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Working against the clock: A model for rural STEMI triage

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ABSTRACT: Residents in rural communities have a higher incidence of cardiac death and risk factors associated with cardiac disease. Living in a rural region can add precious time that amplifies cardiac death during an ST-elevated myocardial infarction (STEMI) episode. The consensus is that improved efficiencies can increase myocardial salvage and decrease STEMI mortality rates. This article identifies issues that may impact pre-hospital STEMI triage of patients in a rural region of the United States (U.S.). A qualitative research design was chosen to gain insight into emergency personnel perceptions of pre-hospital STEMI triage. The participants (n = 18) were obtained from a convenience sample in rural Northeast Texas, U.S. Data were gathered by individual and group semi-structured interviews. Themes were identified, synthesized, and oriented to offer a basis for understanding opportunities to improve the delivery of rural STEMI care. This study demonstrated that quality improvement initiatives aimed at achieving pre-hospital STEMI triage efficiencies have dependencies on teamwork, technology, and training in the context of 3 stages (a) pre-transport, (b) door-to-door, and (c) post-transport. A pre-hospital STEMI triage model is offered based on the findings. By incorporating this model, emergency medical coordinators in rural communities have a better opportunity to facilitate timely reperfusion therapy for this high-risk population.

KEYWORDS: Rural STEMI, EMS, pre-hospital, cardiac crisis, reperfusion therapy

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Background

One in 5 Americans lives in a rural area.[1] Rural community hospitals in the United States (U.S.) service over 46 million people.[2] Residents in rural communities have a higher incidence of cardiac death and risk factors associated with cardiac disease.[3] Having a heart attack in rural America inherits the risk of adding time to a life or death cardiac crisis. Roughly 30% of patients experiencing acute cardiac crisis suffer from ST-elevation myocardial infarction (STEMI).[4] Much existing research has noted emergent STEMI treatment—with a principal emphasis on reperfusion therapy—optimal within 90 minutes of first medical contact.[5] Over 50% of Americans live in rural areas where access to a hospital capable of reperfusion therapy is likely over 90 minutes.[6] Efforts to improve rural community emergency medical services have seen success.[7] However, rural communities remain at higher risk for underutilized STEMI intervention.[8]

A direct relationship between time and cardiac death compels attention to be placed on pre-hospital strategies in rural communities.[9] This study infers *pre-hospital* to mean the time from first medical contact to hospital handoff. Effective pre-hospital STEMI strategies, especially in rural regions, require timely collaborative problem-solving and action-oriented sensemaking.[9,10] Synchronized teamwork is critical for navigating timely pre-hospital STEMI triage. Ford and Schmidt[11] reported implicit challenges when developing effective delivery of emergency medical services (EMS) that required synchronized teamwork. Fernandez et al[12] recently provided a basis for improving the delivery of EMS with their qualitative evaluation of emergency personnel from a large urban Texas community. In that vein, this study narrowed the medical scope to delivery of pre-hospital STEMI triage and placed focus on a rural region of Northeast Texas. Of the 1.5 million people living in Northeast Texas, over 50% live in rural areas[13]; this points toward delayed access to primary percutaneous coronary intervention (pPCI) as a concern for this region. This study endeavors to add prescriptive value to this concern by qualitatively examining emergency personnel who have experience delivering pre-hospital STEMI triage in Northeast Texas. The following questions guided the research:

Research Question 1: What are the key considerations, concerns, or issues that impact pre-hospital STEMI triage for patients in rural locations?

Research Question 2: What are the root causes of issues that negatively impact the timeliness and effectiveness of pre-hospital STEMI triage for patients in rural locations?

Research Question 3: What are potential countermeasures to address issues identified with the timeliness and effectiveness of pre-hospital STEMI triage for individuals in rural locations?

Methods

A qualitative research design was chosen to gain insight into the perceptions of the participant experiences.[14] An individual's

perception—and how that perception exists in consciousness—are relevant considerations for phenomenology.[15] Phenomenology is an ideal framework to do this because it enables the researcher to explicate perceptions from these experiences. Specifically, this research placed focus on the perceptions of emergency personnel who had STEMI triage experience in Northeast Texas. Emergency personnel is required to perceive rural STEMI variables and deconstruct this complex event, most often in unfamiliar environments.[16] Moreover, when attempting to improve performance, organizations should include knowledge of employees within the working context.[17] The incorporation of a STEMI care pathway that requires optimal pre-hospital triage provides an important working context for this study.

Research approach

Using qualitative inquiry as a methodological approach to research, this study sought to make sense of the grounded experiences of emergency personnel during pre-hospital STEMI triage in a rural region of the U.S. By reflecting on their experiences, opportunities were presented to identify connections to improve pre-hospital STEMI triage. This study enlisted sensemaking theory[18] as the basis of inquiry because noted research on STEMI triage is often focused on a group level of analysis to make collective sense of the episode.[19,20] Sensemaking theory has been used in healthcare research to provide an understanding of how healthcare providers turn complex and confusing circumstances into comprehendible situations.[21,22] Furthermore, sensemaking has been applied to organizational theory to examine risks, threats, and hazards in multiple industries, including healthcare.[23] For this study, sensemaking is understood to be (non)relevant pieces of information that emergency personnel must collectively synthesize to generate a shared understanding of a pre-hospital STEMI episode.

Participants

The participant population of interest was obtained from a convenience sample in the Northeast region of Texas. Convenience sampling is consistent with a form of purposeful sampling.[24] Participants were recruited via professional networks connected to the Regional Advisory Councils and local healthcare providers. All 18 participants that agreed to participate in this study were qualified healthcare providers who had pre-hospital STEMI experience in the rural Northeast Texas region. The participants (collectively labeled emergency personnel) included 10 emergency first responders, 4 EMS leaders, 1 registered nurse (RN) STEMI instructor, 1 RN trauma nurse, 1 emergency medical technician (EMT), and 1 emergency room physician. Each interview participant was given an identification pseudonym (Table 1). The researchers determined the demographic composition of the sample was sufficient to capture the pre-hospital perspectives needed for analysis through participant interviews.

Table 1. Interview participant identification pseudonyms (n = 18).

PSEUDONYM	TYPE OF PROVIDER
Interview participant 1 (IP1)	EMS leader
Interview participant 2 (IP2)	EMS leader
Interview participant 3 (IP3)	EMS leader
Interview participant 4 (IP4)	EMS leader
Interview participant 5 (IP5)	RN/STEMI instructor
Interview participant 6 (IP6)	ER physician
Interview participant 7 (IP7)	Emergency first responder
Interview participant 8 (IP8)	Emergency first responder
Interview participant 9 (IP9)	Emergency first responder
Interview participant 10 (IP10)	Emergency first responder
Interview participant 11 (IP11)	Emergency first responder
Interview participant 12 (IP12)	Emergency first responder
Interview participant 13 (IP13)	Emergency first responder
Interview participant 14 (IP14)	Emergency first responder
Interview participant 15 (IP15)	Emergency first responder
Interview participant 16 (IP16)	Emergency first responder
Interview participant 17 (IP17)	Emergency medical technician
Interview participant 18 (IP18)	RN/trauma coordinator

Data collection

Data were gathered by individual and group semi-structured interviews (audio recordings and field notes) made up of questions that aligned with the purpose of the study.[14] Participants read or were read a letter of consent to be interviewed. Initial questions included basic information (eg, name, years in emergency medicine, overall experience with STEMI) to qualify the participant. The interviews were in person and administered by 2 of the researchers. Each interview was roughly 1-hour and began with a summary of the purpose of the interview and a restatement regarding the voluntary nature and confidentiality of the interview. The interviews were then transcribed verbatim by a transcriptionist. The transcripts were then verified by the investigators for accuracy.

Data analysis

To discover themes, the data were reviewed, line by line, by 3 researchers who made notes, comments, and observations in the margins of the transcripts for words or phrases that could be

Table 2. Process domains critical for pre-hospital STEMI triage (n = 18).

THEMATIC CODE	CODE(S) EXAMPLES	DEFINITION
Teamwork	CPR, communication with hospital personnel, direct to Cath lab, field diagnosis, Patient handoff, and follow-up	When those involved (patient, family members, first responders, physicians, hospital personnel, etc.) clearly understand their role, contribution, and desired outcomes in STEMI patient care
Technology	Pulsara, 12 lead EKG, Pulse, helicopter transport, ER bypass, File for Life (see www.folife.org), iPhone health apps, mobile ICU, AED, ECMO, TPA, Nitro spray, onboard physicians	Innovative tools designed, manufactured, and utilized to facilitate STEMI patient care
Training	CPR training, ACLS and AHA protocols, STEMI certification, patient denial, delay in patient transport activation, transport as best option, recognition of symptoms, Large Service Learning initiative, the "look"	Education and practice related to pre-transport patient/family awareness and education, diagnosis, and transport/post transport treatment of STEMI. This is crucial for rural regions in East Texas. See: https://rac-g.org/

Abbreviations: ACLS, advanced cardiac life support; AED, automated external defibrillator; AHA, American Heart Association; CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; EKG, electrocardiogram; ER, emergency room; ICU, intensive care unit; STEMI, ST-elevated myocardial infarction; TPA, tissue plasminogen activator.

synthesized for common concepts. These notes were examined for common characteristics and then grouped into themes during axial coding.[14,25] The data were then organized based upon the research questions and presented to the principal investigators to check for consistency in the data. The researchers determined a saturation of data was evident after 6 transcripts with a total of 18 participants when no new codes emerged.[26] To check for trustworthiness the research questions and themes were read by 2 emergency medical coordinators (EMCs) of 2 Northeast Texas counties. By using their extensive experience in emergency management, the EMCs affirmed that the findings accurately represented the phenomenon of interest.

Results

This section considered the findings of the study by focusing on key emergent themes from the collected data. The researchers' focus was not on respondent actions but rather on respondent comments relevant to their perceptions. Through the iterative process, emergency personnel describes their perceptions of pre-hospital STEMI triage in 3 themes: (1) teamwork; (2) technology; and (3) training; hereafter labeled *process domains*.

Process domains

Process domains are considered a sphere of activity or knowledge and are incorporated here to segment the thematic perceptions of the participants. Each process domain took its form from sensemaking activities while participants reflected on rural STEMI triage episodes. The incorporation of process domains allowed the researchers to synthesis concepts into critical elements for pre-hospital STEMI triage (Table 2).

Teamwork

> . . .that's what community paramedicine does: it allows a network for all these agencies to work together within their community to really solve problems; not band-aid them by taking them to the ER, but figure out where we need to help our citizens, and what's their problem. (IP14)

Teamwork requires collaborative problem-solving and action-oriented sensemaking to effectively reach objectives in an emergent unfamiliar environment.[10] Ford and Schmidt[11] reported implicit challenges when developing an effective emergency response that required synchronized teamwork. Rural emergency organizations are often poorly coordinated with limited resources and effective mechanisms to efficiently handle a STEMI emergency.[27,28] Teamwork is improved when emergency personnel works together to adapt and control the space that is immediately surrounding the patient.[29] To do this, emergency personnel must collectively make sense of an unfamiliar environment, make sense of the patients' emergent condition, and make sense of the emergent needs to afford actionable medical intervention. One participant described how the team concept is considered.

> Here, we have a medic that's going be in charge of the patient. "That's gonna be my patient. I'm the medic in charge". But this team works together, and they all know what needs to happen on a cardiac arrest. "So you've got the airway, you've got the IV, you've got compressions." So you got five people doing everything at one time instead of one guy having to prioritize and get – we learned the team concept. . .that's the big push: to be able to manage your team, be able to use the resources you have an appropriate 'em so you can get everything done as fast as possible. (IP8)

Technology

Recent mobile technology advances (eg, WhatsApp, AliveCore™) have been advocated as a means to early STEMI detection by hospital systems and emergency personnel to make sense of the emergent condition.[30]

> . . .basically we do a 12-lead on any time somebody says they're having chest pain, discomfort. . .even if it's back pain or abdominal pain. . . with the Pulsara app. After they do a 12-lead they can look

Table 3. Key considerations, concerns, and issues that impact the pre-hospital STEMI transport process for patients in rural locations.

CONSIDERATIONS	DESCRIPTION	CONCERNS	PROCESS DOMAIN
Pre-transport	Patient and family awareness and knowledge and preparedness	Patient and family awareness of required treatment and need for timely action	Training
		Patient and family preparedness for cardiac event (in cases which there is a previous history in patient)	Training
Door-to-door transport	Capability of first responder	Available necessary medications and equipment (cost)	Technology
	Hospital options for first provider (pPCI)	Availability of CCL	Teamwork
	External protocols and regulations	First provider expertise (training)	Training
		Accurate diagnosis of STEMI	Training
		Confidence in first responder expertise/diagnosis	Training/teamwork
		Available technology (eg, Pulsara) transmission	Technology
Post-transport/ handoff	Understanding of hospital layout and protocols	First responders knowing the appropriate location to take the patient within the facility	Training/teamwork
	Effective patient handoff processes and procedures	First responders effectively communicating patient information to hospital care providers	Training/technology

Abbreviations: CCL, cardiac catheterization laboratory; pPCI, primary percutaneous coronary intervention; STEMI, ST-elevated myocardial infarction.

> at it and say, maybe this is something. We'll send it to them, or, yes this is definitely a STEMI. So if it's definitely a STEMI, they send out a STEMI alert right then through Pulsara out to the hospital, and that way, the doctor actually gets a picture of what our guys did from the field. Cause we might not be at the hospital for 10 minutes, but they can have the cath lab ready. (IP1)

Astarcioglu et al[31] demonstrated cardiac mobile technology decreased unnecessary cardiac catheterization lab (CCL) transfers and reduced the demand for highly trained EMS or emergency department resources. This finding is particularly important to rural regions whose transfer times are complicated by distance and (often with) rural providers of EMS that may have less training and fewer competency opportunities than their urban counterparts.[27,28] Emergency personnel should seek to obtain accurate field technology that will activate the CCL before the patients' arrival.[32] Field technology can help reduce barriers to early reperfusion (eg, identification of STEMI, misattribution of symptoms, fear of false alarm, not fitting "stereotypical" symptoms, and bystander confusion common in transport delays).[33,34]

> . . .when our guys call something, they're pretty good usually waiting. We go right to the cath lab or right in to see the ER doctor who wants to check a couple of things, but we're usually pretty good. . .[t]hey usually know if we call them, they think we're right most of the time. (IP5)

Training

Emergency personnel tends to train in teams to maintain functionality in the community of practice.[35] O'Connor et al[4] reported that more experienced EMT-paramedics are often employed in highly populated service areas as opposed to the less populated regions—where a greater proportion of EMT-basic and EMT-intermediate responders are employed. Participants indicated, at minimum, rural EMS service providers must actively train members to recognize STEMI and to procure timely ECG data to facilitate triage. Even better, rural EMS service providers should consider training advanced members in ECG interpretation to facilitate CCL activation for expedient STEMI reperfusion.[4]

> So that's part of my job and the training guys. If it's just a minor change like going from 15, to 2, to 32 on compressions to breaths or whatever, a minor, then I'll just send out a little e-mail and say, "Hey, we've got a minor change." Obviously if it's a major change or something that they need training on, we do EMS rotations. We have EMS training coming up in August and we get every single fireman who comes through. (IP7)

Field diagnosis is the most important aspect of STEMI triage.[36] Despite its limitations, the standard 12-lead ECG remains the diagnostic standard in directing the emergency management of acute myocardial infarction patient.[37] The ECG is not always accurate,[38] making emergency personnel training and experience even more crucial; a condition articulated by (IP12): "Just because the computer says it's okay doesn't mean it's okay. So, we always say, treat the patient and what you're seeing versus what the monitor is actually saying."

Extending the analysis suggested each process domain was influenced by contextual factors within 3 distinct pre-hospital transportation stages: (a) pre-transport, (b) door-to-door, and (c) post-transport (handoff). Within each transportation stage, shown in Table 3, considerations, concerns, and issues that impact rural pre-hospital STEMI triage were identified to answer RQ1.

Research has noted a number of factors associated with EMS delay following the onset of chest pain, including

Table 4. Root causes that negatively impact the timeliness and effectiveness of the pre-hospital STEMI transport process for patients in rural locations.

PROCESS DOMAIN	ROOT CAUSE PATIENT/FAMILY	ROOT CAUSE FIRST RESPONDER
Teamwork	Ignoring symptoms and prolonging D2B	Communication issues between hospital and first provider
	Patient/family does not create a safe and efficient environment for first responder upon arrival	Every hospital (ER/Cath Lab) is set up differently
Technology	Lack of awareness (or propagation of) patient assistance apps/systems	Lack of technology to communicate accurate field diagnosis
		Hospital not having ER/Cath Lab ready upon transported patients arrival
Training	Patient/family denies issue is present or underestimates severity	First responder lacks expertise with STEMI
	Family unable to administer CPR	Challenges with rural ESDs evening/weekend volunteer capability (volunteer)
	Believes that driving by car will be quicker	
	Family does not recall or have access to patient medical history or current medication list	STEMI drug treatment protocol changes continuously

Abbreviations: CPR, cardiopulmonary resuscitation; D2B, door to balloon; ER, emergency room; ESD, emergency services district; STEMI, ST-elevated myocardial infarction.

Table 5. Perceived potential countermeasures to address issues identified with the timeliness and effectiveness of the pre-hospital STEMI triage for patients in rural locations.

PROCESS DOMAIN	COUNTERMEASURES
Teamwork	Develop first responder employee retention strategies
	Identify career enhancement/growth opportunities for first responders
	Identify first responder engagement maximizing and burnout minimizing strategies and interventions
	Continue to develop better processes, protocols, and strategies
	Develop stronger communication/trust/working relationships between first responders and hospital personnel/docs
	Develop available standard order sets for STEMI
Technology	Implement transport communication and availability tracking systems
	Implement transport communication and availability diagnostic systems (eg, Pulsara)
	Identify cost-effective ways to improve availability of life-saving technologies and medication in rural areas (eg, AED, EMR access)
Training	Have all first responders (EMS, fire volunteers) trained at the EMC basic paramedic level
	More simulation, hands-on deliberate practice in handling STEMI cases (eg, training of Pulsara technology)
	Community awareness of the importance of recognizing “the look”/symptoms, quick activation, transport by qualified first responder, understanding difference b/w EMS/Paramedics, etc.
	Training/tools to ensure family/patient is prepared for STEMI event (pre-arrival instructions, available med records, verbal/written history, medications, etc.)—particularly for patients with STEMI/cardiac history (“File for Life”)
	More wide-spread CPR training availability in rural areas

Abbreviations: AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; EMC, electromagnetic compatibility; EMR, electronic medical record; EMS, emergency medical services; STEMI, ST-elevated myocardial infarction.

demographics (eg, gender, race, and age) and social influence (eg, neighborhood income).[39] From here, the data were analyzed to identify responder-perceived root causes that were potentially adverse for efficient and effective pre-hospital STEMI triage and transport in rural Northeast Texas. The results of this analysis are presented in Table 4 and serve to answer RQ2.

Hospital systems must increasingly work with EMS agencies to form regional systems that can provide timely access to percutaneous coronary intervention.[40] It is important to address systemic barriers with teamwork, technology, and training and identify countermeasures for effective pre-hospital STEMI triage. Table 5 answers RQ3 by identifying various countermeasures for improving pre-hospital STEMI triage.

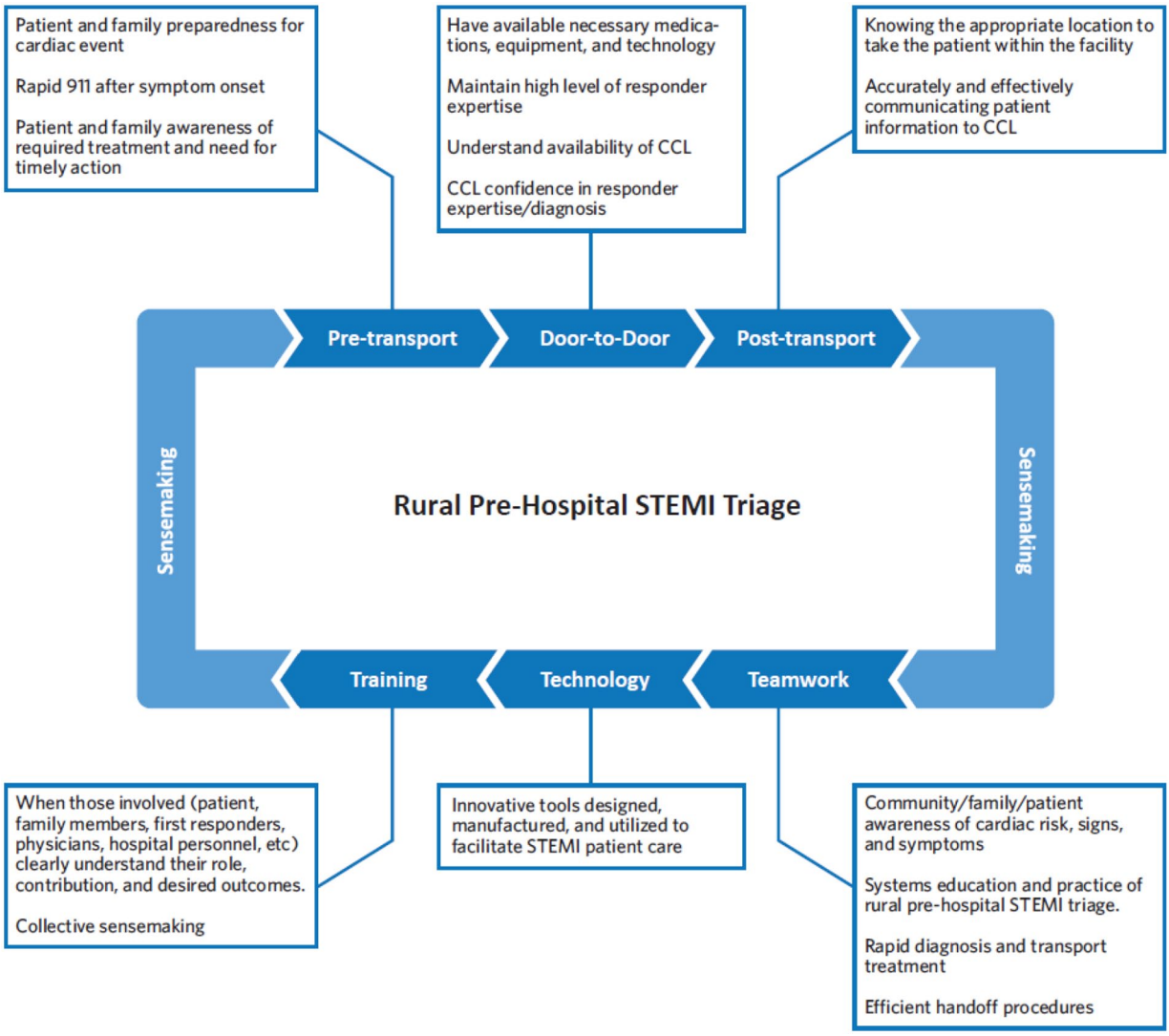

Figure 1. Pre-hospital STEMI triage consideration for rural regions.
Abbreviations: 911, emergency number for calling for medical services; CCL, cardiac catheterization lab; STEMI, ST-elevated myocardial infarction.

Discussion

Previous research has established an important time frame for optimal STEMI outcomes. Living in a rural region can add precious time that amplifies cardiac death during a STEMI episode. The consensus is that improved efficiencies can increase myocardial salvage and decrease STEMI mortality rates. For this reason, pre-hospital STEMI triage in rural regions was an important context to examine. The results of this study address pre-hospital challenges to rural STEMI triage and provide considerations for improved efficiencies for STEMI patients. The findings suggested emergency personnel designate teamwork, technology, and training as important domains for improving pre-hospital STEMI triage. Furthermore, qualitative methods allowed each domain to be contextualized by factors that contribute to pre-transport, door-to-door, and post-transport stages of the STEMI chain. The advantage of compartmentalizing these domains with contextual factors is to guide EMS agencies and EMS personnel to be more sensitive to differences in each stage of transport. By extension, an important outcome of this study is the recognition of a pre-hospital STEMI triage model that considers input for each process domain and each transportation stage (Figure 1). The right care needs to be offered at the right time for this particularly vulnerable group of cardiac patients. Using this model to organize EMS agencies and for development, emergency personnel have the potential to identify key interventional areas in the pre-hospital STEMI triage chain and improve timely access to pPCI in rural regions.

Research limitations of the study

Rich data were obtained from the medical personnel interviews that were conducted. However, data regarding the pre-hospital STEMI triage experience from patients and associated family members was lacking—thus omitting a potentially valuable perspective on this research. The perceptions from hospital employees who treat STEMI patients following post-transport (handoff) were not obtained. These employees may provide a critical perspective not explored in this evaluation. As in most qualitative studies, the sample size was small, which limits the

generalizability of the results. Moreover, the researchers only sought participants from the Northeast Texas region of the U.S. which further limits generalizability.

Future research. The researchers consider 4 initial recommendations for future research followed by a phenomenological consideration. First, the researchers suggest both qualitative and quantitative studies expand on the pre-hospital STEMI triage model to include a broader spectrum of participants across various regions. Second, future studies should consider valuable input to the pre-hospital STEMI triage model of both STEMI patients and pPCI personnel perceptions—including cardiologists. Third, future research should be conducted to determine if the model identified in this study is critical to the long-term success of STEMI outcomes in both urban and rural regions.

The researchers also make a phenomenological observation they considered important to pre-hospital STEMI triage. A critical means to enhanced STEMI outcomes is to improve medical decision-making.[41,42] The pre-hospital STEMI triage model pays little attention to how clinical decision-making is cognized. This model is largely based on the principles of sensemaking in which each emergency personnel is a black box responding to external stimuli. The researchers suggest a stream of future work would be of special interest that focused on how emergency responders utilize their cognitive schemas at various stages of the STEMI episode.

Conclusions

STEMI triage involves a dynamic environment that requires a collaborative support system in rural locations. The rural community hospital is responsible for much of this collaboration. This study demonstrates that quality improvement initiatives aimed at achieving pre-hospital STEMI efficiencies have dependencies on teamwork, technology, and training in the context of pre-transport, door-to-door, and post-transport stages. By incorporating a pre-hospital STEMI triage model, emergency medical coordinators in rural communities have a better opportunity to facilitate timely reperfusion therapy for this high-risk population.

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Author Contributions

This study was conceived by RM and SD and they were the principal investigators. RM and SD were responsible for study design, data collection, and participant interviews. RC, DS, and SM participated in data analysis, synthesis, and interpretation. RC wrote the initial draft. RC wrote the final draft with input from the authors who each read and approved the final manuscript. The authors alone are responsible for the views expressed in this article. The corresponding author attests that all listed authors meet authorship criteria.

Availability of Data and Materials

The qualitative data used and analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval and Consent to Participate

Ethics approval was obtained from the Institutional Review Boards of the University of Texas at Tyler in Tyler, Texas (IRB #Sum2019-126). The principal investigator obtained written consent from participants and informed them that their participation would be voluntary and without professional or personal consequences or benefits of participation. Participants were given the option to read their transcribed interviews and respond to any noted aberrancies. No financial incentives were provided to the participants.

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