant studies; (iii) selecting the studies; (iv) charting the data; and (v) collating, summarizing, and reporting the results.[15] We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist to guide the article's selection for this scoping review. This review was guided by the question, "How telemedicine can facilitate emergency patient management in pre-hospital care?" We used the PCC (Population, Concept, and Context) elements (Table 1) to establish search strategies and formulate article review scoping questions.

Table 1. PCC (Population, Concept, and Context)

Population	Concept	Context
Emergency Patients	Telemedicine	Pre-Hospital Care

Four electronic databases were used to conduct a systematically wide search in March 2022: Health & Medical Collection (ProQuest), Scopus, EMBASE, and Medline (EBSCOhost). The inclusion and exclusion criteria in Table 2 were used to select the studies.

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Full text of published journal articles • Publication date 2017 to present • Studies from any geographical location • English language • Telemedicine in pre-hospital setting for diagnostics or early treatments on emergency patients before their arrival in emergency departments	• Non-peer reviewed literature • Conference proceedings • Studies related to non-emergency patients • Telemedicine for screening or monitoring purposes on non-acute patients with chronic diseases or postoperative surgical care

The search template and keywords for the electronic database search were attached in the Appendix. The search results were exported to the reference manager to remove duplicate articles. Following the removal of duplicate articles, the titles and abstracts were screened by the authors independently. Articles that did not meet the inclusion and exclusion criteria were excluded from the study. After that, we screened the articles through full-text reviews and extracted the results into Microsoft Excel to chart and summarize the data in table forms. The selection process is presented in Figure 1.

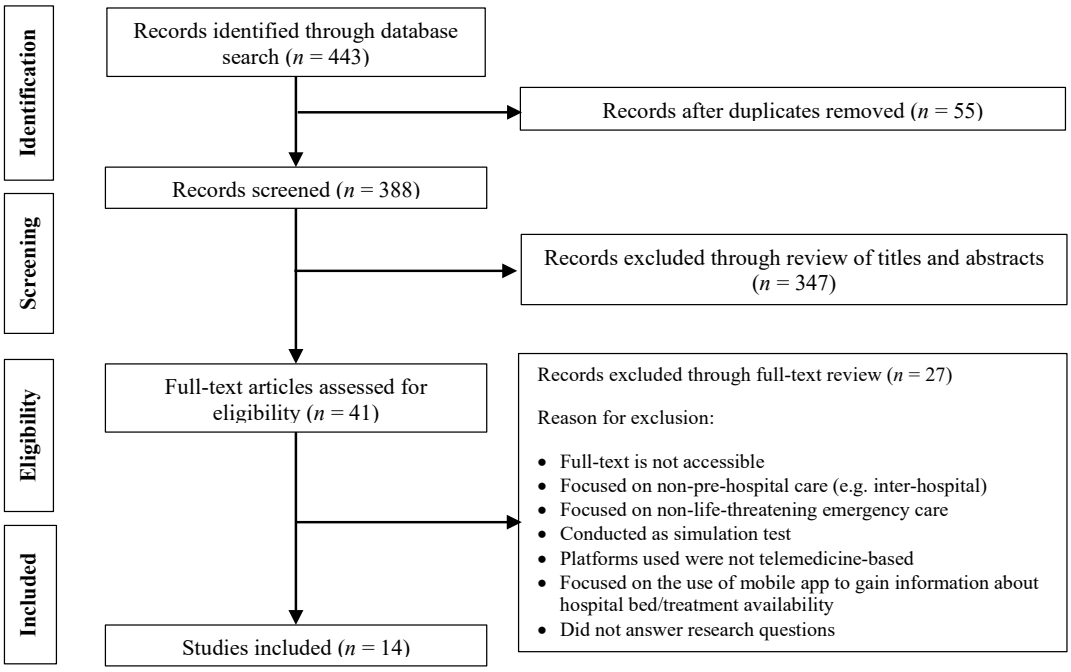

Figure 1. Flow chart for article selection based on PRISMA guidelines

Results

The search results obtained 443 articles, with 21 articles from Health & Medical Collection (ProQuest), 133 articles from Scopus, 252 articles from EMBASE, and 37 articles from Medline (EBSCOhost). A total of 55 duplicate articles were removed, and 388 articles were gathered for title and abstract screening. Full-text articles assessed for eligibility included 41 articles and 347 articles were excluded due to unsuitable title or abstract. Through the full-text review, a total of 27 articles were excluded because they did not meet the inclusion criteria or not accessible. Therefore, articles relevant to the study question and meet the criteria were 14 articles. The summary of the included studies is shown in table 3.

Table 3 below, show that the included studies were published in 2021 (n=7), 2020 (n=3), 2019 (n=3), 2018 (n=1), and 2017 (n=1) and conducted in Germany (n=6), United States of America (n=2), Australia (n=1), Denmark (n=1), Hong Kong (n=1), Iran (n=1), Ireland (n=1), and Netherlands (n=1). Most of the countries that have implemented telemedicine for pre-hospital care in included studies are developed countries. Types of study design used were observational study (n=5), cohort study (n=4), cross-sectional study (n=1), editorial (n=1), case-control study (n=1), prospective feasibility study (n=1), and systematic review (n=1).

Pre-hospital care for cardiovascular disease was discussed in 6 articles, where the stroke was discussed in 3 articles[17,24,27], ST-elevation myocardial infarction (STEMI) was discussed in 2 articles[20,26], and unspecified cardiovascular disease was discussed in 1 article.16 According to a 2021 WHO report, noncommunicable diseases (NCDs) account for 71% of all deaths worldwide. The most prevalent noncommunicable diseases are cardiovascular disease (e.g., strokes and heart attacks), chronic respiratory diseases (e.g., asthma and chronic obstructive pulmonary disease), diabetes, and cancer. The implementation of NCD management strategies is essential to the achievement of both the worldwide aim of a 25 percent relative decline in premature deaths due by NCDs by 2025 and the Sustainable Development Goal (SDG) target of a 33 percent drop by 2030 (Table 3).[30]

Other emergency conditions discussed in included studies were pain-related diseases (n=1)[22], pediatric difficult airway (n=1)[23], and unspecified emergency conditions (n=5)[18,19,21,25,28]. Videoconferencing technology connected to other diagnostic tools was most often used for pre-hospital care (n=10), while pre-hospital ECG (n=2) was used for cardiac problems such as STEMI.[20,26] One of the included studies performed a stroke checklist, which was then transmitted using devices that did not use video technology (Table 3).[24]

Table 3. The summary of the included studies

#	Author	Country, Year	Type of Study	Aims of Study	Telemedicine method	Result
1	de Koning *et al.* [16]	Nether-lands, 2021	Cohort study	To identify the number of patients who did not transport to ED with usual ambulance care as compared with the new pre-hospital triage method entitled Hollands-Midden Acute Regional Triage- Cardiology (HART-c)	Telemedicine is used in a triage method for cardiac patients, which combines paramedic assessment (medical history, physical exam, vital signs, ECG measurements) and expert cardiologist consultation. Live monitoring, hospital data, and real-time admission capacity were used to figure out if admission was needed and, if so, which hospital would be best.	The HART-c triage method is effective in safely reducing unnecessary Emergency Department visits of patients with all types of cardiac complaints, but the cost-effectiveness was not evaluated
2	Geisler *et al.* [17]	Germany, 2019	Cohort study	To investigate the technical feasibility, stability, and acceptability of the audio-visual connection between the Stroke Emergency Mobile (STEMO) and a remote destination, as well as to determine the accuracy and dependability of the onsite and remote neurologist's assessments and treatment decisions.	Integrated with STEMO, a mobile stroke unit (MSU) in Berlin. For videoconferencing and radiography, the telemedicine platforms (Vimed vehicle on STEMO and Vimed Doc at the hospital) were used by the STEMO neurologist to call the remote neurologist.	It is technically feasible to perform remote acute stroke assessment in an MSU using telemedicine, which includes video examination and treatment decisions. The audio-visual quality of the connection is sufficient, and there is a high degree of interrater reliability between the onboard and remote neurologists. Patients who were treated by neurologists aboard an MSU had shorter alarm-to-needle durations and a tendency toward a better functional result
3	Linderoth *et al.* [18]	Denmark, 2021	Cohort study	To assess the change of responses and change of assessments in time-critical conditions to avoid delayed emergency response using live video added to the emergency call	Live video was added to emergency calls by sending a text message link to the caller's smartphone using GoodSAM application. The link was deactivated once the emergency call had been completed.	Adding live video succeeded in 82.2% of attempted video transmissions. The dispatchers' assessment of the patients' conditions changed in 52.1% of the calls, which led to a different emergency response in 27.5% of the cases after getting the video in comparison to calls without video. In 9.9% of the cases, a different disease or injury was found, and in 28.4% of the cases, cardiopulmonary resuscitation, airway obstruction, or patient positioning were improved.
4	Schröder *et al.* [19]	Germany, 2021	Cohort study	To analyze the performance of EMS missions with telemedical consultations for life-threatening conditions and to determine if the participation of a tele-EMS physician provides benefits to patients.	Every ambulance has a mobile communication unit attached to the defibrillator monitor that allows real-time data transmission of audio, data on vital signs, smartphone photos from the scene, video streaming from ambulance camera, and GPS coordinates for location tracking. The tele-EMS physician can see all	Consulting with a tele-EMS doctor can significantly improve the patient's vital parameters in a life-threatening situation

#	Author	Country, Year	Type of Study	Aims of Study	Telemedicine method	Result
					the information that has been provided to the teleconsultation center. The teleconsultation center receives all transmitted data and then provides it to the tele-EMS physician	
5	Cheung *et al.* [20]	Hong Kong, 2018	Observational study	To compare D2B (door-to-balloon) data from group of patients with STEMI who were transported by ambulance with pre-hospital ECG and without pre-hospital ECG, whether by ambulance or with self-arranged transport	Pre-hospital 12-lead ECG was performed for patients with chest pain, and the result was tele-transmitted to attending physicians at the accident and emergency department for immediate interpretation. ED staff were contacted by laptop alarm, fax, email, and an ambulance crew phone call. If STEMI was suspected, the on-call cardiologist was called, and equipment was arranged immediately before patient arrival in ED	The mean D2B time for STEMI patients with pre-hospital ECG (93 minutes), significantly shorter (p=0,003) than for STEMI patients transported without pre-hospital ECG by ambulance (112 minutes) or with self-arranged transport (138 minutes), but no statistically significant difference in 30-day mortality score
6	Felzen *et al.* [21]	Germany, 2019	Observational study	To evaluate the utilization, safety, and technical performance of telemedical emergency service	The tele-EMS physician uses voice communications and is provided with instant access to the vital information about the patient as well as the ambulance's GPS coordinates. Paramedics can instantaneously send pictures and broadcast the video from the inside of the ambulance to the tele-EMS physician.	This telemedical emergency service is a regularly utilized, safe, and technically dependable solution that might ease mobile EMS doctors' burden so they can concentrate on life-threatening emergencies.
7	Lennsen *et al.* [22]	Germany, 2017	Case-control study	To assess the quality of analgesia and the occurrence of serious adverse effects in paramedics' telemedically assisted pre-hospital care.	Two-way voice, real-time vital data, still image, 12-lead ECG and real-time video streaming from inside the ambulance were developed utilizing encrypted data and audio transfer using mobile and in-car data transmission units. When analgesia was needed, the teleconsultation center's workstation could display the Standard Operating Procedure (SOP) that had been taught to EMS personnel to assist the tele-EMS physician in deciding on a treatment strategy.	Telemedically-delegated analgesia resulted in acceptable pain relief equivalent to that provided by pre-hospital EMS doctors. Teleconsultation was determined to be safe, with only minor complications due to analgesia identified in both groups
8	Dalesio *et al.* [23]	USA, 2019	Editorial	To describe telemedicine use for an online pediatric difficult airway response team (pDART).	The pDART uses video laryngoscopic devices, glasses with camera technology, and portable devices or tablet applications to provide privacy-protected and Health Insurance Portability and Accountability Act (HIPAA)-compliant two-way audio communication, and trained pediatric airway experts.	Telemedicine allows instant expert consultation and improves pediatric airway management patient outcomes.
9	Eder *et al.* [24]	Germany, 2021	Observational study	To examine the impact of telemedical prenotification of hospital stroke team (Stroke Angel) in hospital time targets compared to standard of care	All 12 ambulances were equipped with portable devices that allowed them to complete stroke checklists and wirelessly send examination findings and patient data to a nearby hospital for pre-notification and check-in.	Stroke Angel using telemedicine improves the odds of systemic thrombolytic therapy use as compared with a conventional prenotification workflow protocol by reducing in-hospital delays

#	Author	Country, Year	Type of Study	Aims of Study	Telemedicine method	Result
10	Gilligan *et al.* [25]	Ireland, 2021	Prospective feasibility study	To evaluate the obstacle found in the development of a mobile audio-visual pre-hospital telemedicine part of the European Comission funded by LiveCity project	A backpack which consists of a head-mounted contour camera, earpiece, and microphone was used in pre-hospital telemedicine. Data was transmitted using a 3G modem	Challenges were found both in software and hardware suitability, durability, and reliability. High quality mobile video link between the paramedic and ED was unable to perform under 3G network
11	Saberian *et al.* [26]	Iran, 2020	Cross-sectional study	To compare the mortality and morbidity rates of STEMI patients undergoing primary percutaneous coronary intervention (PPCI) with and without pre-hospital ECG and EMS transfer	EMS obtained a pre-hospital ECG and sent it to a cardiologist. Patients with STEMI confirmed by the cardiologist were sent directly to the catheterization laboratory rather than the emergency department (ED)	Pre-hospital telecardiology reduced the probability of 6-month mortality in STEMI patients undergoing PPCI by cutting the time between the first medical contact and the balloon time. Pre-discharge LVEF and in-hospital mortality rates were unaffected
12	Al Kasab *et al.* [27]	USA, 2021	Observational study	To assess the feasibility and efficacy of using a video-based telestroke consults in the emergency medical services unit (TEMS) in a large, established telestroke network	EMS units are equipped with video-conferencing technology between EMS, telestroke provider and local emergency department (ED) provider. Patients are evaluated in the field for eligibility for intravenous alteplase (tPA) or mechanical thrombectomy (MT) by a stroke expert via video or phone call, and then transported to the nearest stroke center (NSC) for tPA or immediately to a comprehensive stroke center (CSC) for MT.	TEMS using video-based telestroke consultation is feasible and could significantly reduce door-to-needle time. Video-based communications are preferable than phone-based consults, allowing doctors to check patients remotely and make better decisions about acute stroke patients' destination and management plan.
13	Bergrath *et al.* [28]	Germany, 2021	Observational study	To assess the systemic consequences of a large-scale pre-hospital telemedicine system and its installation process.	After personal assessment was done by paramedics on-scene, decision about need of telemedicine is made. All real-time vital parameters (values and curves), 12-lead ECG, and still pictures were sent to the telemedicine center. EMS Physician started real-time video transmission via camera attached in the ambulance. Further instruction and medication were informed via telecommunication	In the 1 year after implementation phase, the total number of doctor-led pre-hospital interventions went from 7882 to 8707.
14	Kim *et al.* [29]	Australia, 2020	Systematic Review	To examine telemedicine's decision support capabilities during pre-hospital care and whether decisions made help patients.	Telemedicine with the capability of real-time data transferring and video-enabled communication	Pre-hospital decision-making for diagnosis, life-saving measures, and hospital destination can all be aided by telemedicine. Paramedic skill level, patient severity, and technical challenges on platforms may complicate pre-hospital treatment decisions facilitated by pre-hospital telemedicine.

Discussion

One of the important parts of managing emergency or acute conditions is a quick and accurate diagnosis.[31] In patients with stroke, myocardial infarction, septicemia, or pneumonia, time to effective therapy is a major determinant of prognosis.[32] Kim *et al.*[29] found that remote expert consultation helped make accurate pre-hospital diagnoses using vital signs and image transfers. Vital signs are indicators of certain diseases such as infection, respiratory problems, and heart diseases. According to Schröder *et al.*[19], about two-thirds of patients with life-threatening vital signs can be treated via teleconsultation in the pre-hospital setting, and this is frequently done without the use of invasive procedures. If necessary, advanced airway management such as intubation can be aided with telemedicine using additional devices like Google Glass incorporated with video laryngoscope and two-way audio-visual for expert consultation.[23]

After conducting patients' medical condition and history assessment, physical examination with vital sign monitoring, and other diagnostic procedures, EMS paramedics can either tele-transmit the result to a physician and get notified with text or audio for further advice for diagnosis or therapy[24], or use audio and video features where they can connect virtually to physicians.[16–19,22,24,25,27] Catapan *et al.*[33] found that video teleconsultation has numerous benefits. A few of the benefits are the ability to diagnose accurately, similar to face-to-face, the ability to deliver care without moving the patient, and the ability to adapt to current time constraints for health care. Despite the benefits, there are some drawbacks to employing video-based technology, including the inability to perform a physical examination on the patient, technical difficulties, and a lack of precision in clinical practice. These difficulties can be overcome if physicians have access to well-trained personnel and electronic equipment like stethoscopes and high-definition cameras for viewing inside organs and cavities.[33] However, Kim *et al.*[29] found that medical direction by telephone is somehow more favored in certain conditions, as using telemedicine adds more workload than simply requesting a telephone consultation.

A 12-lead ECG is a medical device that is mostly needed for diagnostic tools for pre-hospital care due to the high mortality of cardiovascular disease. Pre-hospital 12-lead ECG should be obtained early for patients with potential acute coronary syndrome, according to the American Heart Association.[20] Performing pre-hospital ECG and transmitted the result for further evaluation by the emergency department's physician can reduce the time from door to balloon for STEMI patients transported by ambulance with pre-hospital 12-lead ECG tele-transmitted to the emergency department.[20] The method for delivering ECG results from EMS paramedics to a physician or cardiologist may vary according to the telemedicine platforms. A monitor or defibrillator monitor can be used to tele-transmit ECG from ambulances for interpretation by a physician.[16,20] The advantage of

using a monitor that can tele-transmit ECG is that if there is any new change in the ECG, consultation or treatment for this condition can be started immediately.[20]

Another advanced pre-hospital technology is the Mobile Stroke Unit (MSU) for stroke-suspected emergency patients. MSU is a specially designed ambulance featuring a computed tomography (CT) scanner, a point-of-care lab, and stroke medicine. MSU's cost-effectiveness could be improved through telemedicine-linked remote experts that replace physicians on board.[34] Stroke Emergency Mobile (STEMO) in Geisler *et al.* study[17] used telemedicine to connect the MSU to a remote neurologist. The diagnosis result was satisfactory, and the difference in diagnosis and therapy between onboard and remote neurologists was minimal.[17] This finding is consistent with research conducted by Wu *et al.* in the United States, which found significant agreement between telemedicine and onboard vascular neurologists.[34]

EMS quality for pre-hospital care is also determined by how they respond to emergency calls from people who have experienced a medical emergency.[35] GoodSAM, a telemedicine-based application proposed by Linderoth *et al.*[18], connected EMS and bystanders using live videos. A 38.2% improvement in the paramedics' assessment occurred after the live videos. This could make it easier for hospitals to care for patients in the future with better health outcomes.[18] Bystander intervention without clear medical team instruction is thought to increase the risk of the patient's health outcome, particularly in trauma patients.[36] Therefore, having the ability to use telemedicine technology to give instruction to bystanders might be beneficial.

The occurrence of adverse events, mortality, and morbidity are the outcomes to consider after using telemedicine. Felzen *et al.*[21] reported the safety of telemedicine systems for pre-hospital emergency care. Only 0,09% of patients experienced adverse events after receiving tele-delegated high-alert drugs.[21] Lenssen *et al.*[22] analyzed the quality of analgesia administered through telemedicine by physician in pre-hospital emergency care. Telemedicine-delegated analgesia posed no patient safety issues. No severe adverse effects were observed. All the adverse events that occurred could be resolved immediately with teleconsultation with the physician.[22]

Saberian *et al.*[26] assessed the impact of pre-hospital telecardiology on mortality and morbidity in STEMI patients receiving primary percutaneous coronary intervention. Patients who were referred after pre-hospital telecardiology had significantly lower 6-month mortality compared to those without pre-hospital telecardiology. However, in-hospital mortality was similar in both groups. By cutting the time from the door to the drug by 10 minutes and the time from the door to the balloon by 15–20 minutes, mortality and morbidity could be reduced.[26] These findings are similar with what Kim *et al.*[29]

discovered in their investigation, which identified no problems or safety concerns during or after telemedicine intervention.

Some challenges in the development of this new system have already been identified by some researchers, such as the hardware and network components problems (overheating), tendency to break or disconnect devices due to transportation, unstable connection, and missed opportunity to improve patients' condition due to insufficient guidelines and evidence to support the program. The system costs of telemedicine projects for hardware, machine installation, software configuration, and program maintenance also need to be considered. Emergency medical services were also found to not increase the chance of receiving notification through telemedicine.[24,25]

The current telemedicine use in Indonesia is provided in telemedicine-based applications and websites such as Klik Dokter, Alodokter, Halodoc, and many more. Those applications are also integrated with the government application, PeduliLindungi.[37] Since the COVID-19 outbreak, Indonesian hospitals have also begun to offer telemedicine services in order to increase the accessibility of health care. According to Katadata (2021) in the study by Alexandra *et al.*[38], 20% of Indonesian hospitals have already offered clinical teleconsultation services. However, the use of telemedicine in Indonesia is mostly for non-emergency patients as emergency patients need to be referred to health care facilities.[38]

Most of the included studies above were conducted in developed countries; the only developing country is Iran. As Indonesia is also a developing country like Iran, pre-hospital telemedicine method by Saberian *et al.*[26] in Iran might be applied in Indonesia. In the Saberian *et. al* study, the EMS obtained a pre-hospital ECG and sent it to a cardiologist. Patients with STEMI confirmed by the cardiologist were sent directly to the catheterization laboratory rather than the emergency department (ED).[26] Indonesia, on the other hand, lacks a well-organized EMS system. Ambulance service can be provided by primary health-care centres or hospitals but not every primary health-care centers or hospitals' ED can provide emergency care. Indonesia has launched the 119 Emergency Medical Service (EMS) for pre-hospital care in 2016, however it has faced various obstacles in its implementation, including a lack of infrastructure and resources.[39] Ambulances in Indonesia are mostly utilized for referrals or interhospital transfers rather than for emergency response. Patients who know about the ambulance service choose hospital care over waiting for an ambulance because of its long waiting times and ambulance costs.[40]

Indonesia needs to improve the EMS system before applicating telemedicine for emergency patients in pre-hospital care. The ambulance must be equipped with an ECG that can be used by EMS personnel. EMS personnel should also be given access to communicate with the hospital network

through the hospital's SPGDT (Sistem Penanggulangan Gawat Darurat Terpadu or Integrated Emergency Management System) and send the patients' medical history, vital signs, and ECG result using telemedicine via digital application such as Whatsapp. In order for this method to work, the 119 (EMS) should conduct cooperation agreements with several government hospitals to ensure a faster and better hospital response. After ensuring the communication between the EMS personnel and hospital can properly be established, EMS personnel can also be given access to get medical advice needed for the patient, such as administering analgesia like in the Lenssen *et al.*[22] studies.

Our study was conducted to show that telemedicine can be used for pre-hospital emergency care and that various methods can be applied for the usage of telemedicine. This study is subject to pre-hospital emergency telemedicine in any geographical location and not specified in Indonesia, thus, further study specifically for pre-hospital emergency telemedicine in Indonesia can be conducted, especially on the aspect of emergency medical services.

Conclusion

Telemedicine has a significant potential to support pre-hospital care for emergency patients in diagnosing and selecting treatment for patient's better outcomes. However, the application of telemedicine is still in early stage and there are various kinds of method and technology is being used. Most of the use of pre-hospital emergency telemedicine is for consultations between EMS personnel and physicians in health care facilities where the factors that determine the smoothness of this communication are the technology used and the system that must be qualified so that two-way communication can run well. Studies also showed that telemedicine works well in developed countries where EMS systems, equipment, and facilities are well-established. In developing countries such as Indonesia, the use of telemedicine for pre-hospital emergency care needs to be supported by well-organized EMS first before establishing the pre-hospital telemedicine system. The need of future research is certain to seek the requirements in technology and other resources in implementation of this system in any kinds of clinical situation. Also, more definitive measures should be used in future research of this technology.

Acknowledgement

The authors thank the Department of Health Policy and Administration, Faculty of Public Health, Universitas Indonesia, especially Professor Adik Wibowo as Publication Lecturer, for supporting this study.

Funding

There was no funding received from any external source for this review, writing, or publication of this paper.

Conflict of Interest

The authors declare no conflict of interest in writing this article.

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APPENDIX

Table 1. Search Template

		Population	Concept	Context
Key concepts		**Emergency patients**	**Telemedicine**	**Pre-hospital care**
Free text terms / natural language terms (synonyms, medical terms, abbreviations, acronyms, and more specific search terms)		Emergency patient ; medical emergency patient ; emergency ; emergencies	telehealth ; tele-emergency OR teleemergency ; ehealth ; e-health ; mhealth ; m-health ; mobile health ; digital health ; virtual medicine	pre-hospital care ; pre-hospital care ; pre-hospital setting ; pre-hospital setting ; pre-hospital emergency care ; pre-hospital emergency care ; pre-hospital patient care ; emergency medical services
Medline (EBSCO)	**Controlled vocabulary terms** (MeSH)	(MM "Emergencies"	(MM "Telemedicine+")	(MM "Emergency Medical Services+")
	Keyword statement	AB (“emergency patient*” OR “medical emergency patient*” OR “emergenc*”) OR TI (“emergency patient*” OR “medical emergency patient*” OR “emergenc*”)	AB (“telemedicine” OR “telehealth” OR “tele-emergency” OR “teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”) OR TI (“telemedicine” OR “telehealth” OR “tele-emergency” OR “teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”)	AB (“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting” OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services”) OR TI (“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting” OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services”)
Health & Medical Collection (ProQuest)	**Controlled vocabulary terms** (MeSH)		MESH.EXACT("Telemedicine")	MESH.EXACT("Emergency Medical Services")
	Keyword statement	ab(“emergency patient*” OR “medical emergency patient*”	ab(“telemedicine” OR “telehealth” OR “tele-emergency” OR	ab(“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting”

		Population	Concept	Context
		OR “emergenc*”) OR ti(“emergency patient*” OR “medical emergency patient*” OR “emergenc*”)	“teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”) OR ti(“telemedicine” OR “telehealth” OR “tele-emergency” OR “teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”)	OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services") OR ti(“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting” OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services")
EMBASE	**Controlled vocabulary terms** (Emtree)	'emergency patient'/exp	'emergency patient'/exp	'emergency care'/exp
	Keyword statement	'emergency patient*':ab,ti OR 'medical emergency patient*':ab,ti OR 'emergenc*':ab,ti	'emergency patient*':ab,ti OR 'medical emergency patient*':ab,ti OR 'emergenc*':ab,ti	'pre-hospital care':ab,ti OR 'pre-hospital care':ab,ti OR 'pre-hospital setting':ab,ti OR 'pre-hospital setting':ab,ti OR 'pre-hospital emergency care':ab,ti OR 'pre-hospital emergency care':ab,ti OR 'pre-hospital patient care':ab,ti OR 'emergency medical services':ab,ti
Scopus	**Keyword statement**	TITLE-ABS-KEY ("emergency patient*" OR "medical emergency patient*" OR "emergenc*")	TITLE-ABS-KEY ("telemedicine" OR "telehealth" OR "tele-emergency" OR "teleemergency" OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "digital health" OR "virtual medicine")	TITLE-ABS-KEY ("pre-hospital care" OR "pre-hospital care" OR "pre-hospital setting" OR "pre-hospital setting" OR "pre-hospital emergency care" OR "pre-hospital emergency care" OR "pre-hospital patient care" OR "emergency medical services")

Table 2. Keywords for electronic database search

Database	Search String	Result
Medline (EBSCO)	((MM "Emergencies") OR AB (“emergency patient*” OR “medical emergency patient*” OR “emergenc*”) OR TI (“emergency patient*” OR “medical emergency patient*” OR “emergenc*”)) AND ((MM "Telemedicine+") OR AB (“telemedicine” OR “telehealth” OR “tele-emergency” OR “teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”) OR TI (“telemedicine” OR “telehealth” OR “tele-emergency” OR “teleemergency” OR “ehealth” OR “e-health” OR “mhealth” OR “m-health” OR “mobile health” OR “digital health” OR “virtual medicine”)) AND ((MM "Emergency Medical Services+") OR (MM "Emergency Medical Services+") OR AB (“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting” OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services”) OR TI (“pre-hospital care” OR “pre-hospital care” OR “pre-hospital setting” OR “pre-hospital setting” OR “pre-hospital emergency care” OR “pre-hospital emergency care” OR “pre-hospital patient care” OR “emergency medical services”)) **Limiters** - Full Text; Date of Publication: 20170101-20221231; English Language; Scholarly (Peer Reviewed) Journals	**37**
ProQuest (health & medical)	((ab(("emergency patient" OR "emergency patients") OR "medical emergency patient*" OR "emergenc*") OR ti(("emergency patient" OR "emergency patients") OR "medical emergency patient*" OR "emergenc*")) AND (MESH.EXACT("Telemedicine") OR (ab("telemedicine" OR "telehealth" OR "tele-emergency" OR "teleemergency" OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "digital health" OR "virtual medicine") OR ti("telemedicine" OR "telehealth" OR "tele-emergency" OR "teleemergency" OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "digital health" OR "virtual medicine"))) AND (MESH.EXACT("Emergency Medical Services") OR (ab("pre-hospital care" OR "pre-hospital care" OR "pre-hospital setting" OR "pre-hospital setting" OR "pre-hospital emergency care" OR "pre-hospital emergency care" OR "pre-hospital patient care" OR "emergency medical services") OR ti("pre-hospital care" OR "pre-hospital care" OR "pre-hospital setting" OR "pre-hospital setting" OR "pre-hospital emergency care" OR "pre-hospital emergency care" OR "pre-hospital patient care" OR "emergency medical services")))) AND (stype.exact("Scholarly Journals") AND la.exact("ENG") AND pd(20170101-20221231) AND PEER(yes))	**21**
Scopus	(TITLE-ABS-KEY ("emergency patient*" OR "medical emergency patient*" OR "emergenc*")) AND (TITLE-ABS-KEY ("telemedicine" OR "telehealth" OR "tele-emergency" OR "teleemergency" OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "digital health" OR "virtual medicine")) AND (TITLE-ABS-KEY ("pre-hospital care" OR "pre-hospital care" OR "pre-hospital setting" OR "pre-hospital setting" OR "pre-hospital emergency care" OR "pre-hospital emergency care" OR "pre-hospital patient care" OR "emergency medical services")) AND PUBYEAR > 2016 AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j"))	**133**
Embase	('emergency patient'/exp OR 'emergency patient*':ab,ti OR 'medical emergency patient*':ab,ti OR 'emergenc*':ab,ti) AND ('telemedicine'/exp OR 'telemedicine':ab,ti OR 'telehealth':ab,ti OR 'tele-emergency':ab,ti OR 'teleemergency':ab,ti OR 'ehealth':ab,ti OR 'e-health':ab,ti OR 'mhealth':ab,ti OR 'm-health':ab,ti OR 'mobile health':ab,ti OR 'digital health':ab,ti OR 'virtual medicine':ab,ti) AND ('emergency care'/exp OR 'pre-hospital care':ab,ti OR 'pre-hospital care':ab,ti OR 'pre-hospital setting':ab,ti OR 'pre-hospital setting':ab,ti OR 'pre-hospital emergency care':ab,ti OR 'pre-hospital emergency care':ab,ti OR 'pre-hospital patient care':ab,ti OR 'emergency medical services':ab,ti) AND [article]/lim AND [english]/lim AND [2017-2022]/py	**252**