ORIGINAL ARTICLE

EMS System Performance for Sudden Cardiac Arrest in Malang - Indonesia

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ABSTRACT

Introduction: Sudden cardiac arrest (SCA) represents a significant public health challenge characterized by a high mortality rate. Timely resuscitation is essential for survival, highlighting the critical role of the emergency medical services (EMS) system in improving patient outcomes. This study aims to examine the performance of the EMS system in managing SCA cases in Malang, Indonesia, with a focus on identifying the factors that contribute to limitations in its effectiveness. **Materials and methods:** This study evaluates the performance gaps of the EMS system based on key interventions outlined by the Global Resuscitation Alliance (GRA). A qualitative design was employed, involving nine key informants, with data collected through observations, supporting documentation of all SCA cases managed by EMS, and interviews. Thematic analysis was used to identify key themes, with data analyzed through reduction, presentation, and conclusion drawing. **Results:** Time metrics recording recommended by GRA had not been completely implemented because lack of protocol and evaluation by the department resulted in officers' doubts in recording. The GRA performance metrics had never been put into practise because lack of equipment and knowledge resulting in lacking of confidence of the officer in carrying out life support measures. **Conclusion:** A gap analysis of the GRA key elements for EMS revealed limitations in the EMS system's performance in managing prehospital SCA cases in Malang, Indonesia. Improvement strategies are necessary to enhance EMS effectiveness and achieve a higher survival rate for SCA patients.
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INTRODUCTION

Sudden cardiac arrest (SCA) is the most dramatic event that may be experienced in the community. With a sudden loss of consciousness accompanied by an irregular heartbeat and even complete disappearance, most patients will die within 10 minutes if immediate help is not given. In dealing with cases of SCA, the role of society in the community supported by a good prehospital service system is the most important factor in improving patient survival considering that SCA can occur at any time and anywhere (1–5).

According to the American Heart Association (AHA) (2019), there are at least 2 million deaths worldwide due to cardiac arrest. In Indonesia, the Indonesian Heart Association reported in 2016 that SCA incidents range from 300,000 to 350,000 annually, with numbers increasing each year. SCA remains a significant issue with a high mortality rate. However, studies show that survival rates have improved over the past 40 years, particularly for patients who receive immediate cardiopulmonary resuscitation (CPR). Data from tertiary hospitals in Malang City (2021-2022) shows that out of 62 SCA patients, 28 were already deceased on arrival, and 34 received resuscitation, resulting in a mortality rate of 96.77%. The survival rate for Out of Hospital Cardiac Arrest (OHCA) patients in Malang City from 2015-2022 was only 1.8% (2,3,5,6).

Knowledge and education about the management of cardiac arrest patients have been extensively provided to health workers. However, SCA events often occur in the community, where a system is needed to improve patient survival rates. In 2015, prehospital care leaders, researchers, and global experts convened to address the challenge of reducing community-based cardiac arrest mortality. This meeting resulted in the development of agreements outlining 10 programs and 10 steps to

enhance outcomes of OHCA. Subsequently, in 2016, the Global Resuscitation Alliance (GRA) was formally established (1,3,7).

The management of SCA cases in Indonesia prior to the implementation of Health Regulation No. 19 of 2016 was entirely reliant on hospital-based services. Although advancements have since been made, particularly in Malang City—a region experiencing significant progress in the development of the Public Safety Center (PSC) 119—the reliance on hospital services remains a notable factor. PSC 119 Malang City is the first official emergency medical service established by the Indonesian government in Malang City, which had previously relied on volunteer-operated ambulances. With a population of 847,182 in 2023, volunteer ambulances were unofficial and did not employ healthcare professionals, making it difficult to accurately estimate their numbers.

In contrast, PSC 119 operated with three ambulances during 2021-2022, with one or two ambulances available to serve the community during each shift. Most of the handling of OHCA cases still depends on hospital services. It cannot be denied that our pre-hospital services, especially in management of cardiac arrest cases, have been lagging behind for more than 20 years. The development of PSC 119 Malang City services, which was established in mid-2018, was significantly disrupted by the two-year pandemic but began to recover and progress steadily once the pandemic subsided.

This study aims to identify areas for improvement based on the EMS service indicators, including time metrics and performance metrics, established during the GRA meeting and identify the factors that contribute to limitations in it's effectiveness. The findings are expected to enhance the effectiveness of pre-hospital service providers, particularly in the management of SCA cases, to achieve better outcomes in the future.

MATERIALS AND METHODS

Theoretical framework and study design

This study presents a descriptive, qualitative analysis of the emerging pre-hospital system in Malang City, Indonesia. The absence of a well-established basic emergency service infrastructure is the primary reason for conducting the data analysis, which is based on the key interventions outlined by the GRA, this study evaluates these measures within the framework of system factors affecting survival outcomes in cases of OHCA.

These system factors are categorized into two main frameworks: time metrics and performance metrics. The time metrics include the recording of dispatch activation time, ambulance underway time, EMS on-scene time, and EMS at the patient site time. The performance metrics focus on bystander/telephone-CPR, EMS-CPR, EMS high-performance (HP)-CPR, and EMS defibrillation. These system factors influencing survival from OHCA emphasize the importance of timely application of critical interventions, as recommended by the GRA, which serve as key determinants of cardiac arrest outcomes.

Setting and Samples

This research was conducted at PSC 119 Malang City, using data from SCA patients transported to tertiary hospitals in Malang. Established in 2017, PSC 119 Malang City is an integrated emergency service unit with 30 personnel, including 10 healthcare workers and 20 non-healthcare workers. They handle approximately 200 emergency calls per month, many of which involve SCA cases. The research focused on PSC 119 employees who worked between 2021-2022 and were involved in managing SCA cases, with inclusion criteria requiring them to have received Basic Life Support (BLS) training either through in-house training or certified training from an accredited institution.

A total of nine informants met the inclusion criteria and were interviewed for this study. The informants consisted of two individuals currently holding positions as call takers at PSC 119 Malang City, two drivers and five healthcare professionals involved in patient management. Intensive research was conducted from June to July 2023.

Some personnel at PSC 119 Malang City are volunteers. Due to limited resources, task overlap frequently occurs. Interviews with the call takers were expected to provide insights into the recording of time metrics. During times of high patient demand, emergency patient pickups are often handled by just one driver and one healthcare worker, making the driver's role critical during CPR.

Certain personnel at PSC 119 were excluded from the interviews because their working period did not align with the study's inclusion criteria. Additionally, some staff members were unable to provide evidence of prior BLS training.

Measurement and data collection

Data collection was carried out through interviews, observations, and document review. Basic data was gathered by analyzing supporting documents, such as the OHCA registry and PSC 119 Malang City records, to identify system gaps, which were then presented in tables. A semi-structured interview guide was created and pilot-tested for clarity. The questions were designed based on key interventions outlined by the GRA and included open-ended questions with follow-up probes on challenges and limitations in the field. Interviews took place in person at the PSC 119 Malang City office and continued until data saturation was reached, defined as the point where no new concepts emerged after three consecutive interviews. Saturation was achieved after nine interviews. All interviews were audio-recorded,

transcribed, and supplemented with field notes.

Data analysis
Data analysis in this study was done in two stages. First, document data were analyzed descriptively and compared with established standards to identify gaps and weaknesses.

The interview transcripts were analyzed using thematic analysis in three steps: data reduction, data presentation, and conclusion drawing. In data reduction, irrelevant information was summarized or removed. The data were then presented to assess whether they accurately reflected the situation and guided necessary actions. In the final step, key themes and connections were identified, discussed with the research team, and revised based on input. A summary of these themes was shared with participants for feedback (member checking).

Ethical Clearance
This study ensures informants' confidentiality by omitting personal details from reports, using assigned numbers instead of names, and securely storing and disposing of data. Ethical considerations include obtaining written informed consent and safeguarding patient data and registry records. The study received ethical approval from the Health Research Ethics Commission, Dr. Saiful Anwar General Hospital (400/286/K3/302/2023).

RESULTS

The total number of participants who took part in this research was 9 people and all of them were PSC personnel who served in 2021-2022 after the Covid-19 pandemic and were involved in handling cases of sudden cardiac arrest during that period. The first informant was a 28 year old non-medical worker who held the position of call taker and had worked as a volunteer for PSC 119 Malang City for 4 years. The second informant is a 26 year old non-medical worker who holds the position of call taker and has worked as a volunteer for PSC 119 Malang City for 3 years. The third informant is a 28 year old non-medical worker who holds the position of ambulance driver and has worked as a volunteer for PSC 119 Malang City for 3 years. The fourth informant is a 30 year old non-medical worker who holds the position of ambulance driver and has worked as a volunteer for PSC 119 Malang City for 4 years. The fifth informant is a 30 year old midwife who holds the position of field officer and has worked as a volunteer for PSC 119 Malang City for 4 years. The sixth informant is a 26 year old nurse who holds the position of field officer and has worked as an honorary PSC 119 Malang City for 3 years. The seventh informant is a 28 year old nurse who holds the position of field officer and has worked as an honorary PSC 119 Malang City for 4 years. The eighth informant is a 28 year old nurse who holds the position of field officer and has worked as an honorary PSC 119 Malang City for 3 years. The ninth informant is a 34 year old doctor who occupies the position of head of the medical services section and has worked as an honorary PSC 119 Malang City for 4 years.

The patient data analyzed in this study was 14 cases from January 2021 – December 2022 with an average age of 75.8 years (21 years - 77 years) with 9 cases of male patients (64.2%) and 5 cases of female patients (35.8%). Data from these 14 cases were analyzed according to the EMS system factors recommended by GRA for implementation based on data obtained from interviewed informants in accordance with Table I.

Table I: Analysis of key elements in EMS that influence survival in SCA patients

Key Elements		Result	Standard	Gap
Time Metrics	Dispatch activated time	Not fully recorded	Recorded	Yes
	Ambulance underway time	Not fully recorded	Recorded	Yes
	EMS at scene time	Not fully recorded	Recorded	Yes
	EMS at patient site time	Not fully recorded	Recorded	Yes
Performance Metrics	By Stander/Telephone CPR	Not done	Done	Yes
	EMS CPR Started	Not done	Done	Yes
	EMS HP-CPRStarted	Not done	Done	Yes
	EMS Defibrillation	Not done	Done	Yes

EMS: Emergency Medical Service
CPR: Cardiopulmonary resuscitation
HP-CPR: High performance - Cardiopulmonary resuscitation

Time Metrics
From the results of the interview it was found that not all time metrics recording had been carried out. There are several reasons for not completely recording the response times obtained from informants in this study

A. Lack of protocol
Dispatch time recording had not been completely carried out because there was no protocol included in rapid dispatch.

"Yah di PSC kami tidak pernah mencatat waktu tersebut sebab di dinas kesehatan tidak diminta waktu tersebut (waktu dispatch). Kami juga belum ada protokol mengenai waktu tersebut"(ct.1)
"(Well, at PSC we never record that time because the health department doesn't ask for that time (dispatch time). We also don't have a protocol regarding that time)" (ct.1)

"Tidak ada pencatatan waktu tersebut dok di PSC selama saya bertugas. Tetapi terkadang kami melaporkan waktu pada call taker dok"(ct.2)
"(There was no recording of this time at the PSC while I was on duty. But sometimes we report the time to the call taker doc)" (ct.2)

Ambulance underway time recordings and EMS at patients site time had not been completely carried out due to the absence of a protocol that regulates regulates recording if officers depart from locations other than the PSC 119 Malang City

"Selama ini saya belum pernah mencatat waktu dan ini kan bervariasi dok waktunya karena terkadang kita bukan berangkat dari mako. Terkadang kami melaporkan ke call taker" (ad.2)
"(So far I have never recorded the time and this varies because sometimes we don't leave from Mako, But sometimes we report the time to the call taker)" (ad.2)

"Apakah memang idealnya harus dicatat ya dok? Mana sempat dicatat dok, buru-buru dibawa ke rumah sakit"(fw.3)
"(Is it ideal that it should be recorded, doc? If it was recorded, Doc, he was rushed to the hospital)"(fw.3)

B. Lack of evaluation
It was found that not all ambulance underway time recordings, EMS scene time recording, and EMS at patients site time recording had been carried out because this was not part of the recording included in the Key Performance Indicators (KPI) evaluation

"Buat apa dok? Ga pernah diminta (oleh dinas kesehatan) jadi buat apa dikerjakan. Terkadang tempat berangkat juga ga selalu dari pos soalnya ambulans sedikit, kadang ada mobilnya tapi ga ada pengendaranya"(ad.1)
"(What for, doc? It was never asked (by the health department) so why should we do it? Sometimes the place of departure is not always from the post because there are few ambulances, sometimes there are ambulance but no drivers)"(ad.1)

"Yo ndak dok, lah kita aja buru-buru mau langsung bawa ke rumah sakit. Untuk data pencatatan waktu dari dinas (dinas kesehatan) seh kayaknya ga diminta"(fw.1)
"(No, doc, we just rush and take the patient straight to the hospital. About the recording data, it isn't was requested by department (health department))"(fw.1)

"Ya ga pernah di catat dok, kita di tempat kejadian aja udah gopoh, mana sempat lagi menghitung waktunya dok, lagian juga ga diminta dinkes, kita juga ga kepikiran nyatet waktunya" (fw.2)
"(Yes, it was never recorded, doc, we were already nervous at the scene, we don't have time to record it, doc. Besides that, the health department didn't ask us to do that, we also didn't think about the recording of the time)"(fw.2)

Performance metrics
From the results of the interview it was found that all performance metrics had not been done. There are several finding regarding the performance metrics

A. Lack of equipment
The implementation of defibrillation by EMS personnel and bystanders remains unfeasible in Malang City due to the limited availability of automated external defibrillators (AEDs). Bystander defibrillation is only achievable when AEDs are accessible in the vicinity of the cardiac arrest incident. Furthermore, AEDs are currently not equipped in EMS ambulances.

"Ndak pernah dok, emang di Malang ada AED ya? Lek ono pasien kolaps ditontonin tok sama warga sekitar"(fw.3)
"(Never doc, are there AEDs in Malang? If it happen, the collapsed patient was only watched by local residents)"(fw.3)

"AED bukannya hanya ada di bandara ya dok? Setahu saya belum ada ya dok di tempat umum" (fw.2)
"(aren't AEDs only available at airports? As far as I know, there are unavailable in public places yet)"(fw.2)

B. Lack of knowledge and confidence
Telephone CPR had not been carried out and had not been implemented because there was no protocol that regulated this. Apart from that, officers also have not received training to provide CPR guidance over the telephone and are hesitant to determine whether the patient is in cardiac arrest or not.

"Tidak berani dok, karena belum ada pelatihan dan ga ada pengalaman juga sebelumnya. Protokol nya juga belum ada, SOP juga belum ada" (ct.2)
"(I don't dare, doc, because there is no training and no previous experience. There are no protocols yet, no SOPs either)"(ct.2)

"Mana ada dok, kami saja baru dengar tentang telefon CPR dok. Belum ada pembicaraan tentang hal ini juga dok"(ct.1)
"what is that, doc, we just heard about the telephone CPR, doc. There hasn't been any discussion about this either, doc."(ct.1)

EMS HP-CPR had not yet been carried out on patients with cardiac arrest with the consideration of taking the patient as quickly as possible to the hospital. In the training that has been attended so far there is still no topic that discusses CPR in ambulances. Apart from that there is still no mechanical CPR equipment available in ambulances

"Karena kita mau bawa pasien cepat cepat ke rumah sakit dan kami juga belum pernah melakukan RJP di ambulans, belum ada pelatihan yang diberikan juga. Autopulse juga belum tersedia di PSC"(fw.4)
"(Because we want to take the patient quickly to the hospital and we have never done CPR in an ambulance, nor has there been any training given. Autopulse is also

not yet available on PSC)"(fw.4)

"Bingung dok, apa sebaiknya di RJP di lapangan atau segera dibawa ke rumah sakit. Nanti kalau kelamaan RJP di lapangan disalahkan keluarga pasien karena tidak segera dibawa ke RS"(fw.5)
"(I'm confused, Doc, whether it's best to do CPR in the field or immediately take him to the hospital. Later, if the CPR takes too long in the field, the patient's family will be blamed because they were not immediately taken to the hospital)" (fw.5)

EMS personnel still lack confidence in performing CPR in the field, driven by concerns that delays in transporting the patient to the hospital may exacerbate their condition. Furthermore, EMS officers also had never known about HP-CPR before

"Apalagi itu dok HP-CPR? Dok, CPR aja belum dikerjakan. Apalagi HP-CPR denger aja belum pernah. Pokoknya kita mau cepet cepet bawa pasien ke rumah sakit"(fw.3)
"(What's, HP-CPR? Doc, even CPR hasn't been done yet. Moreover, I've never even heard of HP-CPR. The point is, we want to quickly take the patient to the hospital)"(fw.3)

"Waduh dok, RJP aja gak dilakukan apalagi HP-CPR. Saya saja baru tahu tentang HP-CPR ini dok" (fw.5)
"(Doc, CPR wasn't even done, let alone HP-CPR. I just found out about HP-CPR, doc)"(fw.5)

Moreover, EMS personnel demonstrated reluctance in performing defibrillation on patients experiencing SCA due to a lack of ACLS training, which is essential for interpreting ECG and utilizing manual defibrillators. Their training had been confined to BLS, which primarily focuses on the use of AEDs, thereby contributing to their hesitation in employing manual defibrillation techniques in SCA scenarios.

"Soale kita ragu-ragu, durung tau oleh pelatihan tentang defibrilator. Kita mek tau diajari BLS. Mangkane aku ndak wani soale ragu-ragu"(fw.3)
"(We are hesitant, we haven't received training on (manual) defibrillators. We are only taught about BLS. That's why I didn't dare, because I was hesitant)"(fw.3)

"Ga pernah dok, soalnya belum pernah pake defibrilator itu, ga pernah pelatihan juga"(fw.4)
"(Never, doc, because I've never used a (manual) defibrillator, I've never had any training either)"(fw.4)

DISCUSSION

The findings of this study indicate that the current EMS system is predominantly transport-oriented, with insufficient focus on delivering comprehensive care. The data presented in Table 1 highlights several limitations within the Malang City EMS system, with notable gaps in the recording of dispatch time, ambulance travel time, EMS time at the scene, and patient treatment time. More significant gaps are observed in the areas of telephone CPR, CPR performed by EMS personnel, and EMS defibrillation, which have yet to be consistently implemented and require substantial improvement. To further explore these challenges, the author conducted interviews with PSC officers, drawing on foundational data aligned with the GRA recommendations. These interviews aimed to identify the difficulties faced by EMS personnel in managing SCA patients in the field and to uncover the underlying causes of these issues.

The thematic analysis reveals several issues within the system, particularly related to the time matrix, which includes the lack of protocols and inadequate evaluation processes. Additionally, the performance matrix highlights deficiencies in equipment and training, which contribute to a lack of confidence among staff when providing care to SCA patients. While substantial research on cardiac arrest management has been conducted in Indonesia, most studies have centered on hospital-based care, with limited focus on pre-hospital settings, especially in the area of community empowerment. This research gap is understandable, given that the Indonesian government's efforts to establish and develop PSC have only gained momentum in the past decade. Globally, the approach to SCA management also tends to prioritize hospital care, despite the higher frequency of SCA cases occurring in the community, where timely intervention is critical for survival (1–3,8,9).

Rapid dispatch is critical in managing SCA, as it is a time-sensitive condition. Precise time tracking helps identify and address underlying issues. To reduce dispatch delays, protocols—which are currently unavailable in EMS services in Malang—should prioritize symptoms requiring immediate action, as recommended by GRA. These include decreased consciousness, difficulty breathing, stroke symptoms, chest pain, seizures, major trauma, and diabetic hypoglycemia. Rapid dispatch should not be limited to confirmed cardiac arrest cases but should also encompass symptoms potentially leading to cardiac arrest to ensure timely initial treatment (2,3,10,11). Some qualitative studies have highlighted the critical need for standardized protocols to guide ambulance dispatch based on service urgency, as their absence can lead to inconsistent EMS care and suboptimal patient outcomes. Research in Iran illustrates how overwhelming prehospital service demands hinder the implementation of offline emergency medical protocols, complicating decision-making for EMS technicians (12) This issue is particularly acute in low- and middle-income countries (LMICs), where the lack of effective ambulance protocols contributes to high injury-related mortality, accounting for 90% of the global injury burden and 5.8 million deaths annually

(13).

Emergency medical services on-scene time, defined as EMS arrival at the scene until departure to the hospital, is a critical metric for evaluating emergency response efficiency. According to AHA guidelines, this time should not exceed 15 minutes, as shorter scene times have been associated with improved survival rates for SCA patients. However, this research revealed that EMS in the studied region lacks protocols for recording scene time, resulting in no evaluations related to this variable (1,3,14). The lack of comprehensive data collection systems and Key Performance Indicators (KPIs) further limits the ability to assess and improve EMS performance in developing countries. In the absence of these frameworks, there is a significant gap in accountability, and no systematic approach is in place to evaluate response times or patient outcomes (15,16). A systematic review revealed that many EMS systems in these regions lack the infrastructure necessary to effectively gather and analyze data on response times and patient outcomes (17,18). Research has shown that implementing tailored KPIs—such as time-to-treatment for critical conditions and patient satisfaction metrics—can substantially improve EMS performance. In contrast, countries with well-established EMS systems have demonstrated the positive impact of such measures in driving quality improvements and optimizing service delivery (19,20).

Sudden cardiac arrest, often caused by ventricular fibrillation, requires immediate defibrillation to improve survival chances. Studies show that early defibrillation for shockable SCA cases, whether at the scene or during transport to the hospital, significantly increases survival rates. Additionally, performing CPR, especially HP-CPR, as soon as possible helps maintain blood flow to the brain, slowing the death process. Telephone CPR, where laypersons are guided by EMS personnel over the phone, can further extend survival time until EMS arrives. Research indicates that telephone CPR increases survival rates by 69% compared to those who do not receive CPR. The AHA has issued guidelines to support telecommunicator CPR in these efforts (9,14,21,22).

In developing countries, a lack of knowledge and confidence among EMS staff in performing prehospital CPR is a major concern. This deficiency impacts the quality of emergency care and patient outcomes, with many EMS personnel reporting inadequate training in CPR protocols (23,24). Studies in Tanzania and Ghana show that this gap in training leads to a lack of confidence and affects their ability to deliver life-saving interventions effectively (25,26).

In addition to insufficient training, psychological barriers like fear of litigation contribute to EMS personnel's reluctance to perform CPR. Research from various countries, including Ghana, Tanzania and Bostwana, highlights significant disparities in CPR knowledge among healthcare providers, with some regions lacking structured educational programs and ongoing training. Simulation-based training has been identified as an effective way to improve skills and confidence in EMS staff, particularly in high-risk situations (25–27). Continuous professional development programs focused on CPR and emergency response can help bridge the knowledge gap and better prepare EMS personnel for cardiac arrest cases (25,27,28).

This research hopes to enhance the training and preparedness of EMS personnel, who are primarily nurses in Indonesia (as there is no paramedic profession), in managing SCA. By providing in-depth training and drills, the goal is to implement the recommendations to improve the treatment of SCA patients, particularly in Malang City.

However, the study has several limitations, including its single-center design, which prevents generalization of the findings to a broader context in Indonesia. Furthermore, the post-pandemic development of PSCs led to most of volunteer staff no longer working, limiting the sample size.. The challenges in implementing the GRA recommendations, as highlighted in this study's results, are related to a shortage of competent healthcare workers, government policies on AED procurement, and insufficient support for organizing SCA-related training.

Further research is highly encouraged to examine the development of PSCs in Malang City, particularly in relation to SCA management. Such studies would provide valuable insights into the progress of EMS systems in Malang and their ability to implement effective interventions for SCA, contributing to the ongoing improvement of emergency care in the region.

CONCLUSION

The PSC 119 Malang City EMS team did not comply with the GRA recommendations for recording critical time metrics. This non-compliance can be attributed to the the absence of established protocols to guide EMS staff as well as the exclusion of time recording as a KPI in their evaluations. Additionally, PSC 119 Malang City failed to meet the GRA performance metric recommendations, potentially due to a combination of limited staff knowledge, lack of confidence, inadequate equipment to support the required standarts, and the absence of standardized protocols. Improvements are essential to address the identified gaps in EMS practices that influence survival rates in OHCA patients.

Potential solutions include the implementation of four cost-effective interventions: (1) systematic recording of response times, (2) activation of telephone-assisted CPR, (3) application of HP CPR, and (4) rapid dispatch protocols. Establishing KPIs for time recording metrics

is also recommended to support these improvements. Additionally, targeted training on cardiac arrest management, refresher courses for EMS personnel, and regular simulation drills are proposed to enhance staff knowledge, skills, and confidence, ultimately improving the overall effectiveness of the EMS response system.

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