

School of Medicine

Division of Epidemiology

and Public Health

Problems and Opportunities for Improving the Saudi Emergency Medical Service System: A Mixed-Methods Study in Riyadh City

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LIST OF ABBREVIATIONS

ABCDE: airway, breathing, circulation, disability, and exposure

ACLS: advanced cardiac life support

ALS: advanced life support

ANOVA: analysis of variance

BLS: Basic Life Support

CPR: cardiopulmonary resuscitation

CQI: Continuous Quality Improvement

EIRRA: EMS Incident Response and Readiness Assessment

EMS: emergency medical service

IoM: Institute of Medicine

JCAHO: Joint Commission on Accreditation of Healthcare Organizations

KSAU-HS: King Saud bin Abdulaziz University for Health Sciences

KSU: King Saud University

MCIs: mass casualty incidents

MOH: Ministry of Health

NAM: National Academy of Medicine

NHS: National Health Service

NHTSA: US National Highway Traffic Safety Administration

PCRs: prehospital care reports

QA-PHC: quality assessment on pre-hospital care

QIs: quality indicators

SCFHS: Saudi Commission for Health Specialties

SD: standard deviation

SE: standard error

SRCA: Saudi Red Crescent Authority

SRCCAD: Saudi Red Crescent Computer Aid Dispatching System

SRCCAD: Saudi Red Crescent Computer Aid Dispatching System

TSIs: time-sensitive illnesses

UK: the United Kingdom

US: the United States

WHO: World Health Organization

ACKNOWLEDGMENTS

First and foremost, I would like to thank Allah, the God almighty. He has given me enough strength and encouragement throughout all the challenging moments of completing this thesis. I am truly grateful for His unconditional and endless love, mercy, and grace.

I would like to express deepest appreciation for my Ph.D. supervisors, Prof. Sarah Lewis, Dr. Leah Jayes, and Dr. Revati Phalkey, for their continual supervision and valuable feedback. Without their insightful comments, guidance, and persistent support, I would never have been able to complete this thesis. Further, I extend my gratitude to the Scholarship unit at the Deanship of King Saud University for sponsoring my Ph.D. program and the Saudi Red Crescent Authority as well as the directors and assistant directors of all the 13 emergency medical service (EMS) centres led by Dr. Mohammad Alsuwayeh (helicopter emergency medical service medical director) and Mr. Abdulaziz Alshehri (EMS administrator) for their unwavering support during data collection. My sincere gratitude also goes to the Saudi Cultural Bureau in London, United Kingdom for their valuable support in coordinating my movements and activities for Ph.D program in Saudi Arabia and United Kingdom.

Most of all, this thesis is dedicated to my beloved family. To my parents who have been the main source of my support and spiritual motivation. To my small family, my wife and three kids, who have motivated me to accomplish this thesis in a timely manner while also demonstrating the highest level of love, support, and understanding. To my big family, my three brothers and two sisters and also all my relatives in Saudi Arabia. Their constant prayers and support during this entire journey have allowed me to successfully complete this thesis. Special thanks to my older brother, Brigadier-General and Engineer Saleh Alolyani for his advice and limitless support and motivation. Without such a supportive team behind me, I know I could never be where I am today.

ABSTRACT

Introduction: Current evidence suggests that emergency medical service (EMS) systems can improve clinical outcomes of patients with medical emergencies. However, limited studies have evaluated the Saudi EMS system partly due to lack of suitable tools. Also, EMS providers often face challenges when providing their services. In this study, we aimed to develop an EMS evaluation tool and use it to comprehensibly evaluate the structure, process, and outcome of the Saudi EMS system in addition to qualitatively investigating the challenges and proposed solutions to the provision of EMS in Riyadh city.

Methods: After conducting a scoping review of available quality indicators (QIs) and EMS evaluation tools in literature and mapping the Saudi EMS system, we developed a three-part tool for evaluating the country's EMS system: data extraction tool, senior Saudi Red Crescent Authority staff survey questionnaire, and frontline EMS provider survey questionnaire. We used the tool to measure 15 QIs under timeliness, efficiency, effectiveness, patient-centeredness, equity, and safety quality domains, and investigate challenges in the provision of EMS.

Results: One QI in the timeliness domain (initial time to respond), one QI in the effectiveness domain (EMS guidelines), and all the two QIs in the equity domain (EMS centers per population and EMS centers per area) had a low performance. All the QIs in the efficiency domain (complete documentation and performance appraisal) and one QI in the effectiveness domain (involvement of EMS physicians in dispatching EMS response team) had an average performance. All the other QIs (eight QIs) had a high performance. No QI under patient safety could be measured. We also found several challenges in provision of EMS in Riyadh city, majorly issues involving patients (such as patient condition or location that compromise communication and/or privacy); patients' relatives and by-standers (such as intrusion, lack of knowledge about EMS, and lack of cooperation); EMS providers (such as language barrier,

unethical conduct, and inadequate number of EMS providers), and Hajj festival (such as shortage of staff, long shift hours, shortage of equipment in Riyadh city). Commonly proposed solutions to these challenges were deploying enough EMS providers, developing EMS guidelines, increasing public awareness about EMS, working with collaborating services such as police to secure scenes, and continuous medical education for frontline EMS providers.

Conclusion: Triangulation of both quantitative and qualitative data revealed seven aspects of the EMS system that require action or further research: EMS data, organization of services, outcomes of EMS, need for EMS guidelines, care for/communication with patients' relatives, adequacy of resources, and Hajj season.

Chapter 1: Introduction

DEFINITION AND HISTORY OF EMERGENCY MEDICAL SERVICES (EMS)

According to Al-Shaqsi (1), an emergency medical service (EMS) system is "a comprehensive system which provides the arrangements of personnel, facilities, and equipment for the effective, coordinated, and timely delivery of health and safety services to victims of sudden illness or injury" (p. 320). EMS systems were developed to provide faster access to emergency care, community care, patient care en route to hospitals, and care on arrival at hospitals (2). According to the World Health Organization (WHO), EMS is an integral part of any functional and effective healthcare system (3). The role of EMS systems has also been extended to deal with trauma and other forms of medical emergencies while utilising advanced technologies and medical procedures such as endotracheal intubation, placement of intravenous lines, and administration of certain medications (1). Therefore, EMS systems provide emergency medical care that promotes rapid access to life-saving procedures.

FUNCTIONS AND CONTRIBUTIONS OF EMERGENCY MEDICAL SERVICE SYSTEMS

As outlined by the International Committee of the Red Cross, emergency medical system is considered the "Star of Life" across different countries (4), which is a symbol representing ambulances, emergency medical equipment, patches or apparel worn by EMS providers and materials such as books, pamphlets, manuals, reports, and publications that either have a direct application to EMS or were generated by an EMS organization. The star of life symbol was designed by the US National Highway Traffic Safety Administration (NHTSA) with six points representing different aspects of the purpose of EMS as outlined in Figure 1 (5).

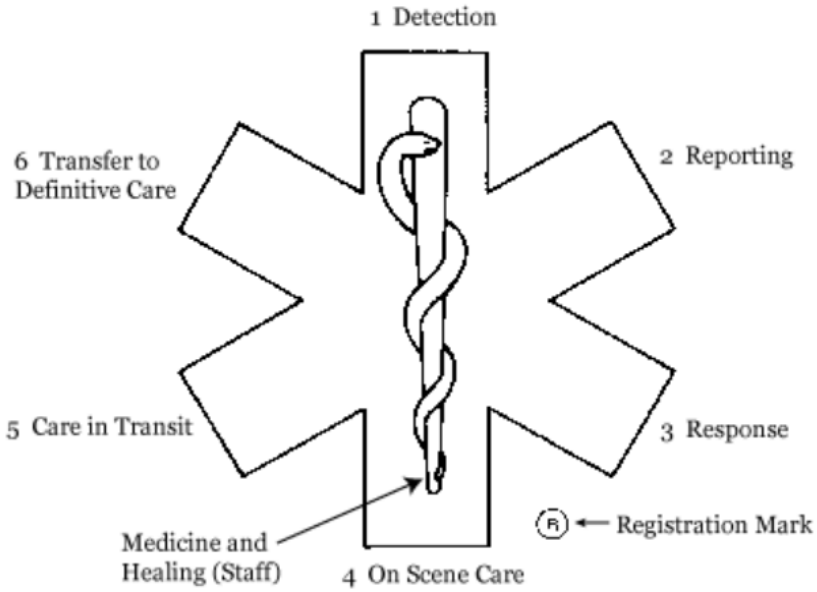

Figure 1. US National Highway Traffic Safety Administration (NHTSA) "Star of Life" (5)

Healthcare providers in EMS systems provide prehospital patient care with the goal of preventing patient mortalities and reducing the risk of long-term morbidities (1). Prehospital care is usually connected to the hospital-based patient care to form a complex adaptive system of emergency medicine (6). The care for patients in emergency settings is a complex one because the patients are always critically ill and require urgent medical attention (7). For instance, it has been reported that patients who require emergency admission to hospitals have a higher risk of mortality especially if they are admitted during weekends (8). It has also been reported that delayed transfer of patients from the point of arrival at the emergency department to inpatient wards is associated with an increase in patient mortality by approximately 20 to 30% (9,10). In addition, research has shown that prehospital care plays a significant role in expedites the patients' passage through emergency care pathway thus ensuing timely care for sepsis patients (11) and dyspnoea patients (12). Qualitative research has also shown that prehospital care is perceived by patients as a critical component of healthcare because of the reassurance they get during care (13).

HISTORY OF EMERGENCY MEDICAL SERVICE SYSTEMS

Historically, EMS systems were developed during wars to provide immediate healthcare services to the injured. Indeed, the first organised use of ambulance, “flying ambulances”, was introduced by French chief military surgeon Baron Dominique Jean Larrey during Napoleon's invasion of Italy in 1796 (14). At the time, these ambulances were light wagons driven by horses; they were staffed with battlefield caregivers for the purpose of removing the injured from war grounds and moving them to hospitals. Since then, the EMS systems have been transformed through the entry of Britain into the Crimean War in 1853 (38 nurses were taken to Scutari's barrack hospital and this reduced patient mortalities) (15), the American Civil War of 1861-1865 (Clara Barton suggested that battle causalities should be treated where they are) (14), and the suggestion by Professor Martin Kirchner in Germany that "casualty should not be brought to the physician but the physician should be brought to the casualty" in 1935 (16). This suggestion by Professor Martin Kirchner laid the foundation for the development of EMS systems in Europe, and in 1957, started the first physician-staffed ambulance in Germany (17).

After the Second World War, Kenneth Easton of the United Kingdom started "immediate care at road accidents" scheme by voluntary primary care physicians in 1949 to address what he referred to as “"the therapeutic vacuum after motor vehicle accidents in rural areas” (17). Professor Martin Kirchner and Kenneth Easton’s concepts were meant to treat patients with emergency conditions such as injuries before transport. In 1962, Sir Harry Platt published the Platt Report on EMS; the report highlighted the situation in hospital casualty departments (they were overcrowded, and they had inadequate services) (18). After viewing “casualty” as a word that may mean “casual services” (inadequate services), Sir Harry Platt proposed the term “accident and emergency”, which is currently used to refer to the then casualty departments of hospitals. In addition, Sir Harry Platt recommended the creation of

orthopaedic consultants to lead accident and emergency departments of hospitals. The Platt Report was the foundation for the current modern EMS systems, which has been advanced to include effective trauma management, air ambulances in casualty evaluations, and recently, prehospital care involving the provision of advanced treatments to patients during transport to hospitals (19). Recently, developments such as telemedicine (20), home-based care (21), and scientific research (22) have further advanced modern EMS systems. In addition, advancements in EMS equipment for cardiopulmonary resuscitation (23) and prehospital airway management (24), as well as development of advanced ambulances such as flying ambulance (25,26), have further expanded modern EMS systems.

MODELS OF IMPLEMENTING EMS SYSTEMS: ANGLO-AMERICAN AND THE FRANCO-GERMAN MODELS

The development and implementation of EMS systems in many countries across the world have evolved around two models: the Anglo-American and the Franco-German models (1). From the 1970s to the end of the 20th century, EMS systems were mainly implemented using distinct features of Anglo-American and the Franco-German models. The two models are based on the philosophy of pre-hospital care delivery. The Franco-German model is based on “stay and stabilize” philosophy with the main aim of bringing hospitals close to the patients (1). The EMS systems based on this model are usually operated by physicians with an extensive scope of practice who make use of advanced technology in providing patient care. Such EMS systems use land and other alternative modes of transport such as air and water ambulances to transfer patients to hospitals and other health facilities (1). The EMS systems based on the Franco-German model is considered a subset of a wider healthcare system and mostly used in Europe (27).

Emergency medical service providers in Europe are emergency physicians who provide a range of prehospital emergency care services (27). The physicians are thus authorised to make complex clinical decisions and provide treatments to the patients at the scenes. Consequently, most of the patients who utilise EMS systems based on the Franco-German model receive complete treatment at the site of the incident, but others may be transported to health facilities for specialized care (1). The patients who are transported to health facilities usually get direct admission to an appropriate ward; the admission is carried out by the field emergency physicians. Examples of countries that implement their EMS systems based on the Franco-German model include Germany (28), Austria (29), France (30), Malta (31), and Greece (32). However, countries with EMS systems based on the Franco-German model do not have a well-developed or largely recognized EMS systems as the EMS systems are not recognized as a separate medical specialty, but as part of hospital-based emergency medicine department (1).

On the other hand, the Anglo-American model of EMS systems is based on the "scoop and run" philosophy with the aim of rapidly transporting patients to the hospital with few pre-hospital treatments (33). In addition to being run by trained paramedics and emergency medical technicians, the EMS systems that are based on this model also work with non-medical personnel such as fire department officers and the police (34). However, clinical staff provide oversight and guidance to the EMS personnel. The EMS systems mainly use land ambulance to transport patients to health facilities, but may also use air evacuation or coastal ambulance (33). Unlike the Franco-German model, the Anglo-American model views an EMS system as a separate medical specialty that is well developed. Under this model, patients are transported to developed and equipped Emergency Departments of hospitals instead of medical wards (33). Some of the countries that implement their EMS systems using the Anglo-American Model are the United Kingdom (35), United States (34), Australia (36), Oman (37), Canada (38), and New Zealand (39).

Therefore, EMS systems based on both the Anglo-American and Franco-German models are only similar in delivering emergency medical care to patients with life-threatening conditions. However, there are certain differences in how EMS systems based on these models provide care to stable patients and how the patients are transported and admitted to hospitals in terms of the aims of the EMS system, the number of patients who are treated at the scene and those transported to the hospital, where the patients are admitted on arrival at the hospitals, the EMS providers, prehospital care provided, and the place of the EMS within the healthcare system (Table 1). Studies have attempted to compare the two models of EMS but none has reported the superiority of one over the other in terms of cost-effectiveness and patient outcomes (40–42). Modern EMS systems such as the Saudi EMS system have used a hybrid model consisting of features of both Anglo-American and the Franco-German models (1). In Iran, advancements in EMS equipment and ambulances as well as human resources a advancements in expertise of EMS providers has been reported to lead to the emergence of a hybrid model of EMS (43). As more equipment and expert EMS providers are available, more EMS systems provide both prehospital care treatments at patient scene while also transporting others to nearest hospitals for specialized care and treatments.

Table 1. Differences between EMS systems based on Franco-German and Anglo-American models

Factor	Franco-German model	Anglo-American model
Main aim	Aims at bringing the hospital closer to patients	Aims at bringing the patients to the hospital
Number of patients treated at the scene	More patients treated at the scene	Fewer patients treated at the scene

Number of patients transported to the hospital	Fewer patients transported to the hospital	More patients transported to the hospital
Admission of patients in the hospital	Patients are admitted to medical wards	Patients are admitted to the Emergency Department
EMS providers	Medical doctors with a wide scope of practice supported by paramedics	Paramedics and trained medical emergency technicians under clinical oversight
Prehospital care provided	Complex prehospital care provided by emergency physicians	Basic life-saving care provided by paramedics and trained medical emergency technicians

ORGANIZATION OF EMS SYSTEMS

Levels of EMS systems

EMS systems are majorly classified into two groups based on the level and scope of the service: Basic Life Support (BLS) and Advanced Life Support (ALS) level as per the hybrid model of the Saudi EMS system as earlier discussed. BSL level EMS systems are premised on the "load and go" approach whereby non-invasive basic prehospital care interventions are conducted at patient scene before transport to healthcare facilities (1). Some of the basic prehospital care interventions in BSL EMS systems include non-invasive cardiopulmonary resuscitation (CPR), full immobilization, fracture splinting, and oxygen administration (1). The BSL interventions are provided by basic ambulance assistants and EMS technicians. On the other hand, ALS EMS systems are premised on the stay and stabilize' approach where both basic and advanced prehospital care interventions are provided at patient scene before transportation to healthcare

facilities (1). These interventions include all non-invasive basic interventions and invasive procedures such as intravenous line placement, endotracheal intubation, needle-chest decompression, administration of medications, and fluid replacement (44). The ALS interventions are provided by paramedics, nurses, and EMS doctors.

Organization of EMS systems in different countries

In different countries, EMS services are provided by the government, private sector, and charitable organizations. In South Africa, EMS services are mainly provided by the government but both the private sector and charitable organizations also provide the services throughout the country (45). Individuals reach EMS services in South Africa by calling '10177', a regional call center, or '112' (for mobile phone users). In this country, EMS services are provided by basic ambulance assistants who are trained for at least two months to provide BSL services; ambulance emergency assistants who are trained for at least four months to provide some ALS procedures including insertion of intravenous lines, administration of intravenous glucose, use of manual defibrillators, and provision of nebulization for asthma patients; critical care assistants or paramedics trained for at least 9 months to provided ASL procedures such as pediatric advanced life support, advanced cardiovascular life support, and advanced trauma life support; and post-graduate technical EMS providers trained for four years to provide general operation and management of EMS systems (46).

In China, the EMS system is primarily funded by provincial and city bureaus of Public Health and are divided into three components: prehospital care service, emergency department care, and intensive care units. The EMS system in China is accessed by calling '120' to a regional call center, that forwards the request to appropriate ambulance dispatch centers (47). Unlike other countries, there are recognized paramedic profession in China; EMS services are provided by drivers, nurses, and medical doctors (47).

In the United Kingdom (UK), EMS services are provided by the National Health Service (NHS), the private sector, and charitable organizations. The EMS service is accessed by calling ‘112’ or ‘999’ to an NHS ambulance station from where an ambulance nearest to the patient location is dispatched. The dispatched ambulances are of two types: 1) ambulance staffed with a paramedic and an ambulance technician and 2) rapid response vehicle (motorcycles) staffed with either a paramedic or ambulance technician (35). Therefore, in the UK, EMS services are provided by EMS technicians and paramedics.

In the United States (US), EMS service is provided by both government-supported and privately-supported systems as well as charitable organizations (34,48). Government-supported EMS systems are based around fire departments in some states, based around police in others, and are separate entities in large states. In most of the states, privately-supported EMS systems partner with municipal services to provide some or all prehospital care services. In other states, hospitals may have their own EMS services (34). In the country, EMS is accessed by calling '911' to reach the fire department, police, and hospital EMS ambulance center from where appropriate ambulances are dispatched (34). The EMS services are provided by five levels of frontline EMS providers, namely first responder, basic EMS technician, intermediate EMS technician, paramedic, and pre-hospital critical-care provider.

In Saudi Arabia, EMS services are provided by the Saudi Red Crescent Authority (SRCA), which is funded by the government (49). The SRCA provides EMS services through ground EMS centers that use algorithms and guidelines of the Saudi Red Crescent Computer Aid Dispatching System (SRCCAD) to disperse ambulances at different urgency levels (50). A dispatched EMS team provides EMS services (basic and advanced life support) aimed at stabilising and transporting the patient to hospitals for further treatments (51). The dispatched team usually consists of an emergency physician or doctor, paramedics, medical emergency technicians, firefighters, and ambulance drivers (51).

Collaborations in providing EMS services

On-scene management of EMS cases is often inter-disciplinary, involving collaboration of frontline EMS providers with other agencies such as police, civil defense, and firefighters. As first responders, police carry our several functions at patient scene including securing the scene, making arrests, controlling by-standers, and providing first aid (52). Civil defense and firefighters also carry out several roles at patient scene including managing incidents, enforcing fire safety and investigation, carrying out firefighting and rescue operations, and detecting and containing hazardous chemicals and toxins (53).

EMS evaluation

History of EMS evaluation

Initially, the principles and frameworks of quality management systems that are used in the business sector have also been incorporated to evaluating EMS systems (54). Particularly, business sector models for quality improvements such as quality assurance, continuous quality improvement and complex total quality management were used to evaluate EMS systems with the goal of improving the end product and customer satisfaction (55,56). In 1992, there was a shift in the methods of evaluating EMS systems from pure quality assurance programs to quality improvement stimulated by the adoption of Continuous Quality Improvement (CQI) concept by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) (54). Based on the concept of CQI, quality indicators based on Donabedian's structure-process-outcome model have been identified to evaluate EMS systems; the model evaluates the structure (characteristics of a health care setting), process (medical care, interventions, and procedures performed in a health care setting), and outcome (health status and conditions of a patient after particular medical interventions) (54,57).

Structure of an EMS system comprises the EMS infrastructure: staffs, equipment, guidelines, and deployments. The process of an EMS system comprises how EMS is provided: timeliness of the response, provision of basic and advanced treatments, adverse events, documentation, and methods use dot address the needs of patients' relatives and bystanders. The outcome of an EMS system comprises changes in patients' health due to the EMS service: patient survival, patient discharge, mortalities, length of hospital stay, etc. (58). The data regarding structure, process, and outcome of an EMS system can be grouped into different quality domains, groups of measurable EMS attributes (54).

Definition and components of EMS evaluations

Evaluation of a healthcare system is a process that involves collecting information or data that is used to facilitate judgements regarding the value and success of healthcare system and importantly to make improvements. Evaluations are conducted in healthcare systems to identify strengths and weakness of healthcare interventions and to make decisions for future course of actions (59). According to the UK The Health Foundation (60), evaluation of EMS systems is not only important in demonstrating the success of an intervention, but is also important in showing whether the planned goals have been achieved and what needs to be leant. In doing this, evaluations help show whether there are beneficial changes achieved by an intervention and whether the changes have been achieved efficiently. Consequently, healthcare evaluations identifies the quality of healthcare systems; quality is defined by the Institute of Medicine (IoM) as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (54) (p.1). Quality evaluation is based on various quality indicators (QIs), defined as quantitative end points used to guide, monitor and improve the quality of patient care (61). These QIs need to be measurable, pragmatic and according to different types of healthcare

services (62). The same principle of healthcare quality applies to EMS, and therefore, evaluation of EMS systems involves measurement of particular indicators to identify strengths, gaps, and quality of an EMS system (54). Such EMS evaluations are significant in determining the quality and safety of prehospital care, a critical component of emergency medicine directly affecting patient outcomes and provide data that can be used for quality improvements (54,63).

Frameworks for EMS evaluation

As EMS is a system made up of prehospital care, transportation, and hospitalization, a comprehensive EMS evaluation framework should include all these components. Pre-hospital care, transportation, and hospital care components are all connected to a single complex adaptive system (emergency medicine) (64). These three components have been reported to affect the clinical outcomes of patients independently. For instance, a study by Murad et al. (65) in Iraq found that prehospital trauma care reduces patient mortality—prehospital care treatments by paramedics and first responders was found to reduce mortalities in patients with major injuries. Similarly, a study in Taiwan found that prehospital care treatments during transportation of out-of-hospital cardiac arrest patients increases their survival (66) Therefore, an evaluation of EMS systems should take into consideration all three components of EMS (structure, process, and outcome).

Tools for EMS evaluations

Several studies have evaluated EMS systems in various countries including the US (67,68) and the United Kingdom (69). Such EMS evaluations are significant in determining the quality and safety of prehospital care: a critical component of emergency medicine directly affecting patient outcomes (54,63). However, no study has evaluated the structure, process, and outcome of the Saudi EMS system (70,71). In chapter 2, a literature review is conducted to identify EMS

evaluation tools and the most suitable tool for evaluating the Saudi EMS system. In Chapter 3, the tool is adapted for use in Saudi Arabia.

Quality domains

Quality domains are attributes of quality that are categorized into certain themes. National Academy of Medicine (NAM), previously known as Institute of Medicine (IOM) identified six categories for the different domains: timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity. According to Moafa et al. (72), these six quality domains are highly recommended by the World Health Organization for health systems and policy makers to reform and optimize outcomes.

1) Timeliness is a quality domain that refers to the organization of an EMS system to reduce needless and potentially harmful delays in responding to EMS calls, providing EMS care, and transporting patients to healthcare facilities (58). Timeliness such as initial response have been reported to affect patient outcomes only in small patient populations (73,74), possibly because timeliness variables are measures of logistics and not the actual prehospital care. Time to arrival of EMS team is known to be important for certain critical conditions, particularly cardiac arrest and major trauma (75).

2) Safety measures potential medical, technical, or operational risks and hazards to patients, bystanders, and EMS staff (58). EMS response teams operate rapid response ambulances, which may pose operative risks to members of the team, patients, and bystanders (58). In addition, EMS involves provision of care to critically ill and severely injured patients without the safety equipment and measures found in hospitals, and the prehospital care environment may have additional risks such as extreme temperatures and traffic jams. Therefore, EMS evaluations needs to consider safety as one of the quality domains (76).

3) The efficiency of an EMS system refers to the strategies put in place to avoid wastage of human and material resources e.g. wastage of EMS staff, equipment, and provision of advanced incident management to reduce dependence on hospital care (58). According to Haugland et al. (58), an efficient EMS system should reduce over-triage, and ensure that available human and non-human resources are optimized for effective delivery of care.

4) The effectiveness of an EMS system refers to the quality of provided prehospital care based on the use of evidence-based protocols, the involvement of physicians in providing EMS care, and provision of appropriate, advanced treatments during an EMS response (58). Under this quality domain, the ability of EMS systems to only provide interventions that have been proven to be effective should to prevent under-treatment is assessed.

5) Patient-centeredness in EMS systems refers to the responsiveness of the EMS care to individual needs, needs of the patient, and those of their relatives (58). This quality domain is based on the approach of provision of patient- and family-centered care, which involves partnership between the patient, patients' relatives, and healthcare providers (77). Consequently, evaluation of EMS quality under this domain involves assessment of whether EMS response was based on patient- and family-centered care approach where the needs of patients' relatives were also addressed.

6) Equity of an EMS system refers to quality EMS care for patients regardless of their gender, ethnicity, socioeconomic status, geographical location, and population density (58). An EMS system can provide equitable service by reducing time taken to transport patient and by bringing hospitals closer to people when providing advanced prehospital care treatments in addition to basic life support (58). Consequently, under this quality domain assessment of whether EMS services are provided to patients regardless of their gender, ethnicity, socioeconomic status, geographical location, and population density as well as whether the

EMS response team has an EMS physician to provide advanced prehospital treatments should be assessed.

In addition, there are other healthcare quality domains such as appropriateness, access, continuity, and acceptability that have been reported in literature (78). Whilst the literature (as reviewed in this section) recommends specific quality domains, and a number of potentially relevant quality indicators for aspects of those domains have been proposed in the literature, there has not been a review to synthesise the recommendations from the literature for which quality indicators are most appropriate to evaluate each quality domain for EMS evaluations. In Chapter 2, a literature review is conducted to identify the most appropriate QIs under the structure, process, and outcome and under each of the six quality evaluations.

PROBLEMS FACED BY FRONTLINE EMS PROVIDERS

Researchers have reported a myriad of challenges faced by frontline EMS providers when responding to EMS cases; among these, challenges affecting communication with patients and/or their relatives, patient privacy, and ability to address needs of patient relatives stands out as key challenges that affect quality of EMS response (79,80). For instance, language barrier during EMS response has been reported to be a significant challenge in providing EMS services in the US where more than 20% of households use non-English language (81). Language barrier has also been reported to be a challenge in providing EMS services in other countries such as Germany (82), Canada (83), South Africa (84), Minnesota (79), Kuwait (85), and Iran (86). Challenges in maintaining patient privacy such as overcrowding and lack of support from other agencies have also been reported in literature in other countries including Finland (87), Australia (88), and Iran (89). In the US, Ayub et al. (80) found that frontline EMS providers report one of the challenges in addressing the needs of patient relatives during EMS response as interferences with patient care. In Saudi Arabia, however, no study has investigated

or reported these challenges; the available studies have focused only on factors affecting the efficiency of EMS paramedics (70) and EMS technicians (90) and public EMS awareness in Western Saudi Arabia (91).

INTRODUCTION TO THE SAUDI HEALTH SYSTEM

Information about Saudi Arabia

Saudi Arabia is located at the furthermost part of southwestern Asia, bordered by the Arabian Gulf, United Arab Emirates and Qatar in the east; Red Sea in the west; Kuwait, Iraq and Jordan in the north; Yemen and Oman in the south. The kingdom occupies approximately four-fifths of the Arab Peninsula with an area of about 2,000,000 square kilometers (92). Politically, Saudi Arabia is a monarchy ruled by the Saud dynasty (Āl Saʿūd), a family who established their royal status after close association with the Wahhābī religious establishment. The country legislation is mainly based on the Islamic law, the Sharīʿah. However, legislations can be mitigated by several other factors such as influence of intertribal politics, inner politics of the royal family, and political expediency (93). The kingdom has a national celebration on September 23 every year to commemorate the founding of the Kingdom by his Majesty King Abdul Aziz Abdul Rahman Al-Saud in 1932A.D (1351 A.H). Saudi Arabia's cultural setting is Arab and Muslim, with a population largely composed of nomads, villagers, and townspeople (93). In terms of religion, the kingdom is an Islamic state and celebrates a Hajj festival, a religious pilgrimage characterized by mass gatherings of people visiting Mecca annually (93).

The Saudi health system

The Saudi health system can be traced to 1925 when a royal decree by King Abdulaziz led to the establishment of the first public health department in Mecca (94). The public health

department was tasked establishing dispensaries and hospitals to provide and monitor free healthcare services to the general population and pilgrims. In 1950, Ministry Of Health (MOH) was established through another royal decree to provide healthcare services throughout the entire country (94). Currently, MOH is the major provider of healthcare services in Saudi Arabia through health centres that provide emergency services and mobile clinics to people in the interior regions of the country and specialised hospitals that provide advanced healthcare services and hospitalisations (51).

The Saudi EMS system

Following the Saudi Yemeni War of 1934, an independent EMS provider under the Charitable Relief Society was formed to provide EMS services, but these services were limited to Mecca and Medina regions (95). The war also led to the establishment of National Ambulance Health Association, and the EMS system was regulated by Public Health and Ambulance Authority. Due to the consequences of World War II, the incomes of private EMS providers diminished; therefore, the Charitable Relief Society was converted from a private entity to a government-owned, public institution under the name Saudi Red Crescent Association (96). In 2008, the name of the Saudi Red Crescent Association was amended to the Saudi Red Crescent Authority (SRCA) (96).

Currently, in Saudi Arabia, prehospital EMS services (which is the focus of this study) are provided by the Saudi Red Crescent Authority (SRCA) through ground EMS centers that use algorithms and guidelines of the Saudi Red Crescent Computer Aid Dispatching System (SRCCAD) to disperse ambulances at different urgency levels (50). A dispatched EMS team provides EMS services (basic and advanced life support) aimed at stabilising and transporting the patient to hospitals for further treatments (51). The dispatched team usually consists of an

emergency physician or doctor, paramedics, medical emergency technicians, firefighters, and ambulance drivers (51).

The latest SRCA annual report indicates that the authority operates 384 ambulance centres distributed in 13 regions of the country. According to the report, Riyadh is the leading region with 77 centres (20% of all the centres) followed by Makkah region (71 centres, 19%) with Najran and the northern border region being the least (each having 12 centres, 3%) (97). Unpublished SRCA data show that, in 2017, the Saudi EMS system attended to 302,983 emergencies: 92938 in Makkah with a population of about 8.8 million people as at 2018 (98) and 60531 in Riyadh with a population of about 6.9 million people as at 2018 (99), and the rest in other regions.

The structure of the Saudi EMS system mainly suits the Anglo-American model (96). The focus of the Saudi EMS system is to transport patients to hospitals for emergency treatment; few patients are treated at the scene, more patients are transported to the hospital, patients are admitted to the Emergency Department upon arrival at hospitals, and the EMS team mainly consists of paramedics and emergency medical technicians. However, the Saudi EMS system also includes certain features of the Franco-German model such as including emergency physicians in the EMS team and providing advanced life support to the patients (96). While the basic life support adopts the "scoop and run" approach where the patient is only stabilised before being transported to the hospital, the advanced life support adopts the "stay and stabilize" approach where advanced medical interventions are provided (51). The basic life support EMS team is usually dispatched when patients requiring the EMS services do not need invasive interventions but need rapid transportation to hospitals (51). Some of the prehospital basic life support services performed by the Saudi EMS team include administration of oxygen, carrying out CPR, dressing wounds, and splinting fractures (51). On the other hand, the advanced life support EMS team is usually dispatched when patients need invasive

interventions such as administering medications, carrying out endotracheal intubation, decompressing needles, and replacing fluids (100).

Although the Saudi EMS system and operations of the SRCA are funded by the government hence affordable (49), the system also faces certain challenges. For instance, the EMS system is faced with the challenge of under-utilization (101) and the lack of adequately trained prehospital care providers (102,103). Particularly, research shows that most of the patients in Saudi Arabia do not utilise the Red Crescent EMS system when being transported to hospitals due to poor EMS infrastructure and lack of awareness (101). The AlHabib et al. (101) study had the strength of having a large sample size, but the study used hospital registry data but hospital enrolment of patients was voluntary. Therefore, some of the observations made in the study may not be representative of clinical practice in all hospitals. In addition, Althubaity et al. (102) reported that most prehospital care providers in Saudi Arabia lack adequate knowledge regarding stroke symptoms. This study interviewed 102 EMS personnel in Riyadh and this a fairly a large sample size (102). Other organisational challenges such as lack of publications of key EMS performance indicators have also been cited as issues facing the EMS system in Saudi Arabia (103). The Al-Ghamdi (103) had the strength of a large sample size (165 ambulance stations), but has the limitation of not compressively investigating the challenges facing provision of EMS services in Saudi Arabia.

In Saudi Arabia in particular, limited studies have assessed the quality of the Saudi EMS system and none of the studies have comprehensively assessed all the quality domains of the EMS system. As at 2018 when this study was conducted, available studies have focused on some aspects of the EMS system only: disparities between EMS utilization and timeliness in rural and urban areas (50), challenges faced by paramedics (70), EMS transportation services (71,104,105), public awareness of the EMS system (91), and factors affecting efficiency of EMS technicians (90). Nonetheless, several studies have highlighted factors that may affect

access to and quality of EMS services. For instance, Hajj mission has been reported as one of the factors that may affect access to and quality of EMS services as the festival is characterized by mass gatherings of people visiting Mecca annually for religious propose (51). During Hajj, EMS centers outside Mecca send ambulances and frontline EMS providers to Mecca thereby affecting their capacity to provide quality EMS services in those locations. Other factors that have been mentioned in literature to affect access to and quality of EMS services in Saudi Arabia include lack of public awareness (91), disparities in availability of EMS services (50), and lack of adequate number of EMS physicians (106). However, none of the studies provides evidence for the impact of Hajj.

Study rationale

Studies report that EMS care and transportation improves the clinical outcomes of various patients including those with breathing difficulties, poisoning, uncontrolled bleeding, acute infectious diseases such as cholera and septic shock, and numerous other injuries and medical emergencies (107–110). These findings show that EMS plays an important role in healthcare hence the need to evaluate EMS systems. However, EMS providers often face certain challenges in providing their services, including overcrowding, inadequate EMS materials and medications, non-standardised EMS protocols, poor decision making, and staff fatigue (111–113). In Saudi Arabia, however, no study has comprehensively evaluated the EMS system; the available studies have focused on some aspects of the EMS system only. Also, no study has been conducted in Saudi Arabia to investigate the effects of Hajj festival on the timeliness of EMS response and prehospital care treatments provided to patients in Saudi Arabia. While most studies investigated the effect of Hajj festival on health outcomes in Makkah where the festival takes place, this study looked at the effects of the Hajj festival in Riyadh where although the festival does not take place there, it puts strains on its EMS infrastructure.

Also, there are no standard tools or quality indicators that have been developed to evaluate EMS systems. Although there are recommended domains and quality indicators, no review has previously synthesized these and to identify the ones that can be applied to Saudi Arabia. Similarly, there are tools available for EMS evaluation in other countries, but these have not been reviewed, and their relevance to the Saudi context is not known. Regarding the challenges faced in the provision of EMS in Saudi Arabia, some of the problems are known but the only way to find out what the problems really are for the staff is to ask them.

STUDY AIMS AND OBJECTIVES

No study has evaluated the structure, process, and outcome of the Saudi EMS system. In addition, there is no standard tool for the evaluation of the country's EMS system. Therefore, we aim to develop an EMS evaluation tool for Saudi Arabia and to comprehensively assess the timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity quality domains of the Saudi EMS system based on its structure, process, and outcome in Riyadh city. Also, researchers in other countries have reported a myriad of challenges faced by frontline EMS providers when responding to EMS cases; among these, challenges affecting communication with patients and/or their relatives, patient privacy, and ability to address needs of patient relatives stands out as key challenges that affect quality of EMS response. In Saudi Arabia, however, no study has investigated or reported these challenges. Therefore, this study was also conducted to identify challenges reported by frontline EMS providers in providing EMS services and opportunities for improvement in Riyadh city. In addition, during Hajj festival, a religious pilgrimage characterized by mass gatherings of people visiting Mecca annually, EMS centers outside Mecca send ambulances and frontline EMS providers to Mecca thereby affecting their capacity to provide quality EMS services in those locations. Therefore, this study was also conducted to investigate the challenges faced in Riyadh city after sending ambulances

and frontline EMS providers to Mecca during Hajj festival. In particular, this study was carried out to meet the following objectives:

1. To conduct a scoping review of tools and indicators that have been used to evaluate EMS systems
2. To map out the structure of the Saudi EMS system to identify aspects of the Saudi EMS system for EMS evaluation and develop a structure, process, and outcome-based tool for evaluating the country's EMS system
3. To describe the characteristics and medical needs of patients using EMS based on sampled PCRs in Riyadh city to understand any disparities in use of EMS and whether patient characteristics affects quality of the service
4. To describe the characteristics of staff employed in the Saudi EMS system in Riyadh city to identify any gaps in staffing and whether the staff are qualified to provide the EMS service
5. To use the "developed" tool to evaluate the Saudi EMS system in Riyadh city
6. To explore from staff perspective their perceptions of the challenges of providing EMS services and opportunities for improvement in Riyadh city
7. To make recommendations on strengths and limitations of the Saudi system in Riyadh city and potential areas for improvement
8. To make recommendations on strengths and limitations of the methods used in this study to evaluate and how these could be improved.

Chapter 2: Quality Indicators and Tools for Evaluating the Saudi EMS system: A Literature Review

INTRODUCTION

The importance of quality improvement in various healthcare settings has been highlighted by several studies and international health organizations (114–116). Quality improvement programs first assess the quality of particular healthcare systems before recommending strategies for improving the quality of health services. Quality assessment is based on various quality indicators (QIs), defined as indicators of healthcare quality (58,62). These QIs also need to be measurable, pragmatic and appropriate to the nature of healthcare service/context (62).

The definition of emergency medical service (EMS) QIs can be best understood from the definition of quality itself. The Institute of Medicine (IOM) defined quality as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (117). A conceptual analysis by Allen-Duck et al. (118) concluded that healthcare quality is defined as "the assessment and provision of effective and safe care, reflected in a culture of excellence, resulting in the attainment of optimal or desired health". In the context of EMS, the definition of quality takes a design of a system where there are specific facilities, personnel, and equipment arrangement to ensure that there is appropriate care that meets expected outcomes (54). The arrangement of specific facilities, personnel, and equipment in EMS is also necessary for ensuring a coordinated and effective way of delivering EMS services (54). Nonetheless, EMS has evolved to fit the needs of various communities in different emergencies such as major road trauma, military, and non-traumatic cardiac arrest. Such customization of EMS has caused heterogeneity in design, making it complex to evaluate and compare quality in EMS (54). Consequently, EMS quality indicators should be a means of measuring the essential

dimensions of quality such that current quality can be assessed, and improvements put in place to improve quality (119).

According to Mainz (120), an ideal healthcare QI should have the following seven key characteristics: (1) should be based on agreed definitions, and described exhaustively and exclusively; (2) should be optimally and highly sensitive and specific; (3) should be valid and reliable; (4) should be sufficiently discriminative; (5) should clearly relate to identifiable events; (6) should permit useful comparisons; and (7) should be evidence-based. In addition, a health QI should be objectively measurable to assess all the attributes of quality: timeliness (58), safety (76), efficiency and effectiveness (42,121), patient-centeredness (77), and equity (58). According to Haugland et al. (58), these quality dimensions are defined as: the potential medical, technical, or operational risks and hazards to patients, bystanders, and the EMS staff (safety); strategies put in place to avoid wastage e.g of EMS staff, equipment, and provision of advanced incident management to reduce dependence on hospital care (efficiency); quality of prehospital care based on use of evidence-based protocols and involving physicians in providing EMS care and advanced treatments (effectiveness); the responsiveness of the EMS care to individual needs, needs of the patient and those of their relatives (patient-centeredness); and quality care for every patient regardless of their gender, ethnicity, geographical location, and socioeconomic status (equity).

In EMS context, QIs such as ambulance response times, patient feedbacks, availability of material and human resources, funding, EMS records, and adverse events have been used to evaluate EMS systems (122–124). However, standard EMS QIs are lacking, there is no consensus on EMS QIs, and the feasibility of measuring some of the QIs may vary from one region or context to another. For instance, some of the available QIs may be appropriate in high-income settings but not in low-income settings (62). In addition, some of these QIs only evaluate some components of EMS systems. In Saudi Arabia, for instance, no study has

comprehensively evaluated the EMS system; the available studies have focused on some aspects of the EMS system only: challenges faced by paramedics (70), EMS transportation (71,104,105), awareness of the EMS system (91), and factors affecting efficiency of EMS technicians (90).

In addition to the lack of standard QIs, there is no standard or widely accepted tool for assessing the quality of EMS systems in any context, especially in Saudi Arabia. A tool is a data collection instrument such as questionnaires that is used to obtain data for measuring particular QIs (58,125). In the EMS context, these tools should collect data for measuring one or more EMS QIs. Data collection tools for assessing EMS quality should also be valid and reliable. Determining the validity of data collection tools involves comparison of data collected by the new instrument with those collected by a gold-standard tool. However, there is no gold-standard tool for evaluating EMS systems. Therefore, validation of EMS tools have been conducted by assessing the feasibility, rankability, variability, actionability and documentation of the QI measurements (125) and by assessing the content of the tool for relevance or permanence (20). In addition, data collection tools for assessing EMS quality should have benchmarks for interpreting its QI measures (125).

Although there is no standard EMS evaluation tools and no tool has been developed for Saudi Arabia or other Arabian Gulf states, a number of studies have identified and/or proposed relevant QIs for assessing the quality of EMS systems in Saudi Arabia and other countries (58,124,126,127). Scoping reviews (72,128–130) have also been conducted to work out what QIs are out there, and to some extent they come up with slightly different lists of potential quality indicators, and they perhaps don’t provide the detail on what the benchmarks for the QIs. In this chapter, the information from these studies and reviews are synthesized by to work out whether there is a consensus on what the indicators should be and to provide a structured approach for deciding on those quality indicators for the current research, to examine how they

fit within the relevant quality domains, and to identify the benchmarks that might be used for them.

LITERATURE REVIEW OF REPORTED EMS QUALITY INDICATORS

The researcher carried out a comprehensive literature search in the CINAHL, PubMed, Cochrane Library, MEDLINE, Google Scholar, and ScienceDirect databases to look for review articles that have synthesised EMS QIs reported in literature. The literature search included the following keywords: emergency medical services or EMS or ambulance services or prehospital care, quality indicators, quality factors, quality tools, quality measures, quality outcomes, and review articles. Review articles that met the following inclusion criteria were included: (1) published in the English language in the past five years, from 2015 to 2020 to identify updated QIs considering the changing technological and infrastructural architecture of EMS (language and date of publication); (2) involved systematic literature review or scoping review designs (study design); and (3) reported QIs for assessing the quality of EMS systems (outcomes). Articles that did not meet this inclusion criteria were excluded.

After the literature search, a total of four review articles met the inclusion criteria and were included for qualitative synthesis: three scoping reviews (128–130) and one systematic literature review (72). The reviews included articles published before April 2016 [Howard et al. (128)]; from January 1, 2000 to April 16, 2017 [Pap et al. (129)]; from 2008 to 2018 for review articles and from 2016 to 2018 for primary articles [Poulsen et al. (130)]; and no specific dates of included articles [Moafa et al. (72)] (Table 2). These reviews included a total of 104 articles: 25 from Howard et al. review article (128), 39 from Pap et al. review article (129), 15 from Poulsen et al. review article (130), and 25 from Moafa et al. review article (72). Although the three scoping review articles (128–130) had the strength of using a simple literature review methodology with a simple aim, they also had certain limitations. For example, the Howard et

al. (128) scoping review did not assess the quality of the research evidence. Secondly, the scoping review did not assess the homogeneity of evidence and lacked a method of data synthesis. The Pap et al. (129), and Poulsen et al. (130) review articles also had the limitations associated with any review methodology including less exhaustive literature search and language limitations. The systematic literature review article (72) had the strength of using an rigorous literature review methodology. However, as reported by the reviewers, the systematic literature review article had a limitation that the average quality of the reviewed studies was moderate.

From the four reviews, total of 43 QIs were extracted after reading articles and noting down the QIs reported by each article, which were categorized into clinical QIs and non-clinical or system or organizational QIs (Table 2). The QIs were also categorized into five quality domains described in Chapter 1: safety, timeliness, efficiency, effectiveness, patient-centeredness, and equity) (Appendix 1) (72), as detailed below:

- Structure: number of EMS units per population and number of EMS units per area using data, initial time to respond, time to arrival of EMS response team, on scene time; time to preferred destination, adverse events using data, complete documentation
- Process: performance monitoring, audit, appraisal, and/or debriefing using survey data; guidelines for actual medical problems; provision of advanced treatments; patients enrolled in research projects using survey data; time-sensitive illnesses; and care for patient relatives using survey data from frontline EMS providers
- Outcome: patients arriving to the hospital alive

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Table 2. EMS quality indicators reported by previous reviews

Citation	Year	Type and aim of the review	Number and design of included studies	Number of quality indicators	Categories of reported quality indicators	Recommendations
Howard et al. (128)	2018	Scoping review, to identify prehospital emergency care-specific Qis	25 articles majority based on Delphi/RAND/Consensus type and Observational Cohort study methodologies. Others were literature reviews or case series and audits	13 Qis	• Clinical domain QIs (Appendix 1) • Non-clinical domain QIs (Appendix 1)	• Most of the QIs originated from high-income or developed countries hence suitable for such contexts • The QIs can be grouped based on the Donabedian's structure-process-outcome model
Pap et al. (129)	2018	Scoping review, to identify QIs used to measure prehospital care quality	Total of 39 articles: Consensus, mixed qualitative method, retrospective case series/audit, observational cohort study, Literature/systematic review, Editorial, focus, perspective, commentary, government sources/industry report, and others)	14 Qis	• Clinical QIs (Appendix 1) • System or organizational QIs (Appendix 1)	• The QIs have 17 major attributes[1] • Exiting QIs should be validated • Other QIs should be developed through scientifically rigorous *de novo* methods • The QIs can be grouped based on the Donabedian's structure-process-outcome model
Poulsen et al. (130)	2019	Scoping review (current published as an Abstract), to identify QIs developed for EMS	15 articles (designs of included studies not reported)	4 Qis	• Clinical QIs (Appendix 1) • Non-clinical QIs (time intervals, resources, and adverse events) (Appendix 1)	• Most QIs are based on time intervals and large disease-specific group • The existing QIs should be validated

Moafa et al. (72)	2019	Systematic literature review, to identify EMS quality indicators in the Arabian Gulf States	25 articles based on Cross-sectional, retrospective, prospective cohort studies, and survey designs	12 QIs	• QIs for assessing the safety, timeliness, effectiveness, patient-centeredness, and equity of EMS systems (Appendix 1)	• EMS response time is an important QI for life-threatening conditions

[1]The 17 major attributes of EMS QIs as reported by Pap et al. (129) include clinical effectiveness, efficiency, equitability, safety, appropriateness, timeliness, accessibility, patient-centeredness, responsiveness, acceptability, continuity/sustainability, availability, capability, caring, cost-effectiveness, interpersonal effectiveness, and leadership

Abbreviations: QIs, quality indicators; EMS, emergency medical service

Across the 4 reviews, the clinical QIs were categorized into two major groups: (1) proportion of patients with time-sensitive illnesses (such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction) who received prehospital emergency care; and (2) proportion of patients who received advanced treatments (such as airway management and pain management) during prehospital care. On the other hand, non-clinical QIs (listed below) were mainly 15, with the first 4 focusing on timeliness:

1. Ability to respond immediately (percentage of immediate response based on the difference between time call received and time response team is deployed) (72,129,130)
2. Time to arrival of EMS response team (mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes) (72,129,130)
3. On scene time (mean time interval between time call received to time of arrival at patient scene in minutes) (72,128–130)
4. Time to preferred destination (mean time interval between time call received to time patient is delivered to preferred destination in minutes) (72,129,130)
5. Proportion of positive patient feedbacks (72,128,129)
6. Proportion of available materials and resources versus required ones (128–130)
7. Proportion of EMS patients recruited into EMS studies (128,129)
8. Proportion of EMS patients arriving alive to health facilities (72,128,129)
9. Proportion of EMS responses that are monitored, debriefed, appraised, and/or audited (128,129)
10. Proportion of expenses against the total budget (128,129)
11. Number of MS physicians, doctors, paramedics, nurses, EMS technicians, and other EMS providers (72,128,129)

12. Proportion of complete EMS records (128,129)
13. Availability of guidelines for communication among the response team, communication with patients and their relatives, and availability of criteria for dispatching response team (128,129)
14. Proportion of adverse events during an EMS response (128,130)
15. Availability of safety guidelines and materials for frontline EMS providers, patients, and by-standers (72,128,129)

The next section of this chapter reviews the literature to identify available EMS evaluation tools that contain all or some of the QIs found in this section.

LITERATURE REVIEW OF REPORTED TOOLS FOR EVALUATING EMS SYSTEMS

A literature search was undertaken in the PubMed, Google Scholar, and ScienceDirect databases to identify studies that have developed tools for evaluating EMS systems based on some or all the reported QIs. For the purpose of this review, a tool was defined as a data collection instrument such as questionnaires that is used to obtain data pertaining to one or more QIs for the evaluation of EMS systems.

Review question

This literature review as conducted to answer the following question: What tools are available for evaluating EMS systems?

Inclusion and exclusion criteria

In this literature review, potentially relevant articles were included or excluded based on their study designs, study population, and outcomes (Table 3).

Table 3. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion	Rationale
Language of publication	Published in the English language	Published in other languages other than English	Due to language limitation
Study design	Literature reviews and original research articles (such as cross-section, cohort, case-control studies, qualitative studies, and other tool development articles)	Case reports and case series	Need for comprehensive reports on each tool
Study populations	EMS patients with any medical emergency: prehospital care and transportation	Patients in other healthcare settings	Relevance to EMS and any medical emergency
Outcomes	Includes one or more EMS QIs	No EMS QI included	To meet the objectives of this review

Abbreviations: EMS, emergency medical service; QI, quality indicator

Databases

In this literature review, a literature search was conducted in CINAHL, PubMed, Cochrane Library, MEDLINE, Google Scholar, and ScienceDirect databases.

Search strategy

The literature search included the following keywords: emergency medical services or EMS or ambulance services or prehospital care, tools, questionnaires, data collection instruments, and evaluation method. Different combinations of the keywords were combined using the Boolean

operators "AND", and "OR" to maximize the yield of literature search. Particularly, "OR" was used within the two domains of the literature search: EMS (emergency medical services OR EMS OR ambulance services OR prehospital care) and tools (tools OR questionnaires OR data collection instruments OR evaluation method). "AND" was used to combine the keywords in the two domains into the following search term: "(emergency medical services OR EMS OR ambulance services OR prehospital care) AND (tools OR evaluation method OR questionnaire)." The literature search in all the databases were refined by year of publication to obtain recent and updated tools: 2010 to 2020 in Science Direct and Google Scholar databases and 10 years in PubMed.

Data management

To avoid duplicates due to literature search in several databases, bibliographic management software (Mendeley desktop) was used to identify and remove duplicates. Citations of identified articles were entered into a Mendeley folder and the "search duplicates" command used to identify and remove any duplicates.

Data extraction

Data regarding EMS quality indicators and how the indicators can be assessed were manually extracted and grouped into six different quality dimensions (timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity).

Data synthesis

The extracted data were synthesised by grouping the particular quality indicators and their assessment tools into six quality dimensions: timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity

Results

After the literature search, four studies met the inclusion criteria and were included (58,124,126,127). Each of the studies had potential tools developed for Australia, Austria, Denmark, Finland, Norway, Scotland, United Kingdom and the United States of America (58); the United States of America (124); Brazil (126); and Sweden (127). None of the studied had a validated tool, but two of them had tools that have been used in a study: Haugland et al. (58) EMS questionnaire used by Haugland et al. (125) to evaluate physician-staffed helicopter EMS systems in Finland, Sweden, Denmark, and Norway; and Sund (127) EMS simulation model Used in the SALSA study (Table 4).

Description of the tools

providing four tools that were included for qualitative synthesis: the Haugland et al. (58) EMS questionnaire, Dantas et al. (126) quality assessment on pre-hospital care (QA-PHC) instrument, Mehmood et al. (124) Comprehensive EMS assessment tool and Sund (127) EMS simulation model (Tables 4 and 5).

Evidence on validity/feasibility of the various tools

All the tools have not been validated due to lack of a gold-standard tool of measuring EMS QIs, but the feasibility, rankability, variability, actionability and documentation of the QI measurements of the Haugland et al. (58) EMS questionnaire has been established (125). Similarly, the relevance or permanence of the contents of Dantas et al. (126) QA-PHC instrument has been established by a prehospital care team of 11 nurses and 24 doctors (126). However, there are no reports regarding validation or feasibility of the Mehmood et al. (124) Comprehensive EMS assessment tool and Sund (127) EMS simulation model.

Table 4. Previously reported tools for evaluating EMS systems

Citation	Year	Type of study	Reported tool	Development and validation	Indicators and domains measured by the tools	Where it is being used
Haugland et al. (58)	2017	Consensus methodology	EMS questionnaire	Tool developed by a multidisciplinary team consisting of three general practitioners, two EMS medical directors, a director of a public health institute, a specialist in community medicine, a patient-organization leader and ten physicians working in EMS. The tool has not been validated, but its feasibility, rankability, variability, actionability and documentation of the QI measurements has been established by Haugland et al. (125) in a prospective observational study	26 QIs for assessing structure, process, and outcome of EMS systems (Table 5) Quality dimensions: timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity	Used by Haugland et al. (125) to evaluate physician-staffed helicopter EMS systems in Finland, Sweden, Denmark, and Norway
Dantas et al. (126)	2015	Content validation of expert opinions	QA-PHC instrument	Tool developed by a team of 11 nurses and 24 doctors working in pre-hospital care of Rio Grande do Norte. Not validated, but the relevance or permanence of its contents have been established by the same team	17 QIs for assessing the structure and process of EMS systems (Table 5). No quality dimensions reported	No known study has used the QA-PHC instrument
Mehmood et al. (124)	2018	Consensus methodology	Comprehensive EMS assessment tool	Tool developed by an expert team made up of an EMS physician, a trauma surgeon, public health professionals, health system researchers, and EMS administrator. No validation reports	50 QIs for assessing building blocks, system outputs, and outcomes of EMS systems (Table 5) No quality dimensions reported	No known study has used the Comprehensive EMS assessment tool

Sund (127)	2013	Simulation methods	EMS simulation model	Tool developed by Sund using driving times with geographic information systems No validation reports	2 QIs: ambulance response times and survival of patients with out-of-hospital cardiac arrest (Table 5)	Used in the SALSA study

Abbreviations: QIs, quality indicators; EMS, emergency medical service; QA-PHC, quality assessment on pre-hospital care

Table 5. Quality indicators in the EMS tools

Tool	Quality indicators		
	Structure	Process	Outcome
Haugland et al. (58) EMS questionnaire	1. Immediate EMS response 2. Enrolling patients to scientific study 3. Staffing dispatch centre with EMS physician at all times 4. Number of EMS units per population and area 5. Performance of interfacility transports, duration of prehospital care delivery by EMS doctors 6. Training for EMS staff 7. Qualifications of EMS staff 8. Availability of EMS guidelines 9. Availability of systems for collecting patient feedback	10. Time intervals 11. Appraisal of an EMS response 12. Adverse events reported during an EMS response 13. Completeness of EMS documentation 14. Involvement of a physician or doctor in dispatching EMS team 15. Competence of EMS response team 16. Provision of advanced treatments during EMS response 17. Ability to address relative and by-stander needs	18. Patient mortality during EMS response 19. Documented complaints for patients and their relatives as well as receiving hospitals
Dantas et al. (126) QA-PHC instrument	Structure • Conservation status	Process • Access to EMS service	Outcome None

	• Overall physical structure of service • Comfort in the ambulance • Availability of material resources • Safety for ambulance costumers • Safety for EMS professionals • Continuous learning • Safety demonstrated by professional staff	• Welcoming nature of EMS staff • EMS service with humanity • EMS response time • Maintaining costumers' privacy • Availability of care guidelines Relationship between professionals and costumers • Costumer opportunity to make complaints, • Multiprofessional articulation	
Mehmood et al. (124) Comprehensive EMS assessment tool	Structure/Building blocks • Service delivery • Health work force • Availability of information, • Availability pf medical products • Leadership and governance	Process (system outputs) • Access to EMS services • Quality of EMS services • Area covered by EMS system • Safety of EMS system	Outcome • Disease outcomes • Responsiveness of EMS systems • Social and financial risk prevention • Efficiency of EMS systems
Sund (127) EMS simulation model	• Ambulance response times • Survival of patients with out-of-hospital cardiac arrest		

Abbreviations: QIs, quality indicators; EMS, emergency medical service; QA-PHC, quality assessment on pre-hospital care

Application of the tools in previous studies

Unlike the other tools, a component of the Haugland et al. (58) EMS questionnaire with 15 QIs has been used in a prospective observational study (125). In the study, 16 physician-staffed helicopter EMS systems in Finland, Sweden, Denmark and Norway registered data for 15 of the QIs in the tool. The questionnaire was largely successful: the study demonstrated its feasibility in obtaining required data for measuring the QIs and the QIs had adequate variability (125). However, the study found that the tool could not adequately collect data on adverse events; therefore, the researchers suggested using the adverse events collected by the tools simply as 'sentinel events' and not for quantitative analysis.

Conclusions on the most appropriate tool to use

In addition to evidence on validity/feasibility of the various tools and application of the tools in previous studies, we also assessed the tools for their comprehensiveness and availability of benchmarks to interpret measures of QIs in the tools to identify the most appropriate tool.

Comprehensive nature of the tools

We used the Donabedian's structure-process-outcome quality of care model (131) in deciding which tool provides a more comprehensive assessment/evaluation for each of the structure, process and outcome components as outlined in Table 5. Among the four tools, only the Haugland et al. (58) EMS questionnaire and the Mehmood et al. (124) Comprehensive EMS assessment tool assess the structure, process, and outcome of EMS systems; therefore, they can be considered comprehensive tools. The Dantas et al. (126) QA-PHC instrument only assesses the structure and process of EMS systems and the Sund (127) EMS simulation model only assesses EMS response times and outcomes of patients with out-of-hospital cardiac arrest.

Availability of benchmarks to interpret measures of QIs in the tools

In addition, a good EMS evaluation tool should have benchmarks for discovering whether the best performance of an EMS system is being achieved (125). However, none of the tools have any reported or proposed benchmarks except Haugland et al. (58) EMS questionnaire, which has proposed benchmarks for 15 of its QIs (Appendix 2). The benchmarks were proposed by Haugland et al (125) in a later prospective study using 15 of QIs in the tool. Unlike all the other tools, only the Haugland et al. (58) EMS questionnaire contains all the 15 non-clinical QIs identified in the first section of this chapter, all of which has proposed benchmarks. However, the tool does not contain any of the clinical QIs identified in the first section of this chapter. The strengths and limitations of these four EMS tools are summarised in Table 6.

Table 6. Strengths and limitations of the EMS tools

Tool	Strengths	Limitations
Haugland et al. (58) EMS questionnaire	• Developed by a multidisciplinary team consisting of general practitioners, EMS medical directors, health institute directors, community medicine specialist, patient-organization leaders, and physicians • Feasibility, rankability, variability, actionability and documentation of the QI measurements has been established (125) • 15 of the QIs have been measured in a prospective observational study (125) with good findings • It is comprehensive: assess the structure, process and outcome of EMS systems • Contains all the 15 non-clinical QIs identified in the first section of this chapter • Contains QIs with benchmarks for interpreting QI measurements	• Has not been validated, probably due to lack of a gold-standard tool for measuring EMS QIs. • Does not contain the clinical QIs identified in the first section of this chapter • It was developed for physician-staffed EMS systems in developed countries (Finland, Sweden, Denmark and Norway) hence may not be appropriate for other contexts
Dantas et al. (126) QA-PHC instrument	• Relevance/permanence of its contents has been established (28)	• Developed by a team of nurses and doctors only • Has not been validated or used in any study • It is not comprehensive: only assesses the structure and process of EMS systems • Does not contain all the 15 non-clinical QIs identified in the first section of this chapter • Its QIs have no reported benchmarks

Mehmood et al. (124) Comprehensive EMS assessment tool	• Developed by a multidisciplinary team consisting of an EMS physician, a trauma surgeon, public health professionals, health system researchers, and EMS administrator • It is comprehensive: assess the structure, process and outcome of EMS systems	• Has not been validated or used in any study • Does not contain all the 15 non-clinical QIs identified in the first section of this chapter • Its QIs have no reported benchmarks
Sund (127) EMS simulation model	• None	• Developed by one individual • Has not been validated or used in any study • It is not comprehensive: only assesses 2 QIs (ambulance response times and survival of patients with out-of-hospital cardiac arrest), not the structure, process, and outcome of EMS system • Does not contain all the 15 non-clinical QIs identified in the first section of this chapter • Its QIs have no reported benchmarks

Abbreviations: QIs, quality indicators; EMS, emergency medical service; QA-PHC, quality assessment on pre-hospital care

Based on this analysis, the Haugland et al. (58) EMS questionnaire was identified as a potentially relevant tool for assessing the quality of the Saudi EMS system. This tool contains all the 15 non-clinical QIs identified in the first section of this chapter and all the 15 QIs have proposed benchmarks. However, the tool does not measure clinical QIs so if it were to be used, the researcher would want to add these clinical QIs. Therefore, the researcher added the clinical QIs to the 15 non-clinical QIs in the Haugland et al. (58) EMS questionnaire to come up with the following 17 QIs:

1. Ability to respond immediately (percentage of immediate response based on the difference between time call received and time response team is deployed)
2. Time to arrival of EMS response team (mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes)
3. On scene time (mean time interval between time call received to time of arrival at patient scene in minutes)
4. Time to preferred destination (mean time interval between time call received to time patient is delivered to preferred destination in minutes)
5. Patients arriving to the hospital alive (percentage of patients arriving to the hospital alive)
6. Performance monitoring, audit, appraisal, and/or debriefing (percentage of EMS responses that are monitored, debriefed, appraised, and/or audited)
7. Adverse events (percentage of adverse events during prehospital care)
8. Complete documentation (percentage of complete EMS records)
9. Guidelines for actual medical problems (percentage of available guidelines against the medical problems responded to)
10. Involvement of EMS physicians in dispatching EMS response team (percentage of EMS responses in which an EMS physician was involved)

11. Necessity of EMS physicians in providing appropriate care (percentage of appropriate prehospital care due to inclusion of EMS physicians in the response team)
12. Provision of advanced treatments (percentage of EMS patients who received advanced treatments such as airway management and oxygenation and pain management)
13. Significant logistical contributions of EMS physicians (percentage of appropriate prehospital care treatments due to involving EMS physicians in dispatching an EMS response team)
14. Patients enrolled in research projects (percentage of EMS patients recruited into EMS studies)
15. Care for relatives (percentage of EMS responses which an EMS response team cared for patient's relatives directly or through collaborating services such as the police)
16. Percentage of patients with time-sensitive illnesses (such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction) who received prehospital emergency care
17. Percentage of patients who received advanced treatments (such as airway management and pain management) during prehospital care

CONCLUSION

Although there are no standard QIs or tools for evaluating EMS systems, recent reviews and studies have identified QIs and tools that maybe appropriate. The researcher identified 43 QIs that have been reported by literature reviews in the past 5 years; these QIs are categorized into clinical QIs and non-clinical QIs. The clinical QIs were mainly two while the non-clinical QIs

were mainly 15. A review of the literature identified the Haugland et al. (58) EMS questionnaire as an EMS evaluation tool that contains all the 15 non-clinical QIs and all these 15 QIs have been used in a study and have proposed benchmarks. However, clinical QIs are not contained in the tool. Therefore, the researcher added the clinical QIs to the 15 non-clinical QIs and assessed the feasibility of collecting data required for measuring each of these 16 QIs in Saudi Arabia in the next Chapter.

Chapter 3: Development of a tool and methods to evaluate the Saudi EMS system

INTRODUCTION

In the previous chapter, 17 quality indicators (QIs) from a review of available literature reviews and a review of QIs contained in developed EMS evaluation tools were identified. In this chapter, the Saudi EMS system is mapped to identify potential sources of data for measuring these 17 QIs in Saudi Arabia. Part two and three provide an overview of the study objectives and the data collection tools, and discusses the study methods in detail.

PART 1: MAPPING THE SAUDI EMS SYSTEM

History of the Saudi EMS system

The history of the Saudi EMS system can be traced to the Saudi Yemeni War of 1934. After the war, prehospital care was limited to Mecca and Medina, and was provided by an independent EMS provider under the Charitable Relief Society (95). The war also led to the establishment of National Ambulance Health Association, and the EMS system was regulated by Public Health and Ambulance Authority. Due to the consequences of World War II, the incomes of private EMS providers diminished; therefore, the Charitable Relief Society was converted from a private entity to a government-owned, public institution under the name Saudi Red Crescent Association (96). In 2008, the name of the Saudi Red Crescent Association was amended to the Saudi Red Crescent Authority (SRCA) (Figure 2) (96).

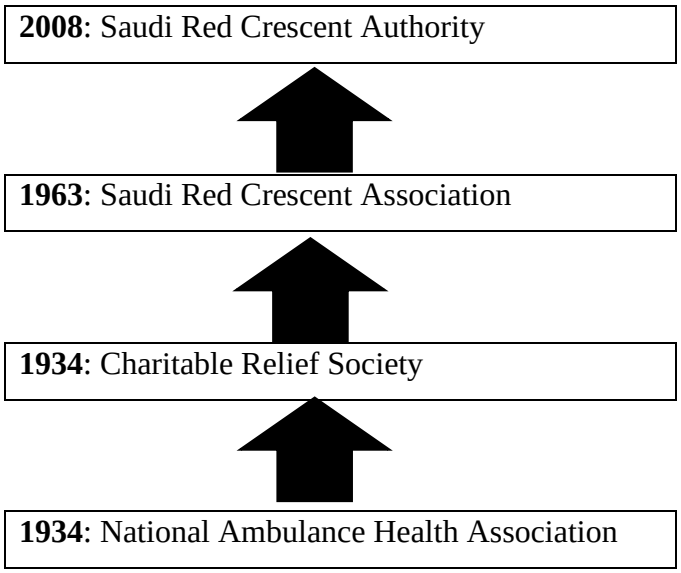


Figure 2. Key milestones in the development of the EMS system

Transitions in levels of EMS provider education in Saudi Arabia

The transitions in the level of EMS provider education in Saudi Arabia are summarized in Figure 3. Professional training of EMS providers in Saudi Arabia can be traced back to 1934 when the first aid providers were trained. The trainings were restricted to First Aid and First Responder training courses, which were limited to industry-level trainings (95,132). During this stage, EMS was offered as part of other health programs such as nursing as demonstrated by the founding charter of the Saudi Red Crescent Authority SRCA 1386 H (1966) stating in the second part (article 6) that "the Saudi Red Crescent will strive to elevate the nursing profession and train both male and female nurses on hospital work and emergency situations" (95,132).

In the second phase, professional development of EMS providers started with the creation of first diploma programs in EMS, which aimed at producing well-trained paramedics in 2005. The diploma programs provided paramedic education by using a new model of advanced life support (ALS) care and other prehospital care areas of emergency medicine (95,132).

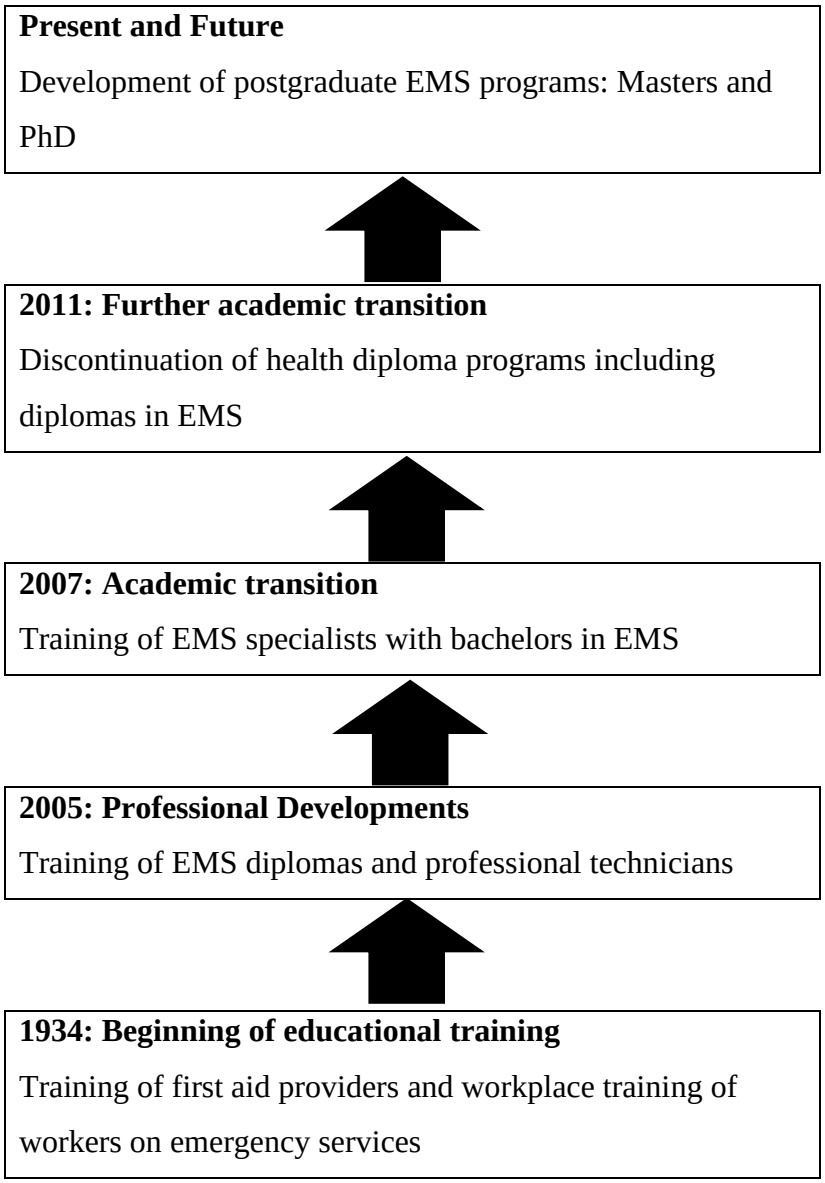


Figure 3. Key educational milestones in the development of the Saudi EMS system

From 2007, there was an academic transition that saw the introduction of Bachelor's degree program in EMS at university or college level. The EMS bachelor's degree programs were first introduced at King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) and in King Saud University (KSU) (133). The Bachelor's degree programs were introduced in Saudi Arabia due to lack of sufficient number of professional paramedics (133). The

Bachelor's degree programs were adopted from Flinders University in South Australia, and currently more than ten private and public universities and colleges offer the programs (95).

In 2011, there was further academic transition that saw the discontinuation of health diploma programs including diplomas in EMS. In this phase, universities and colleges in Saudi Arabia focused on offering bachelor's degree program in EMS (95). With these academic transitions, the current EMS education programs in Saudi Arabia have positively impacted the provision of EMS education in the following ways: (1) improvement of EMS as a professionally recognized discipline; (2) improvement of accessibility to quality EMS education; and (3) expansion of skills for managing societal and individual resources towards education. However, there are still limited publications on EMS in Saudi Arabia pointing to poor EMS research. Therefore, further academic transitions may see the introduction of Masters and PhD programs in EMS to improve empirical research capacity of current EMS issues.

Model of the Saudi EMS system

According to the Saudi Red Crescent Authority (96), the Saudi EMS system is based on a hybrid model of both Franco-German and Anglo-American models (1). In this hybrid model, the EMS system "stays and stabilizes" patients with the main aim of bringing hospitals close to the patients with many pre-hospital care treatments provided by many paramedics including physicians with an extensive scope of practice (Franco-German model) (1). At the same time, the EMS system rapidly transports patients to the hospital with few pre-hospital care treatments (Anglo-American model) (33). The focus the Saudi EMS system is to transport patients to hospitals for emergency treatment; although patients are treated at the scene, a majority are transported to the hospital. Patients are admitted to the Emergency Department upon arrival at hospitals, and the EMS team mainly consists of paramedics and emergency medical

technicians. However, the Saudi EMS system also includes certain features of the Franco-German model-a model based on “stay and stabilize” philosophy aimed at bringing hospitals close to the patients (1). For example, the Saudi EMS system includes emergency physicians in the EMS team and provides advanced life support to the patients at the scene (70). While the basic life support adopts the “scoop and run” approach where the patient is only stabilised before being transported to the hospital, the advanced life support adopts the “stay and stabilize” approach where advanced medical interventions are provided (134). The basic life support EMS team is usually dispatched when patients requiring the EMS services do not need invasive interventions but need rapid transportation to hospitals (134). Some of the prehospital basic life support services performed by the Saudi EMS team include administration of oxygen, carrying out cardiopulmonary resuscitation (CPR), dressing wounds, and splinting fractures(134). On the other hand, the advanced life support EMS team is usually dispatched when patients need invasive interventions such as administering medications, carrying out endotracheal intubation, decompressing needles, and replacing fluids (100).

Institutional and organizational context

Act and laws establishing Saudi Red Crescent Authority and emergency medical services

The SRCA, which provides EMS services in Saudi Arabia, was established by the Saudi Red Crescent Authority Organization Statute in 2008. The statute has 26 articles outlining the operations and regulations of the authority (132). The statute outlines twelve duties and responsibilities of SRCA among them is delivery of EMS services as the sole service provider in the country, “including ambulatory transfer and pre-hospital health services provider for patients including victims of accidents and crisis” (132).The statute also outlines the laws that SRCA is committed to as “Islamic Sharia laws and the Basic Law of Governance and related

bylaws, as well international agreement of relevance without interfering in political or religious issues when providing their services within Saudi Arabia." (132).

Regulation and governance of the Saudi EMS system

According to the Saudi Red Crescent Authority Organization Statute, SRCA, although an independent entity, shall report to the Minister of Health who also chairs the board of directors of the authority (132). Other members of the board include the following: "president of the authority: member and vice chairman; representative of Ministry of Health: member; representative of Ministry of Human Resources and Social Development: member; representative of civil defense directorate: member; representative of Saudi Human Rights Commission: member; the representatives of government agencies holding no less than the 14th rank or the equivalent thereof; and seven members to be assigned by a decree of the council of ministers based on nomination from the chairman for a one-time expandable period of three years" (132).

In addition, EMS providers in Saudi Arabia are governed by the Saudi Commission for Health Specialties (SCFHS), which govern the practice of all health professionals including EMS providers. The SCFHS governs health professionals including EMS providers through licensing of healthcare workers, clinical practice registration, approval of specific education programs, and establishing associations of health workers for provision of emergency care (95).

Structure and organization of the Saudi EMS system

Currently, the Saudi EMS system has three levels: prehospital care, transportation, and hospitalisation. The Saudi Red Crescent Authority (SRCA) provides prehospital care and transportation (135). Whereas the nationwide network of primary health centres and specialised

hospitals provide the hospitalisation component of the EMS system (134) (Figure 4). The primary health centres provide emergency services and mobile clinics to people in the interior regions of the country.

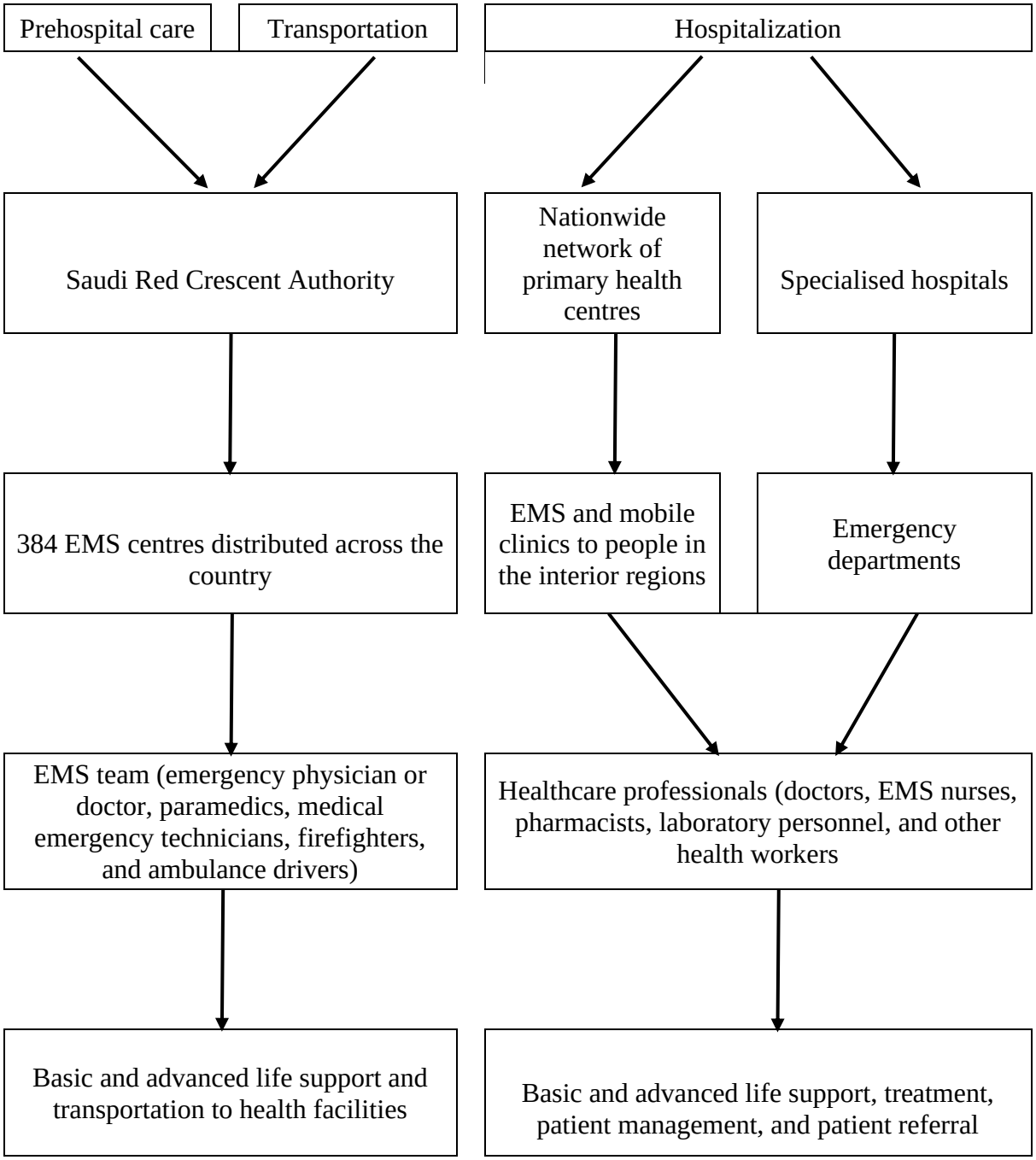


Figure 4. The structure of the Saudi Emergency Medical Service (EMS) system

The specialised hospitals in the country's main cities operate emergency departments that provide 24 hours' emergency medical care for acute medical conditions (136). The hospitals also dispatch EMS teams, and provide both prehospital- and hospital-based emergency care through the nearest SRCA centre (134,137). Through the centres, SRCA offers both air and ground ambulance services and emergency interventions at the pre-hospitalisation phase (97). A dispatched EMS team provides EMS services (basic and advanced life support) aimed at stabilising and transporting the patient to hospitals for further treatments and also transports patients to hospitals (134). The dispatched team usually consists of an emergency physician or doctor, paramedics, medical emergency technicians, firefighters, and ambulance drivers (134).

The 2017 SRCA annual report indicates that the authority operates 384 ambulance centres distributed in 13 regions of the country: Riyadh, Mecca, Medina, Qassim, Eastern Province, Assir, Tabuk, Hail, Northern Borders, Jazan, Najran, Al Baha, and Al Jouf. According to the report, Riyadh is the leading region with 77 centres (20% of all the centres) followed by Makkah region (71 centres, 19%) with Najran and the northern border region being the least (each having 12 centres, 3%) (97). Unpublished SRCA data shared by the SRCA director for the Riyadh region show that, in 2017, the Saudi EMS system attended to 302, 983 emergencies: 92938 in Makkah and 60531 in Riyadh, and the rest in other regions.

Funding

The SRCA is funded by the government of the Kingdom of Saudi Arabia with additional funding from private contributions. According to Mutairi et al. (134), reports show that funding for SRCA by the government of the Kingdom of Saudi Arabia rose up from 373 million US dollars in 2009 to 433 million US dollars in 2010 to cover the operations costs within Saudi Arabia. As the authority's budget is funded by the government, access to EMS is free of any

charges. The Mutairi et al. (134) article where most of the information regarding the institutional and organizational context of the Saudi EMS system is a review article published in 2016. Although the review article does not give methods of literature search and does not appraise the quality of the included studies, it uses reliable sources of data such as SCRA, Saudi Ministry of Health reports, Saudi Ministry of Economy and Planning, World Health Organization and primary Saudi studies. Also, the review article cites primary research articles in Saudi Arabia as well as other published and un-published sources thus it includes a wide range of sources, study designs and methodologies to provide diverse and broad topics regarding the Saudi EMS system. Therefore, the data in this review article are considered reliable.

Material resources

According to the 2017 SRCA annual report, SRCA has a total of 1206 ambulance vehicles and 83 advanced life support vehicles (Table 7) (138). These vehicles are fitted with native ambulance features (such as vehicle body, siren, power supply, GPs system etc.), materials for patient transfer, materials for patient monitoring, search and rescue devices, oxygen and airway devices, safety and hygiene materials, and materials for patient treatment.

Table 7. Number of Saudi Red Crescent Authority ambulance and advanced life support vehicles

Region	Ambulance vehicles	Advanced life support vehicles
Riyadh	261	24
Mecca	230	27
Medina	87	7
Qassim	64	3
Eastern Province	164	15
Assir	89	3
Tabuk	61	2
Hail	40	2
Northern Borders	38	0
Jazan	50	0

Najran	42	0
Al Baha	40	0
Al Jouf	40	0
Total	1206	83

Human resources

Human resources at the SRCA includes senior staff (directors, assistant directors, and administrators of each EMS center) and frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers). According to Mutairi et al. (134), reports show that SRCA had a total of 6754 staff members as at 2015; this includes 1683 administrators, 86 EMS physicians, 4164 technicians, and other workers. In a survey conducted among EMS providers working for SRCA, AlShammari et al. (139) found most of the providers were males, were aged 29 to 39 years, had diplomas, had 5 to 9 years' experience, were paramedics, had clinical/patient care as their main professional role, and were Saudi in nationality (Table 8).

Table 8. Profile of the Saudi Red Crescent Authority staff as surveyed by AlShammari et al. (139)

	Category	**Frequency**	**Percent**
Gender	Male	866	93.4
	Female	61	6.6
	Total	927	100.0
Age groups	18-28	230	24.8
	29-39	552	59.5
	40-49	122	13.2
	50 or above	23	2.5
	Total	927	100.0
Highest qualification	Certificate	68	7.3
	Diploma	707	76.3
	Bachelor's degree	114	12.3
	Master's degree	24	2.6

	PhD	14	1.5
	Total	927	100.0
Years of EMS experience	1-4	315	34.0
	5-9	508	54.8
	10 or more	104	11.2
	Total	927	100.0
Primary medical discipline	Paramedic	585	63.1
	Nurse	257	27.7
	Physician	83	9.0
	Public health	1	.1
	Pharmacist	1	.1
	Total	927	100.0
Main professional role	Administrative/ leadership	150	16.2
	Education/ academic	328	35.4
	Clinical/patient care	449	48.4
	Total	927	100.0
Nationality	Saudi	792	85.4
	Egyptian	53	5.7
	Jordanian	41	4.4
	Syrian	21	2.3
	Indian	11	1.2
	Pakistani	3	.3
	Sudanese	5	.5
	Filipino	1	.1
	Total	927	100.0

Source: Report by AlShammari et al. (139)

Service provision mapping

Type of services

According to the Saudi Red Crescent Authority Organization Statute (132), the SRCA has twelve duties and responsibilities:

1. “Conduct preparations and work during peacetime and wartime as considered cooperation and integration with the armed forces medical departments for the benefit of every civil and military victims in quoted situations in 1949 Geneva four treaties and other two additional protocols of 1977, that includes in specific the following:”

- “Transfer of the sick and wounded victims and establishment of the Red Crescent hospitals in locations assigned by the military command.”
- “Provide aid and transfer means to victims of wars.”
- “Mediate to exchange communications among POWs and victims of wars.”
- “Work on supplying and storing of shelter facilities and equipment, medicines, and all necessities for the treatment of the sick and wounded victims and the care of prisoners.”

2. “Representing the Kingdom of Saudi Arabia in international forum as the sole entity that represents Red Crescent in Saudi Arabia.”
3. “Delivering of medical emergency services as the sole service provider in the Kingdom, including ambulatory transfer and pre-hospital health services provider for patients and victims of accidents and crisis.”
4. “Preparedness and response for crisis as well contribution in providing relief services in the Kingdom according to the accredited national plan.”
5. “Participate in delivery of Saudi relief aid to victims of crisis outside the Kingdom.”
6. “Cooperate with other specialized entities in delivering health services to pilgrims.”
7. “Work on providing training to the community on first aid and how to response and deal with crisis and accidents as well spread awareness and health culture in cooperation with other specialized entities and training and educational institutions.”
8. “Contribute in providing health, humanitarian and social services in compliance with objectives of the Authority.”

9. “Spread humanitarian principles of International Red Cross and Red Crescent Movement and International humanitarian law to establish humanitarian values in the society.”
10. “Promote relations and exchange knowledge and aid with staff of IRCRC and other similar entities.”
11. “Encourage individuals in the society, especially youth, to volunteer in activities conducted by the Authority.”
12. “Perform other works and activities in time of peace and war that achieve goals of the Authority.”

Key among these duties and responsibilities is the provision of EMS services. The SRCA provides EMS services through ground EMS centers that use algorithms and guidelines of the Saudi Red Crescent Computer Aid Dispatching System (SRCCAD) to dispatch ambulances at different urgency levels (50). The EMS response is a process that begins with a patient’s phone call to a call center after which the call center through nearest EMS center or hospital dispatches an EMS team (consisting of frontline EMS providers such as EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) and ambulance to the patient scene. The team then moves to the patient’s location, provides prehospital care to the patient and transfers the patient to the hospital. This is an operational process that is universally referred to as the ambulance run. The ambulance runs are registered in the SRCCAD to generate run reports over time interval. The ambulance run process for SRCA ambulances is illustrated in Figure 5 (50).

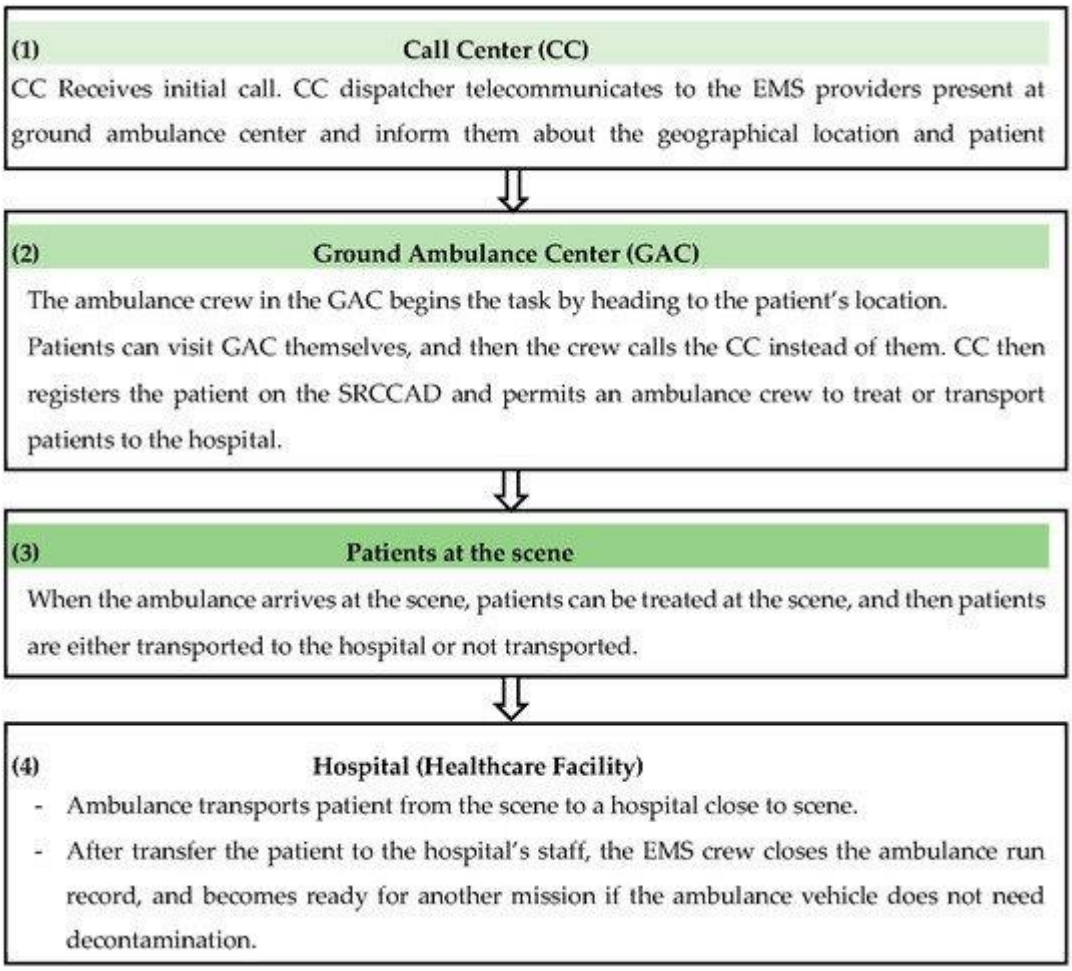


Figure 5. Ambulance run process for Saudi Red Crescent Authority ambulances. Source: A report by Moafa et al. (50).

Care quality and performance measurement

There seems to be no published reports of internal quality and performance measurement in SRCA. In addition, limited studies have assessed the quality of EMS services in Saudi Arabia. Available studies have focused on some aspects of the EMS system only: challenges faced by paramedics (70), EMS transportation services (71,104,105), public awareness of the EMS system (91), and factors affecting efficiency of EMS technicians (90). Nonetheless, several studies have highlighted factors that may affect access to and quality of EMS service. For instance, Hajj mission has been reported as one of the factors that may affect access to and quality of EMS services as Hajj is characterized by mass gatherings of people visiting Mecca

annually for religious propose (134). During Hajj, EMS centers outside Mecca send ambulances and frontline EMS providers to Mecca thereby affecting the quality of EMS services in those locations.

PART 2: TOOL DEVELOPMENT

Potential sources of EMS data in Saudi Arabia

Although the 17 QIs identified in the previous chapter appear to be relevant for assessing the quality of the Saudi EMS system, it is necessary to assess potential sources of data for measuring these QIs in the country. Particularly, QIs from Haugland et al. (58) EMS questionnaire have only been used in physician-staffed helicopter EMS systems in Finland, Sweden, Denmark and Norway. Therefore, some of the QIs may not be measurable in Saudi Arabia. For instance, the Saudi EMS system may lack adequate sources of data for the tool because the system is not as advanced as that in Finland, Sweden, Denmark and Norway. Similarly, the clinical QIs may be challenging to measure in Saudi Arabia because of missing link of data between prehospital care and hospital care, but the data may be available in the future. This section therefore looks at each of these quality indicators and tries to identify sources of potential data for measuring the indicators or to identify where new data is required.

1. Review of existing data: prehospital care reports and SRCA annual report

The SRCA keeps a record, prehospital care report (Appendix 3), of patients who utilise their EMS services. The record includes several aspects of clinical and non-clinical data: ambulance response times, people or individuals requesting the ambulance, institution providing the ambulance services, aid given to patients before the arrival of the EMS team, type of call, patient's protective equipment, patient location, patient possessions, chief complaints of the patient, details of communications and patient examinations, history and treatments,

medications administered, and reasons for not transporting the patient if any. The SRCA also prepares and publishes an annual report containing data on the total number of first aid and ambulance centres by region, number of EMS cases by region, patients, causalities, medical services and interventions provided by the SRCA EMS team, and the total number of patients and with specific diseases including medical emergencies attended by the EMS system. Non-EMS data that may be relevant to EMS evaluation (such as area in km^2 of each Saudi region and population of each region) can be obtained from SGAS records.

2. Collection of primary data: surveying senior SRCA staff and frontline EMS providers

Data that are not present in the prehospital care reports and SRCA annual report but are required to assess the quality of the Saudi EMS system were obtained through a survey of EMS staff involved in the management of the EMS system and those involved in the actual response. As discussed earlier in this chapter, the Saudi EMS system is managed by a director and an assistant director at each EMS centre (senior SRCA staff) while the actual response is carried out by frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers). Therefore, senior SRCA staff and frontline EMS providers can be a potential source of data for assessing the quality of the Saudi EMS system.

Sources of data for the 17 QIs in Saudi Arabia

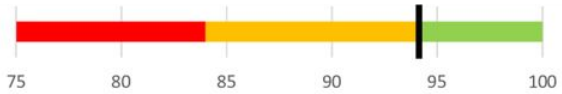
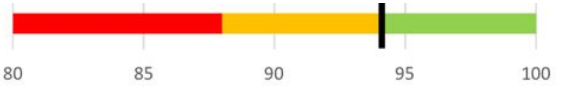
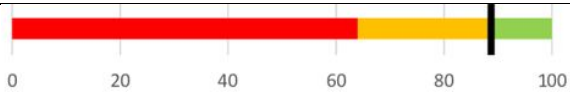
As shown in Table 9, all the 17 QIs were mapped across these potential sources of data in Saudi Arabia and found that 15 of these QIs can be measured in Saudi Arabia using secondary data (prehospital care reports, SRCA annual reports, and SGAS records) and primary data (data obtained from a survey of senior SRCA staff and frontline EMS providers).

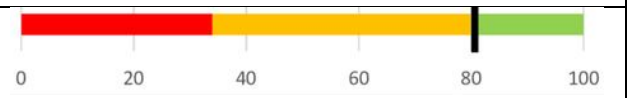
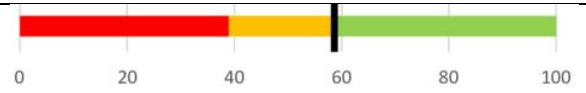
Particularly, necessity of EMS physicians in providing appropriate care (percentage of appropriate prehospital care due to inclusion of EMS physicians in the response team) and

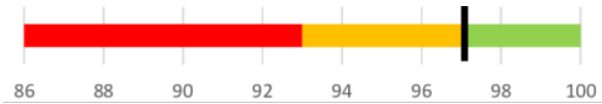
significant logistical contributions of EMS physicians (percentage of appropriate prehospital care treatments due to involving EMS physicians in dispatching an EMS response team) could not be measured in Saudi Arabia. These QIs could not be measured in this study because the study only focused on prehospital care without looking at patient outcome data in hospitals, which are required to measure these two QIs.

Using these 15 QIs and their sources of data together with questions intended to meet the third study objective, we developed a three-part tool for evaluating the Saudi EMS system: data extraction tool (Appendix 4), questionnaire for a survey of senior SRCA staff (directors and assistant directors of SRCA EMS centres) (Appendix 5), and questionnaire for a survey of frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) (Appendix 6).

Table 9. Sources of data and benchmarks for evaluating the Saudi EMS system

Quality indicator	Required data	Source of data in Saudi Arabia	Benchmark proposed by Haugland et al. (125)[1]
1. Ability to respond immediately (percentage of immediate response based on the difference between time call received and time response team is deployed)	• Time call received • Time response team is deployed	Prehospital care report	
2. Time to arrival of EMS response team (mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes)	• Time EMS response team is deployed • Time EMS response team arrives at patient scene	Prehospital care report	
3. On scene time (mean time interval between time call received to time of arrival at patient scene in minutes)	• Time call received • Time EMS team arrives at patient scene	Prehospital care report	
4. Time to preferred destination (mean time interval between time call received to time patient is delivered to preferred destination in minutes)	• Time call received • Time patient delivered to preferred destination	Prehospital care report	
5. Patients arriving to the hospital alive (percentage of patients arriving to the hospital alive)	• Number of patients delivered to hospital alive • Total number of patients transported via EMS	Prehospital care report	
6. Performance monitoring, audit, appraisal, and/or debriefing (percentage of EMS	• Total number of EMS responses	Survey frontline EMS providers	

responses that are monitored, debriefed, appraised, and/or audited)	• Number of EMS responses monitored, debriefed, appraised, and/or audited		
7. Adverse events (percentage of adverse events during prehospital care)	• Number of EMS responses with adverse events • Total number of EMS responses	Prehospital care report	
8. Complete documentation (percentage of complete EMS records)	• Number of incomplete records • Total number of records	Prehospital care reports	
9. Guidelines for actual medical problems (percentage of available guidelines against the medical problems responded to)	• Availability of guidelines for each medical problem • List of medical problems attended	Survey senior SRCA staff and prehospital care reports	
10. Involvement of EMS physicians in dispatching EMS response team (percentage of EMS responses in which an EMS physician was involved)	• Number of EMS responses in which an EMS physician was involved • Total number of EMS physicians	Survey frontline EMS providers	
11. Necessity of EMS physicians in providing appropriate care (percentage of appropriate prehospital care due to inclusion of EMS physicians in the response team)	• Number of appropriate prehospital care treatments due inclusion of EMS physicians in the response team • Total number of prehospital care treatments	No available data source	
12. Provision of advanced treatments (percentage of EMS patients who received	• Number of EMS patients who received advanced treatments	Prehospital care reports	

advanced treatments such as airway management and oxygenation and pain management)	• Total number of EMS patients		
13. Significant logistical contributions of EMS physicians (percentage of appropriate prehospital care treatments due to involving EMS physicians in dispatching an EMS response team)	• Number of appropriate prehospital care due to involving EMS physicians in dispatching an EMS response team • Number of prehospital care treatments	No available data source	
14. Patients enrolled in research projects (percentage of EMS patients recruited into EMS studies)	• Number of patients recruited into EMS studies • Total number of EMS patients	Survey senior SRCA staff	
15. Care for relatives (percentage of EMS responses which an EMS response team cared for patient's relatives directly or through collaborating services such as the police)	• Number of EMS responses where patient relatives are cared for • Total number of EMS responses	Survey frontline EMS providers	
16. Percentage of patients with time-sensitive illnesses (such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction) who received prehospital emergency care	• Number of EMS patients with time-sensitive illnesses • Total number of EMS patients	Prehospital care reports and annual report	None
17. Percentage of patients who received advanced treatments (such as airway	• Number of patients who received advanced treatments • Total number of EMS patients	Prehospital care reports	None

management and pain management) during prehospital care			

[1] Green zone, high performance; yellow zone, average performance; red zone, low performance. The benchmark is set at the transition between green and yellow zones (at the lower end of the fourth quartile where higher values reflect better performance) and marked with a black and fat vertical line.

Senior SRCA staff include directors and assistant directors of EMS centres; Frontline EMS providers include EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers

Abbreviations: SRCA, Saudi Red Crescent Authority; EMS, emergency medical service; SGAS, Saudi General Authority on Statistics

Data extraction tool (Appendix 4)

The data extraction tool contains two sections: section 1 for extracting data from annual report and section 2 for extracting data from each prehospital care report.

Questionnaire for senior SRCA staff survey

The questionnaire for senior SRCA staff survey contains 5 semi-structured questions to measure structure and process QIs that unavailable in the pre-existing data. Examples of these QIs include availability of guidelines for each medical problem and number of patients recruited into EMS studies.

Questionnaire for frontline EMS providers survey

The questionnaire for frontline EMS providers survey has nine semi-structured questions intended to obtain data required to measure three QIs: performance monitoring, audit, appraisal, and/or debriefing; involvement of EMS physicians in dispatching EMS response team, and care for patient relatives. In addition to measuring these QIs, some of the questions in the questionnaire for frontline EMS provider survey collected data for meeting the third objective of the study: general activities carried out during an EMS response and strategies, challenges faced, and recommended solutions for communicating with patients, maintaining patient privacy, and addressing the needs of the patient's relatives.

PART 3: TOOL APPLICATION

Study design

In this study, we used both secondary data analysis and original data collection through survey methodologies to meet the study objectives. Secondary data analysis is a research methodology that uses existing data to replicate or extend previously observed findings or to address new

research questions (140). This methodology is preferred by many researchers because existing data are efficient, readily available, have large sample size, and measures many variables. In this study, there are potential sources of data for some of QIs as previously discussed, we needed to include as many PCRs as possible, and we needed to use PCRs and SRCA annual report to measure many variables hence the adoption of the secondary data analysis as one of the study methodologies. Therefore, we used secondary data analysis was used to measure the following eleven QIs: ability to respond immediately, time to arrival of EMS response team, on scene time, time to preferred destination, patients arriving to the hospital alive, adverse events, complete documentation, provision of advanced treatments, percentage of patients with time-sensitive illnesses, number of EMS units per population, and number of EMS units per area.

We also used survey methodology to measure five QIs that could not be measured by secondary data analysis, namely: performance monitoring, audit, appraisal, and/or debriefing (survey of frontline EMS providers); availability of guidelines for actual medical problems (survey of senior SRCA staff); involvement of EMS physicians in dispatching EMS response team (survey of frontline EMS providers); patients enrolled in research projects (survey of senior SRCA staff); and care for patient relatives (survey of frontline EMS providers). Although survey methodology is a qualitative research method used to investigate a human phenomenon, such as perceptions, emotions, and opinions (141), we used it in the quantitative component of this study to collect data required to measure five QIs listed above.

Qualitative component of the study

In addition to collecting data required to measure five QIs that could not be measured by secondary data analysis, survey methodology was also used to collect data required to determine the challenges faced during an EMS response, and proposed solutions for

communicating with patients, maintaining patient privacy, and addressing the needs of the patient's relatives. The qualitative component of the study was necessary as the QIs are all quantitative measures that have been predefined – it makes presumptions about what is important and then tests them. However, qualitative data takes a different perspective – it is a type of research which helps to understand the situation from the perspectives of the individuals involved. It is used to explore opinions and attitudes – what is important from staff perspectives. We intended to do these as surveys, but had to do them as online surveys for logistical reasons — it was not feasible to conduct surveys within the limited data collection period of the PhD timelines.

The survey questionnaire for senior SRCA staff sought to collect the following information: whether SRCA in Riyadh send EMS personnel and ambulances to Mekkah during Hajj, challenges they face in providing EMS services in Riyadh when they send EMS providers and ambulances to Makkah, whether they legally partner with other government agencies to provide EMS services, whether they have any the EMS guidelines, whether their dispatch centre is staffed 24/7 by a specially trained pre-hospital physician, and whether they recruited any EMS patients to a research study in 2018. The survey questionnaire for frontline EMS providers sought to collect the following information: whether they were deployed to respond to medical emergencies in 2018; whether a physician and/or a paramedic from EMS was involved in deciding the EMS unit to deploy; challenges they face during an EMS response when communicating with patients and/or their relatives, when maintaining the privacy of your patients, and when addressing the needs of the patient's relatives; and whether they were debriefed after an EMS response.

The questions in the survey questionnaires were developed based on information that was required to measure five QIs that could not be measured using existing data as earlier discussed. Also, other qualitative questions were included in the survey questionnaires to

provide further information to the measures of QIs. For example, one of the questions in the survey questionnaire for frontline EMS providers asked how the needs of patients' relatives were addressed to provide additional qualitative information for understanding the QI care for relatives.

Ethical considerations

Ethical approval and permission to carry out this study were obtained from the Institutional Review Board of King Fahad Medical City on December 12, 2018 (No. 18-652E). Ethical approval was also obtained from the University of Nottingham Faculty of Medicine and Health Science Research Ethics Committee on January 11, 2019 (No. 178-1812). We obtained written informed consent using the study information sheet (Appendix 7) and informed consent form (Appendix 8) from the general SRCA director for the entire Riyadh region and directors or assistant directors of each of the 13 EMS centres. For frontline EMS providers, the first page of the electronic questionnaire provided the study information and sought their informed consent before proceeding to respond to the questionnaire. For the prehospital care reports, the principal researcher used unique identifiers to select the prehospital care reports without using or extracting personal information such as patient names to ensure anonymisation of the data collection process.

Pilot study

We piloted the tools— data extraction tool (Appendix 4), questionnaire for senior SRCA staff survey (Appendix 5), and questionnaire for frontline EMS providers survey (Appendix 6)—at an EMS center outside Riyadh city but within the Riyadh region. Particularly, we used the data extraction tool to obtain data from 10 randomly sampled PCRs recorded in 2018, electronically surveyed senior SRCA staff (director and assistant director of the EMS center), and also

electronically surveyed frontline EMS providers at the EMS center (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers). As there were no changes in the study methods between the pilot study and the main study, data from the pilot center were included to boost the sample size.

Sampling

According to the SRCA 2018 annual report, there are a total of 77 EMS centres in Riyadh (97) (Figure 6). Unpublished SRCA data shows that out of the total 77 EMS centres in Riyadh, 40 centres (38 located in Riyadh city and 2 located in rural regions of Riyadh) attended to more than 1,000 medical emergencies in 2017 (Appendix 9), suggesting that these EMS centres in this region represent high-burden centres.



Figure 6. Map of Riyadh, Saudi Arabia (Google Maps, Google LLC)

For secondary analysis of data, 12 EMS centres from the 38 centres in Riyadh city were used to obtain a representative sample. Particularly, all the names of the 38 centres in (Appendix 10) were entered into an online randomiser (www.random.org/lists; Randomness

and Integrity Services Ltd, Dublin, Ireland) to sample 12 EMS centres randomly to accurately obtain a representative sample. The online randomizer rearranged the names of the EMS centres (Appendix 10). The first 12 centres in the randomized list were picked. Therefore, we sampled prehospital care reports from the following 12 EMS centres in Riyadh city: Sahafa, Towaiq, Malaz, Nadheem, Ha'yir, Amanah, Rabwa, Derab, Rawdha, Orouba, Eshbailya, and Oraijaa. In each of the 12 EMS centres, the principal researcher randomly sampled 36 prehospital care reports from January 1, 2018 to December 31, 2018: three reports from each month. Sampling the PCRs across from January to December was necessary to capture any seasonal variations in the number of EMS patients. The three prehospital care reports from each month were a convenient sample size and it was necessary to sample from each month to get a representative sample of the year. In total, 432 prehospital care reports were retrieved from the 12 EMS centres in Riyadh city across the 12 months of 2018. Random sampling of the prehospital care reports was carried out by first grouping the reports for every month into 12 groups. Once grouped, the principal researcher assigned unique identifiers to each report in the group, entered the list of the unique identifiers to an online randomiser (www.random.org/lists; Randomness and Integrity Services Ltd, Dublin, Ireland) and used the first three identifiers in the randomised list to select three prehospital care reports from each group. We used a single SRCA annual report for 2018 because it aligns with the timing of your data collection; therefore, sampling was irrelevant for this component of the study. As there were no changes in the study methods between the pilot study and the main study, data from the pilot center were also included to boost the sample size. Therefore, a total of 13 EMS centers were included.

For the survey of senior SRCA staff, the Director and Assistant Director of each of the 13 EMS centres together with the Director and Assistant Director for the entire Riyadh region were surveyed. Therefore, a total of 28 senior SRCA staffs (two from each of the 13 EMS

centre, one general director for Riyadh, and one assistant general director for Riyadh region). For the survey of the frontline EMS providers, frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) in the 13 EMS centres were surveyed.

Secondary data analysis

After obtaining ethical approval and permission to carry out this study from the Institutional Review Board of King Fahad Medical City and from the University of Nottingham Faculty of Medicine and Health Science Research Ethics Committee, we used the developed data extraction tool (Appendix 4) to collect data from the SRCA 2018 annual report and the 432 sampled prehospital care reports. The data were recorded in the data extraction tools.

Survey of senior Saudi Red Crescent Authority staff

After obtaining the ethical approval and informed consent, we surveyed the 28 senior SCRA staff using the questionnaire for senior SRCA staff survey (Appendix 5). We only included directors and assistant directors who have worked for SRCA centres in Riyadh city for at least 2 years in the 13 EMS centres in order to obtain reliable estimate of performance. The senior SRCA staff recorded their responses in the questionnaire.

Survey of frontline EMS providers

The principal researcher electronically sent the questionnaire for frontline EMS providers (Appendix 6) in Google form to all the frontline EMS providers in the 13 sampled EMS centres through the SRCA general director or assistant general director of each centre. The frontline EMS providers included EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers. The first page of the electronic questionnaire provides the study information

and sought their informed consent before proceeding to respond to the questionnaire. We restricted the survey to frontline EMS providers who had provided EMS response to medical emergencies because they would be better placed to share their experiences and challenges. To do add this restriction, the first question asked the frontline EMS providers if they have provided EMS response to medical emergencies in 2018 and only accessed the other questions if their answer to this question is affirmative.

Data acquisition, management and storage

The data collected by the data extraction tool and the two questionnaires were recorded in the hard copy of each tool, managed, and stored according to the European Union General Data Protection Regulations. Data were first entered into Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) before exporting into SPSS (IBM, New York, United States) by two independent researchers (the principal researcher and trained assistant researcher) collectively to control for errors. Particularly, the researcher trained research assistants to help him collect data within the limited timelines, trained additional data entry clerks to help him organize raw qualitative data, and compared own translations of Arabic responses to English responses with translations provided by hired certified translators in Riyadh to ensure accuracy.

Quantitative data analysis

The data were analyzed under study population; measures of quality indicators categorized under timeliness, safety, efficiency, effectiveness, and patient-centeredness quality dimensions; and addressing the needs of patient relatives during EMS response. Quantitative data were analyzed first by looking at the distribution using histograms, and then using means and/or medians with SD or ranges as appropriate. Binary data were presented as percentages with 95% confidence intervals to show the precision of these estimates. Analysis was done for

each EMS center to compare measures of QIs among EMS centers to determine any differences in the levels of EMS quality, and for the entire study area – comparing centres descriptively by graphing means or percentages with 95% confidence intervals. Further analysis was also carried out using analysis of variance (ANOVA) and T-test for continuous variables and Chi-Square test for categorical variables to test the relationship between QIs and other QIs or between QIs and patient characteristics. These tests were necessary to determine whether one QI or patient characteristic affect the quality of EMS service. Particularly, we used independent Samples T Test to test the relationship between time-sensitive illnesses and timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination). We also used T-test to compare timeliness quality indicators during Hajj and non-Hajj periods. We used analysis of variance (ANOVA) to test the relationship between time call received and timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination). We used Chi-Square test to test the relationship between time call received and arrival to hospital alive.

The results were presented in graphs and tables. PHE Tools were used to calculate the range of confidence intervals for single proportion data. Missing data were defined as data that were not filled in the PCRs when they ought to have been filled and were therefore reported as missing but excluded from analysis. Missing data were also used to measure one QI: complete documentation (percentage of complete EMS records).

Study population

Using data from the PCRs, we described the characteristics of patients who use the EMS service to understand any disparities and to use the information to investigate if patient characteristics affected certain QIs. Particularly, we looked at patient characteristics before prehospital care

(gender, age, and pre-existing patient conditions) and patient characteristics during prehospital care (location, type of emergency call, injuries to different parts of the body, chief patient complaint, and type of traumatic brain injury based on Glasgow Coma Scale score). Using frontline EMS providers survey data, we looked at the characteristics of the providers in terms of level of education, expertise (paramedics, nurses, doctors, EMS technicians, etc.), and number of years they had worked for SRCA to understand qualifications and level of expertise of the providers as well as determine the model of the Saudi EMS system. For example, if the system had more EMS doctors who provide prehospital care treatments at patient scene, then the system can be considered as based on Franco-German model. Using senior SRCA staff survey data, we looked at their designations (either director or assistant director) to understand the accuracy of the responses that they fill in the survey questionnaire.

Measures of quality indicators

Measures (percentages or means) of each of the 15 QIs were categorized under timeliness, safety, efficiency, effectiveness, and patient-centeredness quality dimensions. In addition to presenting the final measure for each QI, detailed results for each QI measure such as distributions is presented as Tables and graphs.

1. Timeliness of the Saudi EMS system

The timeliness of the Saudi EMS system was assessed using the following four QIs: (a) Initial time to respond (within one minute after receiving the alarm call), (b) time to arrival of EMS response team, (c) on scene time, and (d) time to preferred destination. Data from prehospital care reports was used to measure all the timeliness QIs.

(a) Ability to respond immediately

Initial time to respond was statistically defined as the percentage of immediate response based on the difference between time call received and time response team is deployed. To get this percentage, time taken for EMS team to be deployed was first calculated using the following formula.

$$\text{Time taken to deplay EMS team (mins)} = \text{Time of dispatch} - \text{Time call received}$$

Secondly, the percentage of immediate responses (responses within 0 mins) was then calculated using the following formula.

$$\text{Percentage of immediate responses (\%)} = \frac{\text{Total immediate deployments}}{\text{Total deployments}} \text{X } 100$$

The percentages were calculated for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby percentages above 94% indicated a high performance, 84% to 94% average performance, and below 84% low performance.

(b) Time to arrival of EMS response team

Time to arrival of EMS response team was statistically defined as the mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes. To get this measure, the researcher first calculated time of arrival using the following formula:

$$\text{Time to arrival of EMS response team (mins)} = \text{Time at scene} - \text{Time EMS team deployed}$$

The researcher then calculated the mean time of arrival for the EMS response team for each EMS center and for the entire Riyadh city, and interpreted the findings using the Haugland et al. (125) benchmarks whereby mean time of arrivals below 22 mins indicated a high performance, 22 to 31 mins average performance, and more than 31 mins low performance.

(c) On scene time

On scene time was statistically defined as the mean time interval between time call received to time of arrival at patient scene in minutes. To get this measure, the researcher first on scene time using the following formula:

$$\text{Time at scene (mins)} = \text{Time at scene} - \text{Time call received}$$

The researcher then calculated the mean on scene time for each EMS center and for the entire Riyadh city, and interpreted the findings using the Haugland et al. (125) benchmarks whereby mean on scene times below 20 mins indicated a high performance, 20 to 22 mins average performance, and more than 22 mins low performance.

(d) Time to preferred destination

Time to preferred destination was statistically defined as the mean time interval between time call received to time patient is delivered to preferred destination in minutes. To get this measure, the researcher first time to preferred destination using the following formula:

$$\text{Time to preferred destination (mins)} = \text{Time at hospital} - \text{Time call received}$$

The researcher then calculated the mean time to preferred destination for each EMS center and for the entire Riyadh city, and interpreted the findings using the Haugland et al. (125) benchmarks whereby times to preferred destinations below 60 mins indicated high performance, 60 to 70 mins average performance, and more than 70 mins low performance.

2. Patient safety

The safety of the Saudi EMS system was assessed using one QI: adverse events and data from prehospital care reports. Adverse events were statistically defined as percentage of number PCRs with recorded adverse events against total number of PCRs. This percentage was calculated using the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby percentages below 1%

indicated a high performance, 1% to 3% average performance, and more than 3% low performance.

$$\text{Percentage of adverse events (\%)} = \frac{\text{No. of PCRs with recorded adverse events}}{\text{Total number of PCRs}} \text{X } 100$$

3. Efficiency of the Saudi EMS system

The efficiency of the Saudi EMS system was assessed using the following two QIs: (a) complete documentation and (b) performance monitoring, audit, appraisal, and/or debriefing.

(a) Complete documentation

Complete documentation was statistically defined as percentage of PCRs with complete records (with all variables entered) against total number of PCRs. This percentage was calculated using prehospital care reports and the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby percentages more than 80% indicated a high performance, 35% to 80% average performance, and below 35% low performance.

$$\text{Percentage of PCRs with complete records (\%)} = \frac{\text{No. of PCRs with complete records}}{\text{Total number of PCRs}} \text{X } 100$$

(b) Performance monitoring, audit, appraisal, and/or debriefing

Performance monitoring, audit, appraisal, and/or debriefing was statistically defined as percentage of frontline EMS providers reporting that EMS responses were monitored, debriefed, appraised, and/or audited against the total number of frontline EMS providers who completed the survey. Data obtained from surveying frontline EMS providers was used to measure this QI. This percentage was calculated using the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks

whereby percentages more than 90% indicated high performance, 65% to 90% average performance, below 65% low performance.

$$\text{Percentage of debriefed responses (\%)} = \frac{\text{No. of debriefed EMS providers}}{\text{Total number of EMS providers}} \text{X } 100$$

4. Effectiveness of the Saudi EMS system

The effectiveness of the Saudi EMS system was assessed using the following six QIs: (a) guidelines for actual medical problems, (b) provision of advanced treatments, (c) involvement of EMS physicians in dispatching EMS response team, (d) patients enrolled in research projects, (e) patients arriving to the hospital alive, and (f) time-sensitive illnesses.

(a) Guidelines for actual medical problems

Guidelines for actual medical problems was statistically defined as percentage of the number of medical problems with guidelines against total number of actual medical problems obtained from the annual report. This QI was measured using data from senior SRCA staff surveys and records of EMS problems obtained from the 2018 annual report. This percentage was calculated using the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 78% indicated high performance, 45% to 78% average performance, and below 45% low performance.

$$\text{Percentage of available guidelines (\%)} = \frac{\text{No. of medical problems with guidelines}}{\text{Total number medical problems}} \text{X } 100$$

(b) Provision of advanced treatments

Provision of advanced treatments was statistically defined as percentage of PCRs recording provision of advanced treatments (such as airway management and oxygenation and pain management) against total number of PCRs. This percentage was calculated using data from prehospital care reports and the formula below for each EMS center and for the entire Riyadh

city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 59% indicated high performance, 39% to 59% average performance, and below 39% low performance.

$$\text{Percentage of advanced treatments (\%)} = \frac{\text{No. of PCRs recording advanced treatment}}{\text{sTotal number of PCRs}} \text{X } 100$$

(c) Involvement of EMS physicians in dispatching EMS response team

Involvement of EMS physicians in dispatching EMS response team was statistically defined as percentage of frontline EMS providers reporting that EMS physicians were involved in dispatching them against total number of frontline EMS providers who completed the survey. This percentage was calculated using data form frontline EMS provider surveys and the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 98% indicated high performance, 10% to 98% average performance, and below 10% low performance.

$$\text{Percentage of dispatches by a physcian (\%)} = \frac{\text{No. of EMS providers reporting being dispatched by phycians}}{\text{Total number of EMS providers surveyed}} \text{X } 100$$

(d) Patients enrolled in research projects

Patients enrolled in research projects was statistically defined as percentage of senior SRCA staff acknowledging that they recruit patients into EMS studies against total number of senior SRCA staff who were surveyed. This percentage was calculated using data from senior SRCA staff surveys and the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 4% indicated high performance, 1% to 4% average performance, and below 1% low performance.

$$\text{Percentage of research enrollments (\%)} = \frac{\text{No. of senior staff admitting to enrolling patients}}{\text{Total number senior staff surveyed}} \text{X } 100$$

(e) Patients arriving to the hospital alive

Patients arriving to the hospital alive was statistically defined as percentage of PCRs recording patients arriving to the hospital alive against total number of PCRs. This percentage was calculated using data from prehospital care reports and the formula below for each EMS center and for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 94% indicated high performance, 89% to 94% average performance, and below 89% low performance. When measuring this QI, any data that were missing because the patients were not transported were excluded from analysis.

$$\text{Percentage of research enrollments (\%)} = \frac{\text{No. of PCRs recording patients arriving to hospital alive}}{\text{Total number of PCRs}} \text{X } 100$$

(f) Time-sensitive illnesses

Time-sensitive illnesses (TSIs) were statistically defined as percentage of patients with time-sensitive illnesses (such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction) who received prehospital emergency care against total number of patients. For both children and adults, it is widely accepted that all conditions involving airway, breathing, circulation, disability, and exposure (ABCDE) are TSIs (142). Using the ABCDE approach as described by Thim et al. (142), we grouped TSIs into the following eight categories: TSI 1: Cardiovascular conditions; TSI 2: Neurological conditions; TSI 3: Trauma related conditions; TSI 4: Gastrointestinal emergencies; TSI 5: Infectious emergencies; TSI 6: Poisoning/Intoxication; TSI 7: Respiratory conditions; and TSI 8: Diabetes (particularly hypoglycemia). Percentage of total TSIs was calculated using data from 2018 annual report and the formula below for the entire Riyadh city, and interpreted using data reported in literature as this QI has no reported benchmarks.

$$\text{Percentage of time senstive illnesses (\%)} = \frac{\text{No. of patients with time senstive illnesses}}{\text{Total of patients}} \text{X } 100$$

5. Patient-centeredness in the Saudi EMS system

Patient-centeredness in the Saudi EMS system was assessed using one QI: Care for patient relatives. This QI was statistically defined as percentage of frontline EMS providers acknowledging providing care for patient relatives directly or with collaborating services against total number of senior SRCA staff surveyed. This percentage was calculated using data from senior SCRA staff surveys and the formula below for the entire Riyadh city, and interpreted using the Haugland et al. (125) benchmarks whereby more than 97% indicated high performance, 93% to 97% average performance, and below 93% low performance.

$$\text{Percentage of care for patient relative (\%)} = \frac{\text{No. of frontline EMS providers reporting care}}{\text{Total number of frontline EMS providers surveyed}} \text{X } 100$$

6. Equity of the Saudi EMS system

The equity of the Saudi EMS system was assessed using the following two QIs: (a) number of EMS units per population and (b) number of EMS units per area.

(a) Number of EMS units per population

Number of EMS units per population was statistically defined as the number of EMS centres per 100,000 population in each Saudi region. This measure was calculated using data from the annual report and SGAS population records and the formula below for each Saudi region and for the entire Saudi Arabia, and interpreted using the standards set by world health organizations.

$$\text{EMS centers per 100,000 population} = \frac{\text{No. of EMS centres}}{\text{Total population}} \text{X } 100{,}000$$

(b) Number of EMS units per area

Number of EMS units per area was statistically defined as the number of EMS centres per area (10,000km^2) of each Saudi region. This measure was calculated using data from the annual

report and SGAS geographical area records and the formula below for each Saudi region and for the entire Saudi Arabia, and interpreted using the standards set by world health organizations.

$$\text{EEMS centres per area (km2)} = \frac{\text{No. of EMS centres}}{\text{Area in km2}} \text{X } 10{,}000$$

Qualitative data

We used content analysis to analyze qualitative data from frontline EMS providers and senior SRCA staff. Together with a member of the supervisory team who is an expert in qualitative research, we developed themes from qualitative data after which we counted the number of responses within each of these themes, and where there were any disagreement between the researcher and the member of the supervisory team on emerging themes, we held a supervisory meeting with all members of the supervisory team where the themes were reviewed and defined after a critical discussion. Detailed qualitative methods are discussed in Chapter 5.

Chapter 4: Quantitative Results - Characteristics of Patients Using EMS Services in Riyadh City, Measures of Process and Outcome Quality Indicators, Relationships Between Quality Indicators and Other Quality Indicators or Patient Characteristics

INTRODUCTION

In this chapter, the quantitative results of the study are presented. Details of the study sample are described: sampled prehospital care reports (PCRs), senior Saudi Red Crescent Authority (SRCA) staff surveyed and frontline EMS providers surveyed. This is followed by presentation of the results of the study: characteristics of patients using EMS services in Riyadh city and measures of process and outcome quality indicators (timeliness, patient safety, efficiency, effectiveness, patient-centeredness, and equity).

In addition to assessing the quality of the Saudi EMS system in Riyadh city, this study also investigated the characteristics of patients using EMS services in Riyadh city and investigated how these patient characteristics influence EMS quality indicators. Research has shown that there is an increasing demand for prehospital care and ambulance transportation; however, a growing number of patients do not receive these services (143). The patients are referred to other levels of healthcare service. Therefore, it is important to investigate the characteristics of patients who receive EMS services in Riyadh city to establish the nature of the patient population being served by this service and how these characteristics compare with other similar or different contexts.

In addition, research evidence suggests that patient characteristics affect the quality of EMS service they receive. For example, studies conducted in Ghana (1) and Germany (2) have shown that ambulance response times, which are some of the quality indicators in this study, affects patient survival during prehospital care. Therefore, this study investigated the relationship between timeliness quality indicators and patient arrival to hospital alive. Also,

studies conducted outside Saudi Arabia have established a relationship between ambulance response times and time-sensitive illnesses (1,3) as well as a relationship between prehospital care treatments such as cardiopulmonary resuscitation and airway management and patient survival. (4) However, no study has been conducted in Saudi Arabia to investigate these relationships. Therefore, this study investigated relationships between timeliness quality indicators and time-sensitive illnesses.

In addition, studies conducted elsewhere have reported that time call received is associated with patient survival (5,6), number of prehospital care treatments, (6) and ambulance response times (7). However, no study has been conducted in Saudi Arabia to investigate these relationships. Also, it is necessary to investigate any disparities in service delivery (response times and other quality indicators) depending on the time the call is made. Therefore, this study investigated relationships between patient arrival to hospital alive and time call received, and time call received, and timeliness quality indicators and time call received.

Also, Saudi Arabia has a mass gathering of people, mostly pilgrims, in Makkah during Hajj festival. During this festival, EMS infrastructure and personnel are sent to Makkah to provide EMS services to millions of Muslims attending the religious festival (8). Consequently, the number of ambulances and EMS providers are reduced in other Saudi regions such as Riyadh where the festival is not taking place. Therefore, it is necessary to investigate whether there are any significant differences in ambulance response times and prehospital care treatments provided to EMS patients during the period of Hajj festival and non-Hajj period that can be used to inform policy and quality improvements. This study compared measures of timeliness quality indicators during Hajj and non-Hajj periods to determine any significant differences using analysis of variance.

METHODS

Detailed study methods are described in Chapter 3. Briefly, data regarding the characteristics of patients using EMS services in Riyadh city and measures of process and outcome quality indicators were collected using pre-existing data (prehospital care reports and SRCA annual report) and primary data (senior SRCA staff and frontline EMS provider survey data). Particularly, data from 442 sampled prehospital care reports was used to measure timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination); one efficiency QI (complete documentation); and three effectiveness QIs (advanced treatments, patients arriving to the hospital alive, and time-sensitive illnesses). Senior SRCA staff survey data (data collected from electronic survey of 28 directors and assistant directors of the sampled EMS centers and entire Riyadh region) was used to measure two effectiveness QIs (EMS guidelines and patients enrolled in research projects). Frontline EMS provider survey data (data collected from the electronic survey of all frontline EMS providers in the sampled EMS centers) was used to measure one efficiency QI (performance monitoring, audit, appraisal, and/or debriefing) and the patient-centered QI (care for patient relatives). Data from the 2018 annual report was used to measure the two equity QIs (EMS centers per population and EMS centers per area). All data regarding characteristics of patients using EMS services in Riyadh city were obtained from the sampled PCRs. The data used to measure the QI guidelines for actual medical problem were collected from 2 senior SRCA staff from each EMS center: director and assistant director.

RESULTS

Study sample

Prehospital care reports (PCRs)

A total of 442 prehospital care reports were sampled from randomly selected 12 EMS centers in Riyadh city and one EMS center outside Riyadh city for pilot study. We randomly sampled 36 PCRs from each EMS center: a convenient number of 3 PCRs from each month of 2018 (from January to December, 2018). Analysis of the distribution of the PCRs by month across all the EMS centers revealed that the PCRs were equally sampled from January to December (37 for each month) except for September, November, and December that had 36 PCRs each and June that had 38 PCRs. Among the sampled PCRs, 37 were from January, February, March, April, May, July, August, and October each; 38 were from June; and 36 were from September, November, and December each. The unequal distribution of PCRs is due to the inclusion of the 10 PCRs from Center 8 (center for the pilot study). As there were no changes in the study methods between the pilot study and the main study, data from the pilot center were included to boost the sample size.

Some of the variables of interest to this study were missing in the sampled 442 prehospital care reports, as detailed in Table 10.

Table 10. Missing records for different key variables in the sampled prehospital care reports

Variable	Number of PCRs with complete records	Number of PCRs with missing records	Percentage of incomplete records (%)
Gender	442	0	0.00
Age	428	14	3.17
Pre-existing medical conditions	218	224	50.68
Patient location	406	36	8.14
Type of emergency call	402	40	9.05
Chief patient complaint	441	1	0.23

Type of traumatic brain injury based on Glasgow Coma Scale score	435	7	1.58
Time call received	410	32	7.24
Time EMS team is dispatched	401	41	9.28
Time EMS team arrives at patient scene	421	21	4.75
Time of departure from patient scene	318	13 (Excluding 111 not transported)	3.93
Time of arrival at hospital	221	108 (Excluding 111 not transported and 2 with missing departure time)	32.83
Transportation	440	2	0.45
Patients arriving to the hospital alive or dead	329	0 (Excluding 111 not transported and 2 with missing departure time)	0.00

Senior Saudi Red Crescent Authority (SRCA) Staff

We surveyed 28 senior SRCA staff: this included 1 director and 1 assistant director from each EMS center and the general director and assistant director for the entire Riyadh region. In each EMS center, all the surveyed senior SRCA staff responded to the survey questionnaire (100% response rate).

Frontline EMS providers

The survey questionnaire was electronically sent to all the frontline EMS providers in the sampled 13 EMS centers (185 frontline EMS providers), 105 frontline EMS providers completed the survey (Table 11). The overall response rate was 56.8%; Center 2 had the highest response rate at 91.7% and Center 10 had the lowest response rate at 22.2% (Table 11). All the

frontline EMS providers were males (105, 100.0%), 90 (85.7%) had university education while 15 (14.3%) had high school education. Most of the EMS providers were paramedics (98, 93.33%); 4 (3.81%) were EMS technicians; and 3 (2.86%) were doctors. All the frontline EMS providers who completed the survey reported that they responded to medical emergencies in 2018. The mean number of years the frontline EMS providers had worked for SRCA was 5.87 years (SD = 3.57; minimum 1 year and maximum 17 years). The distribution of years the frontline EMS providers worked with SRCA is shown in Figure 7.

Table 11. Number of frontline EMS providers who completed the survey in each EMS center (*N* = 105)

EMS center	Total invited	Number who responded to the survey	Response rate (%)
Center 1	11	3	27.3
Center 2	12	11	91.7
Center 3	11	7	63.6
Center 4	21	7	33.3
Center 5	12	9	75
Center 6	9	7	77.8
Center 7	9	5	55.6
Center 8	11	6	54.5
Center 9	19	11	57.9
Center 10	18	4	22.2
Center 11	20	16	80
Center 12	11	4	36.4
Center 13	19	15	78.9
Total	185	105	57.4

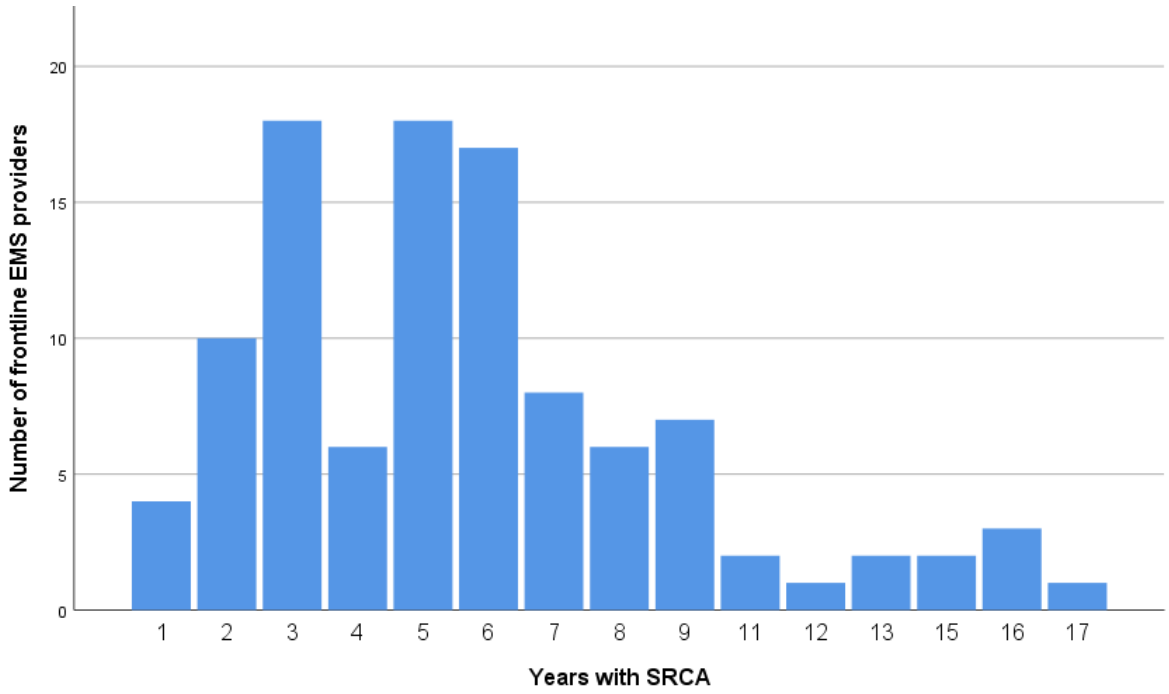


Figure 7. Number of years frontline EMS providers worked for Saudi Red Crescent Authority

Characteristics of patients using EMS services in Riyadh city

Patient characteristics before prehospital care

Analysis of the PCR data revealed the characteristics of the patients before arrival of the prehospital care team, particularly their gender, age, and pre-existing patient conditions. In terms of gender, more males used the EMS services compared to females [299 male patients (67.6%) Vs. 143 female patients (32.4%)] (Table 12). The youngest patient who used the services was aged 3.5 months, the oldest was aged 110 years. A high number of older patients aged 60 years and above (114 patients, 25.8%) used the services compared with the other age groups (Table 12). The mean age of patients who used the services was 44.86 years (SD = 23.34). Fourteen prehospital care reports had missing records of the age of the patients.

In terms of pre-existing medical conditions of the patients, 218 prehospital care reports (49.3%) out of the sampled 442 reports had data on these conditions. As shown in Table 12, the most common pre-existing patient condition was comorbid diabetes mellitus and

hypertension affecting 85 (19.2%) of all the 442 patients. The prehospital care reports also had records of 5 patients with allergic reactions and 2 patients with epidemic diseases (HIV and tuberculosis) (Table 12).

Table 12. Patient characteristics before prehospital care

	N	Percentage (%)
Total	442	100
Gender		
Male	299	67.6
Female	143	32.4
Age		
Under 18 years	35	7.9
18 to 24 years	56	12.7
25 to 31 years	72	16.3
32 to 38	43	9.7
39 to 45 years	39	8.8
46 to 52 years	31	7.0
53 to 59 years	38	8.6
60 years and above	114	25.8
Missing	14	3.2
Pre-existing patient conditions		
Diabetes mellitus and hypertension	85	19.2
Seizures	21	4.8
Hypertension	30	6.8
Loss of consciousness	13	2.9
Surgical history	3	0.7
Chronic obstructive pulmonary disease	2	0.5
Hepatitis	1	0.2
Psychiatric patient	3	0.7
Endocrine system	32	7.2
Tumour/Cancer	4	0.9
Stroke	3	0.7
Pregnancy	5	1.1
Asthma	8	1.8
Renal failure	3	0.7
Paralysis	1	0.2
Cardiovascular conditions	4	0.9
Total	218	49.3
Missing	224	50.7
Allergy		
Not allergic	211	47.7
Allergic	5[a]	1.1
Total	216	48.9

Missing	226	51.1
Epidemic diseases		
Negative	217	49.1
Positive	2[b]	0.5
Missing	223	50.5

[a] Out of the 5 patients who had allergic reactions, one was allergic to aspirin, one was allergic to shrimp, and the allergy details for the 3 remaining patients were missing in the prehospital care reports.
[b] The two positive cases of epidemic diseases were HIV in one patient and tuberculosis in another patient.

Patient characteristics during prehospital care

During prehospital care, analysis of the data in the sampled prehospital care reports revealed the characteristics of the patients in terms of their location, type of emergency call, injuries to different parts of the body, chief patient complaint, and type of traumatic brain injury based on Glasgow Coma Scale score (9). In terms of patient location, most of the patients were located at home (212 patients, 48.0%) while the least number of patients were located at schools (7 patients, 1.6%) (Table 13). Thirty-six prehospital care reports had missing data on patient location.

Table 13. Patient characteristics during prehospital care

Patient location	N (%)	Missing (%)
School	7 (1.6)	
Business	20 (4.5)	
Road/off road	96 (21.7)	36 (8.1)
Home	212 (48.0)	
Others	71 (16.1)	
Type of emergency call		
Trauma	90 (20.4)	
Motor vehicle accident	46 (10.4)	40 (9.0)
Other medical conditions	266 (60.2)	
Injuries to different parts of the body	No. with injury (%)	No. without recorded injuries to different parts of the body (%)
Head injuries	47 (10.6)	395 (89.4)
Arm injuries	28 (6.3)	414 (93.7)

Back injuries	30 (6.8)	412 (93.2)
Chest injuries	41 (9.3)	401 (90.7)
Abdominal injuries	21 (4.8)	421 (95.2)
Pelvic injuries	8 (1.8)	434 (98.2)
Leg injuries	35 (7.9)	407 (92.1)
Chief patient complaint	**N** (%)	Missing (%)
TSI 1: Cardiovascular conditions	74 (16.7)	
TSI 2: Neurological conditions	10 (2.3)	
TSI 3: Trauma related conditions	127 (28.7)	
TSI 4: Gastrointestinal emergencies	25 (5.7)	
TSI 5: Infectious emergencies	3 (0.7)	
TSI 6: Poisoning/Intoxication	1 (0.2)	
TSI 7: Respiratory conditions	31 (7.0)	
TSI 8: Diabetes	6 (1.4))	
Total time-sensitive illnesses	277 (62.7)	1 (0.2)
Non-TSI 1: Musculoskeletal pain	26 (5.9)	
Non-TSI 2: Allergy	1 (0.2)	
Non-TSI 3: Minor burns	1 (0.2)	
Non-TSI 4: Cold	4 (0.9)	
Non-TSI 6: Mild fever	10 (2.3)	
Non-TSI 7: Others[1]	122 (27.6)	
Total non-time-sensitive illnesses	164 (37.1)	
Type of traumatic brain injury based on Glasgow Coma Scale score		
3 to 8 (Severe traumatic brain injury)	34 (7.7)	
9 to 12 (Moderate traumatic brain injury)	18 (4.1)	7 (1.6)
13 to 15 (Mild traumatic brain injury)	383 (86.7)	

[1]Non-TSI 7: Others refers to non-time-sensitive illnesses that were not grouped in in the 6 categories. TSI, time-sensitive illness

In terms of type of calls made to the nearest EMS centers, 46 (10.4%) were due to motor vehicle accident, 90 (20.4) were due to trauma, and 266 (60.2) due to other medical conditions, with 40 (90.0%) missing (Table 13).

Eight chief patient complaints were grouped as time-sensitive illnesses (TSI): TSI 1: Cardiovascular conditions; TSI 2: Neurological conditions; TSI 3: Trauma related conditions; TSI 4: Gastrointestinal emergencies; TSI 5: Infectious emergencies; TSI 6: Poisoning/Intoxication; TSI 7: Respiratory conditions; and TSI 8: Diabetes. On the other hand, eight chief patient complaints were grouped as non-time-sensitive illnesses: Non-TSI 1:

Musculoskeletal pain; Non-TSI 2: Allergy; Non-TSI 3: Minor burns; Non-TSI 4: Cold; Non-TSI 6: Mild fever; and Non-TSI 7: Other non-time-sensitive illnesses. Most of the patients had time-sensitive illnesses compared with non-time-sensitive illnesses [277 patients (62.7%) Vs. 164 patients (37.1%)].

Particularly, the most common chief complaint among the patients as recorded in the prehospital care reports was trauma-related conditions, which are time-sensitive illnesses reported in 127 patients (28.7%). One of the prehospital care reports lacked records of the chief patient complaint.

Of the sampled 442 PCRs, 210 recorded injuries to different parts of the body while 232 had no records. The most common problems were injuries to the head, arms, back, chest, abdomen, pelvis, and legs (Table 14). Analysis of the Glasgow Coma Scale (10) data in the prehospital care reports revealed that most of patients had mild traumatic brain injury or had mild consciousness levels (Glasgow Coma Scale score of 13 to 15; 383 patients; 86.7%) (Table 13).

In terms of the time call received, analysis of the PCR data revealed that most of the calls were received from 18:01 to 00:00 hrs (128 PCRs, 28.96%), but 32 PCRs (7.24%) did not have records of when the call was received (Figure 8). The least number of calls were received from 00:01 to 6:00 hrs (89 PCRs, 20.14%).

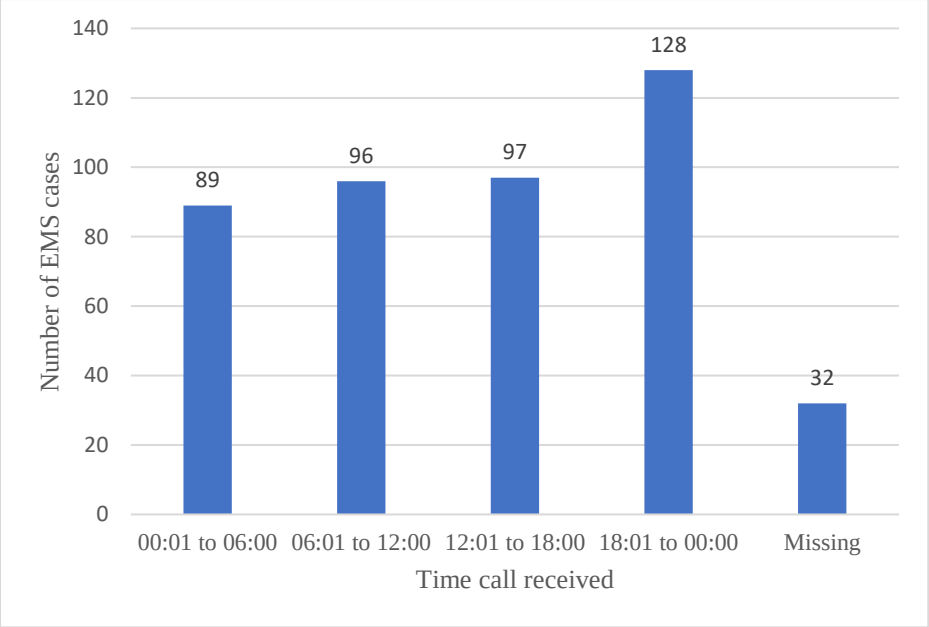


Figure 8. Distribution of number of EMS cases by time call received (*N*=442)

Prehospital care services received by the patients

Analysis of the sampled prehospital care reports revealed that the patients received prehospital care treatments and transportation. Out of the total 442 patients, 361 (81.7%) received prehospital care treatments, 78 (17.6%) did not receive any treatment, while 3 (0.7%) did not have records of any treatments in their prehospital care reports (Table 14). Among the 361 patients who received prehospital care treatments, 14 (3.9%) received basic life support: assessing signs and symptoms of patient conditions and performing cardiopulmonary resuscitation (CPR) and defibrillation while 347 (96.1%) received advanced life support: cardiac monitoring, intravenous cannulation, needle cricothyrotomy, advanced medications, advanced cardiac life support (ACLS), pre-hospital trauma life support, and other forms of advanced life support. Out of the total 442 patients, 329 (74.4%) were transported to healthcare facilities, 111 (25.1%) were not transported, and 2 (0.5) did not have any records of transportation in their prehospital care reports (Table 14).

Table 14. Prehospital care treatments received by the patients based on sampled prehospital care report data (N = 442)

	N	Percentage (%)
Total	442	100
Treatments received		
No treatments	78	17.6
Basic life support	14	3.2
Advanced life support		
Cardiac monitoring	28	6.3
Intravenous cannulation	14	3.2
Needle cricothyrotomy	1	0.2
Advanced medications	5	1.1
Advanced cardiac life support (ACLS)	6	1.4
Pre-hospital trauma life support	114	25.8
Multiple treatments	179	40.5
Missing	3	0.7
Transportation		
Transported	329	74.4
Not transported	111[a]	25.1
Missing	2	0.5

[a] The 111 patients were not transported because:

- They were treated and released at the scene: 6
- They refused transportation: 88
- They were treated on site but refused transportation: 2
- They were transported by a third party: 9
- They were deceased at the site: 6

In summary, results on characteristics of patients using EMS services in Riyadh city indicate:

- More males used the EMS services compared to females [299 male patients (67.6%) Vs. 143 female patients (32.4%)]
- A high number of older patients aged 60 years and above (114 patients, 25.8%) used the services compared with the other age groups
- The most common pre-existing patient condition was comorbid diabetes mellitus and hypertension affecting 85 (19.2%) of all the 442 patients

- Most of the patients who made the alarm calls were located at home (212 patients, 48.0%) while the least number of patients were located at schools (7 patients, 1.6%)
- Most commonly recorded chief complaint was trauma (28.7%), though most of the calls were due to other medical conditions other than trauma or motor vehicle accidents.
- Most of the calls were made from 1801 to 0000 hrs (128 PCRs, 28.96%)
- Most of the patients (361; 81.7%) received some kind of pre-hospital treatment, and most of the treatments provided were categorized as advanced life support rather than basic life support
- Most of the patients (329, 74.4%) were transported to healthcare facilities.

Measures of process and outcome quality indicators

Timeliness

Using PCR data, we measured four quality indicators for timeliness: initial time to respond, time to arrival of EMS response team, on scene time, and time to preferred destination.

Initial time to respond

Initial time to respond was defined as percentage of immediate responses (responses in less than one minute) based on the difference between time call received and time response team is deployed. Out of the 442 sampled PCRs, 69 (15.6%) had missing data on time call received and/or time response team is deployed; therefore, these PCRs were excluded from the analysis. The distribution of the response time in the entire Riyadh city is shown in Figure 9. The maximum response time was 12 mins, minimum was 0 mins, median was 0 mins, interquartile range was 1 min, and mean was 0.45 minutes (SD = 0.99).

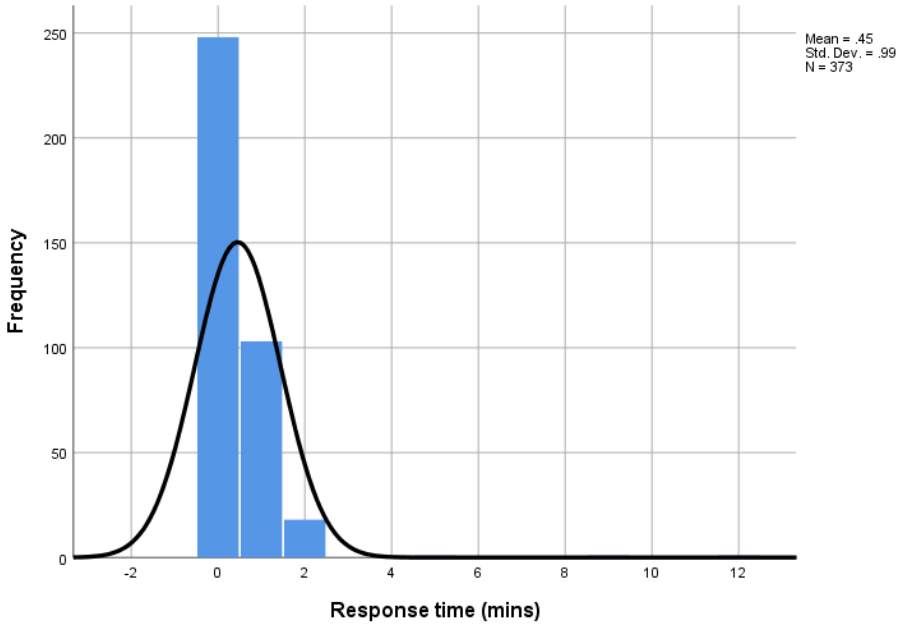


Figure 9. Distribution of response times in the entire Riyadh city. The mean response time for the entire Riyadh was 0.45 mins (SE = 0.05).

The mean initial response time was lowest at Center 10 (0.06 mins; SD = 0.242) and highest at Center 5 EMS center (0.96 mins; SD = 1.732) (Figure 10). Nine of the 13 EMS centers had more than 50% immediate responses with Center 10 having the highest immediate response rate (93.9% of all the responses taking place in less than one minute after receiving a call) (Table 15). In the entire Riyadh city, 248 responses (66.5%) were immediate (occurred in less than one minute) (Table 15). Based on Haugland et al. (125) benchmarks, none of the centers had a high performance (immediate responses above 94%), Centers 4, 10, and 13 had an average performance (immediate responses of 84% to 94%), and all the other centers had a low performance (immediate responses below 84%). Overall, all the sampled EMS centers in Riyadh city had a low performance (66.5%).

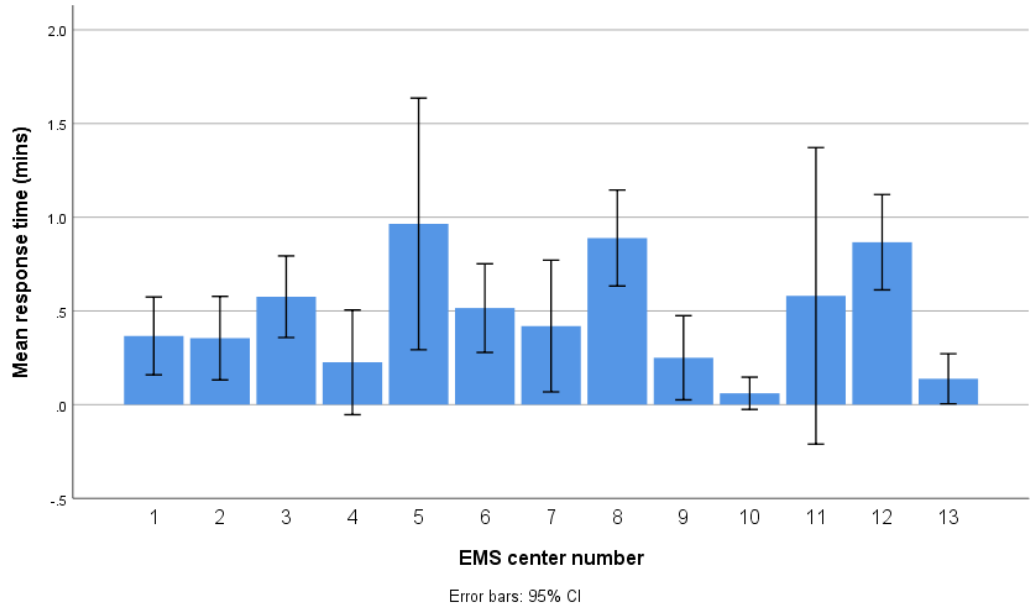


Figure 10. Mean initial response time for each EMS center. Response time is the difference between time call received and time response team is deployed. The mean response time for the entire Riyadh was 0.45 mins (SE = 0.05)

Table 15. Number of EMS responses at different response times

EMS Center	Number (percent) responses in less than a minute	
	0 min	>0 mins
Center 1	20 (69.0)	9 (31.0)
Center 2	22 (71.0)	9 (29.1)
Center 3	16 (48.5)	17 (51.5)
Center 4	27 (87.1)	4 (12.9)
Center 5	13 (46.4)	15 (53.6)
Center 6	19 (57.6)	14 (42.4)
Center 7	22 (71.0)	9 (29.0)
Center 8	1 (10.0)	9 (90.0)
Center 9	19 (79.2)	5 (20.8)
Center 10	31 (93.9)	2 (6.1)
Center 11	24 (77.4)	7 (22.6)
Center 12	9 (30.0)	21 (70.0)
Center 13	25 (86.2)	4 (13.8)
Entire Riyadh city	248 (66.5)	125 (33.5)

Time to arrival of EMS response team

Time to arrival of EMS response team (mean time interval between time EMS response team is deployed to time of arrival at patient scene) for the entire Riyadh city was 13.98 mins (SD =

8.772). The distribution of the time to arrival of EMS response team in the entire Riyadh city is shown in Figure 11. The maximum time to arrival of EMS response team was 58 mins, minimum was 0 mins, median was 12.00 mins, and interquartile range was 10 mins.

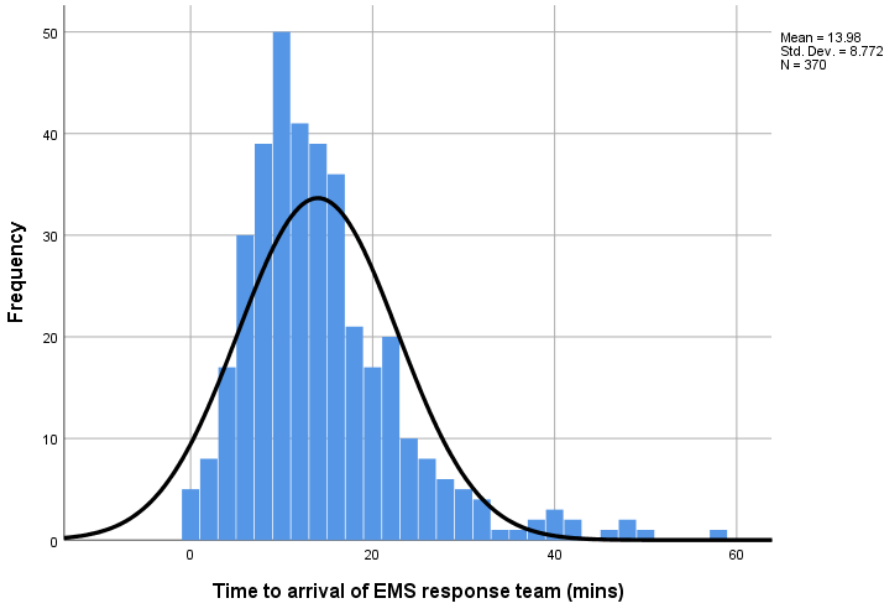


Figure 11. Distribution of the time to arrival of EMS response team in the entire Riyadh city. The mean time to arrival of EMS response team for the entire Riyadh was 13.98 mins (SE = 0.46).

Time to arrival was lowest at Center 13 (11.13 mins; SD = 6.918) and highest at Center 8 (17.7 mins; SD = 6.165 (Figure 12; Table 16), but these differences were not statistically significant (all the confidence intervals overlap). Out of the 442 PCRs included in this study, 72 (16.3%) had missing records of time EMS response team was deployed and/or time of arrival at patient scene and were therefore excluded from this analysis. Based on the Haugland et al. (11) benchmarks, all the centers had a high performance (mean time of arrivals below 22 mins); none of the centers had an average performance (22 to 31 mins) or low performance (more than 31 mins). Overall, all the sampled EMS centers in Riyadh city had a high performance (11.13 mins; SD = 6.918).

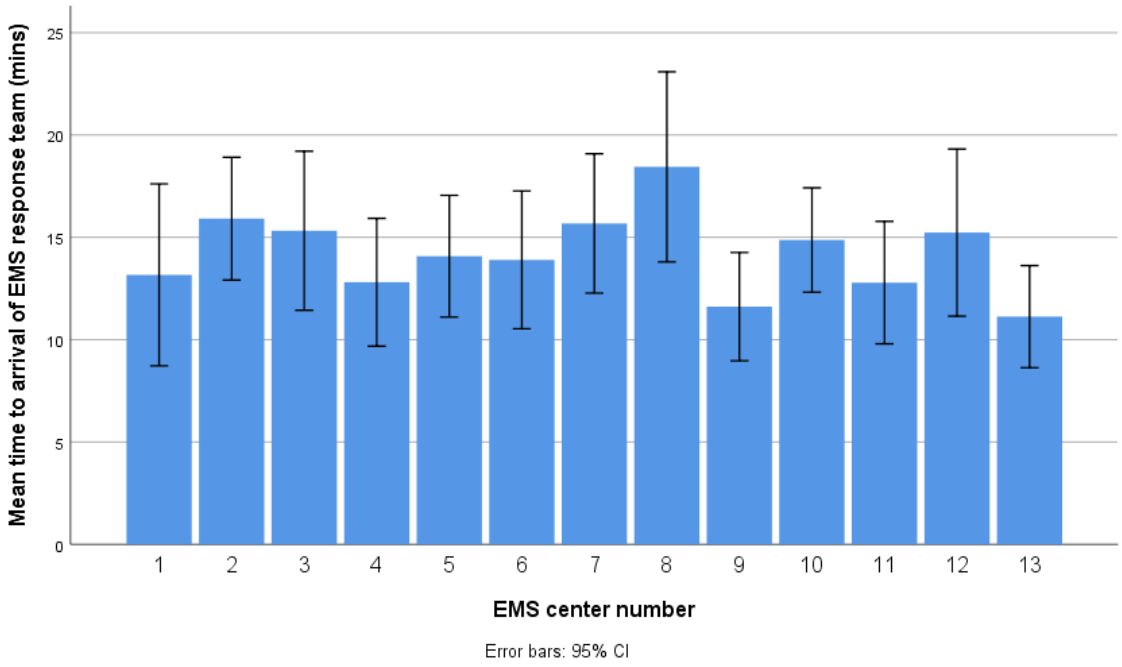


Figure 12. Mean time to arrival of EMS response team for each EMS center. Time to arrival of EMS response team is the mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes. The mean time to arrival of EMS response team for the entire Riyadh was 13.98 mins (SE = 0.46).

On-scene time

On-scene time (mean time interval between time call received to time of arrival at patient scene in minutes) for the entire Riyadh city was 14.6 mins (SD = 8.811). The distribution of on-scene time in the entire Riyadh city is shown in Figure 13. The maximum on-scene time was 60 mins, minimum was 0 mins, median was 13.00 mins, and interquartile range was 10 mins.

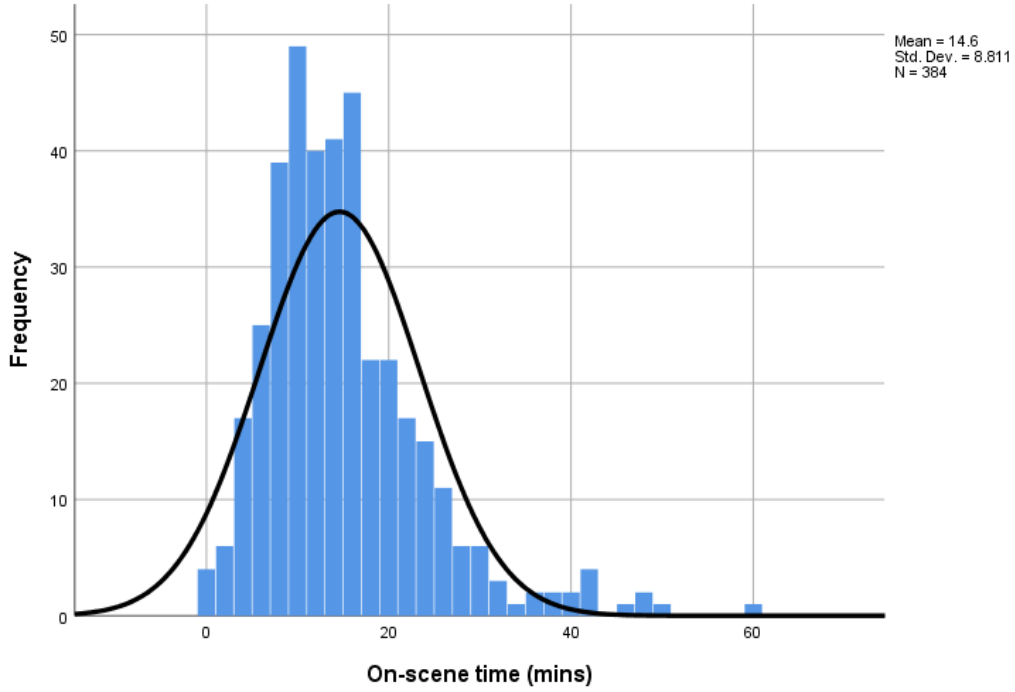


Figure 13. Distribution of the on-scene time in the entire Riyadh city. The mean on-scene time for the entire Riyadh was 14.6 mins (SE = 0.45)

The on-scene time was lowest at Center 13 (11.19 mins; SD = 7.139) and highest at Center 8 (18.6 mins; SD = 6.328) (Table 16; Figure 14). Out of the 442 PCRs included in this study, 58 (13.1%) had missing records of time call received and/or time of arrival at patient scene and were therefore excluded from analysis. Based on the Haugland et al. (11) benchmarks, all the EMS centers had a high performance (mean on scene times below 20 mins); none of the centers had an average performance (20 to 22 mins) or low performance (more than 22 mins). Overall, all the sampled EMS centers in Riyadh city had a high performance (14.6 mins; SD = 8.811).

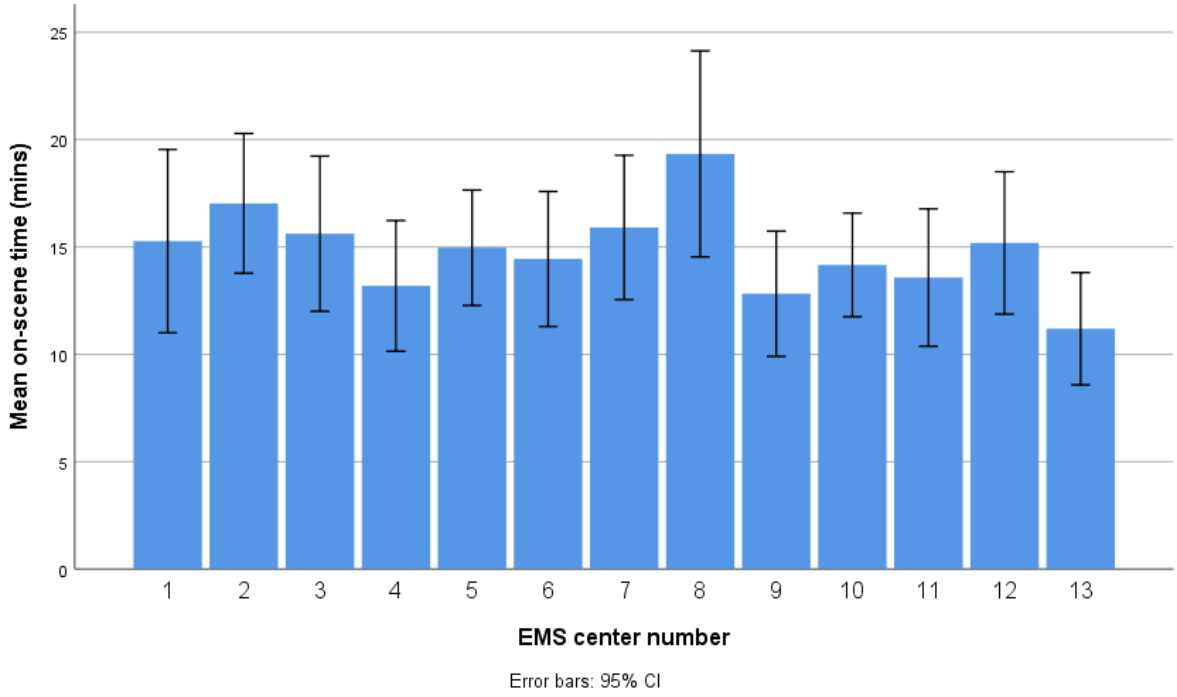


Figure 14. Mean on scene time for each EMS center. On scene time is the mean time interval between time call received to time of arrival at patient scene in minutes. The mean on-scene time for the entire Riyadh was 14.6 mins (SE = 0.45)

Time to preferred destination

Time to preferred destination (mean time interval between time call received to time patient is delivered to preferred destination in minutes) for the entire Riyadh city was 52.87 mins (SD = 22.536). The distribution of time to preferred destination in the entire Riyadh city is shown in Figure 15. The maximum time to preferred destination was 153 mins, minimum was 11 mins, median was 50 mins, and interquartile range was 26 mins.

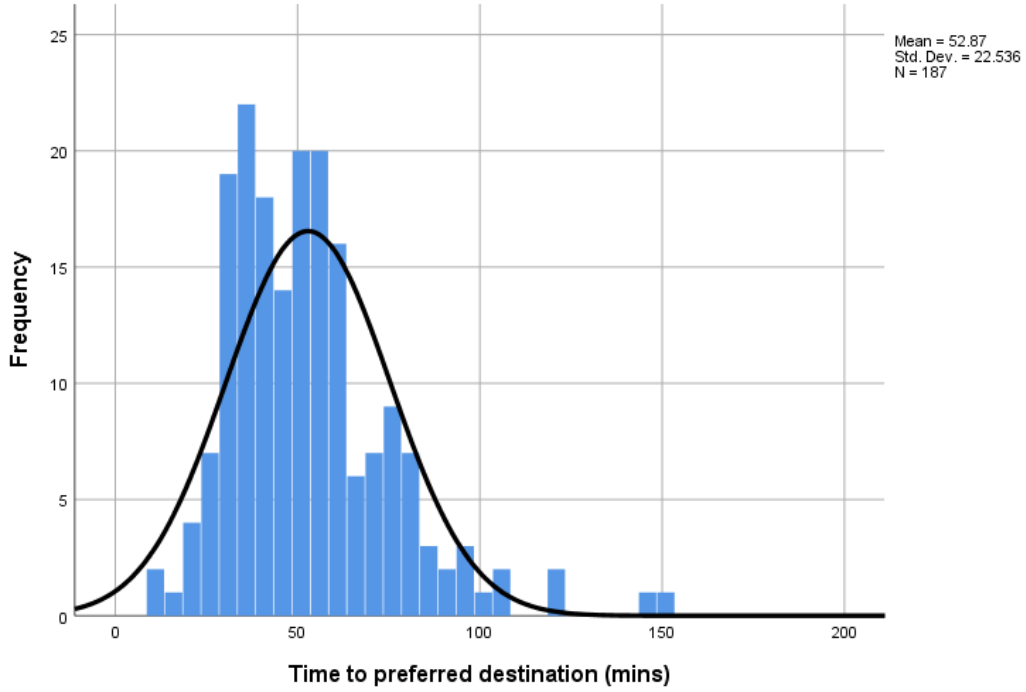


Figure 15. Distribution of the time to preferred destination in the entire Riyadh city. The mean time to preferred destination for the entire Riyadh was 52.87 mins (SE = 1.648)

Although there were no significant differences (all the confidence intervals overlapped) in time to preferred destination across the EMS centers, the time appeared to be lowest at Center 11 EMS center (34.20 mins; SD = 19.524) and highest at Center 1 (67.32 mins; SD = 27.447) (Table 16; Figure 16). Out of the 442 PCRs included in this study, 255 (57.7%) had missing data on time call received and/or time patient is delivered to preferred destination and were therefore excluded from this analysis. Based on Haugland et al. (11) benchmarks, all the EMS centers except Centers 1 and 2 had a high performance (mean times to preferred destinations below 60 mins). Centers 1 and 2 had an average performance (60 to 70 mins) and none of the centers had a low performance (more than 70 mins). Overall, all the sampled EMS centers in Riyadh city had a high performance (52.87 mins; SD = 22.536).

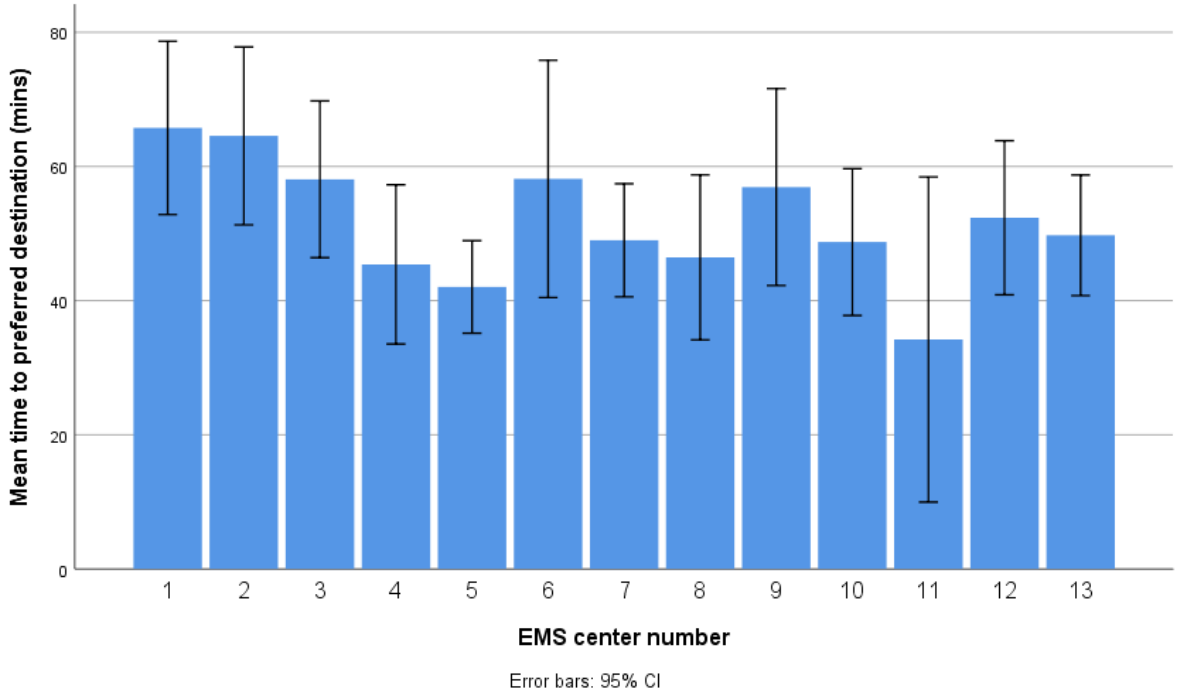


Figure 16. Mean time to preferred destination for each EMS center. Time to preferred destination is the mean time interval between time call received to time patient is delivered to preferred destination in minutes.

Table 16. Time to arrival of EMS response team, on-scene time, and time to preferred destination of each EMS center and entire Riyadh city

		Initial time to respond (mins)	Time to arrival of EMS response team (mins)	On-scene time (mins)	Time to preferred destination (mins)
Center 1	Mean	0.37	13.24	15.37	67.32
	Std. Deviation	0.556	12.109	12.218	27.447
	Minimum	0	0	0	34
	Median	0.00	10	12.5	66
	Maximum	2	48	48	123
Center 2	Mean	0.35	15.91	17.03	64.56
	Std. Deviation	0.608	8.6	9.032	26.651
	Minimum	0	4	4	36
	Median	0.00	16	16	57
	Maximum	2	45	46	147
Center 3	Mean	0.58	15.32	15.62	58.08
	Std. Deviation	0.614	10.591	10.36	18.387
	Minimum	0	3	4	27
	Median	1.00	12	13	53.5
	Maximum	2	58	60	90
Center 4	Mean	0.23	12.81	13.19	45.4

	Std. Deviation	0.762	8.514	8.445	16.588
	Minimum	0	4	4	28
	Median	0.00	12	12	42.5
	Maximum	4	50	50	84
Center 5	Mean	0.96	14.08	14.97	42.04
	Std. Deviation	1.732	7.364	7.063	15.936
	Minimum	0	4	4	11
	Median	1.00	11.5	14	38
	Maximum	9	28	28	78
Center 6	Mean	0.52	13.9	14.44	58.14
	Std. Deviation	0.667	9.019	8.721	30.629
	Minimum	0	1	2	25
	Median	0.00	13	14	54
	Maximum	2	48	48	153
Center 7	Mean	0.42	15.68	15.91	49
	Std. Deviation	0.958	9.286	9.475	16.957
	Minimum	0	0	0	20
	Median	0.00	13	13	47
	Maximum	5	34	37	79
Center 8	Mean	0.89	17.7	18.6	45.4
	Std. Deviation	0.333	6.165	6.328	15.429
	Minimum	0	9	9	31
	Median	1.00	17.5	18.5	37.5
	Maximum	1	29	30	73
Center 9	Mean	0.25	11.61	12.82	56.93
	Std. Deviation	0.532	7.21	7.523	25.415
	Minimum	0	0	1	21
	Median	0.00	9	10.5	52
	Maximum	2	37	37	107
Center 10	Mean	0.06	14.87	14.16	48.73
	Std. Deviation	0.242	6.946	6.578	19.761
	Minimum	0	2	3	28
	Median	0.00	13	13	47
	Maximum	1	29	29	104
Center 11	Mean	0.58	12.79	13.57	34.2
	Std. Deviation	2.157	7.714	8.253	19.524
	Minimum	0	2	2	13
	Median	0.00	12.5	13.5	30
	Maximum	12	32	32	60
Center 12	Mean	0.87	15.23	15.19	52.36
	Std. Deviation	0.681	10.113	9.195	19.89
	Minimum	0	5	6	31
	Median	1.00	13.5	13	50.5
	Maximum	2	41	41	96
Center 13	Mean	0.14	11.13	11.19	49.73
	Std. Deviation	0.351	6.918	7.139	16.228

	Minimum	0.00	0	0	15
	Median	0	10	10	52
	Maximum	1	39	40	80
Entire Riyadh city	Mean	0.45	13.98	14.6	52.87
	Std. Deviation	0.99	8.772	8.811	22.536
	Minimum	0	0	0	11
	Median	0	12	13	50
	Maximum	12	58	60	153

Initial time to respond: time interval between time call received and time response team is deployed

Time to arrival of EMS response team: time interval between time EMS response team is deployed to time of arrival at patient scene in minutes

On scene time: time interval between time call received to time of arrival at patient scene in minutes

Time to preferred destination: time interval between time call received to time patient is delivered to preferred destination in minutes

Patient safety

We aimed to determine patient safety by measuring percentage of patients who suffered adverse events during prehospital care. However, records of adverse events were missing from the PCRs; therefore, this quality indicator could not be measured. Ideally, adverse events should have been recorded in the PCRs, but these records were missing.

Efficiency

We used the PCR data and frontline EMS provider survey data to measure two quality indicators for efficiency of the Saudi EMS system: complete documentation (PCR data) and performance monitoring, audit, appraisal, and/or debriefing (frontline EMS provider survey data).

Complete documentation

Complete documentation was defined as percentage of complete EMS records (PCRs with all mandatory fields filled; mandatory fields were name, gender, ambulance response times, people or individuals requesting the ambulance, patient location, and chief complaints of the patient). In the entire study area (Riyadh city), most of the PCRs were incomplete (279 incomplete PCRs, 63.10% Vs 163 complete PCRs, 36.90%) (Table 17). All the centers had incomplete PCRs, except Center 8 EMS center where all the PCRs were complete. Center 11 EMS center had the lowest number of complete PCRs (4 complete PCRs, 11.10% Vs. 32 incomplete PCRs, 88.90%. Based on the Haugland et al. (11) benchmarks, Center 8 had a high performance (percentage of percentage of complete EMS records above 80%). Centers 1, 2, 5, 6, 7, 9, 10, and 13 had an average performance (35% to 80%) while Centers 3, 4, 11, and 12 had a low performance (below 35%). Overall, all the sampled EMS centers in Riyadh city had an average performance (36.90%).

Table 17. Number and percentage of complete prehospital care reports Vs incomplete prehospital care reports

EMS center	Complete PCRs	
	N	%
Center 1	16	44.40%
Center 2	17	47.20%
Center 3	11	30.60%
Center 4	9	25.00%
Center 5	15	41.70%
Center 6	13	36.10%
Center 7	16	44.40%
Center 8	10	100.00%
Center 9	13	36.10%
Center 10	14	38.90%
Center 11	4	11.10%
Center 12	12	33.30%
Center 13	13	36.10%
Entire Riyadh city	163	36.90%

Complete PCRs were those with all mandatory fields filled; mandatory fields were name, age, gender, ambulance response times, type of calls, patient location, and chief complaints of the patient. The PCRs had the following fields missing: ambulance response times (188), type of emergency call (40), patient location (36), age (14), and chief complaints (1).

Performance monitoring, audit, appraisal, and/or debriefing

Analysis of frontline EMS provider survey data revealed that 92 (87.60%) of all the 105 surveyed frontline EMS providers reported being debriefed after an EMS response (Table 18). In seven of the 13 EMS centers (Centers 1, 2, 3, 5, 7, 10, and 12), all the surveyed frontline EMS providers reported being debriefed after an EMS response. In the other EMS centers, more than 50% of the frontline EMS providers reported being debriefed. Among frontline EMS providers who reported being debriefed in all the centers, 25 (23.80%) reported being debriefed all the time, 30 (28.60%) most of the time and 37 (35.20%) sometimes. Six of the frontline EMS providers (5.70%; one from Center 6, one from Center 8, three from Center 11 and one from Center 13) reported that they were never debriefed after responding to medical emergencies in 2018. When analyzed by the type of frontline EMS provider being debriefed, paramedics were debriefed most by senior SRCA staff and by face-to-face conversation (Table 19). In the entire study area, 87 frontline EMS providers (82.90%) reported being debriefed by Senior SRCA staff while the most common debriefing method reported by the frontline EMS providers was face-to-face conversation, reported by 70 frontline EMS providers (66.70%). Based on the Haugland et al. (11) benchmarks, , all the sampled EMS centers in Riyadh city had an average performance (87.60% reported being debriefed).

Table 18. Number of frontline EMS providers responding to a question of whether they were debriefed after responding to an emergency in 2018

EMS Center	Yes, all the time		Yes, most of the time		Yes, sometimes		Never		Don't know	
	N	%	N	%	N	%	N	%	N	%
Center 1	0	0.00%	3	100.00%	0	0.00%	0	0.00%	0	0.00%
Center 2	4	36.40%	3	27.30%	4	36.40%	0	0.00%	0	0.00%
Center 3	2	28.60%	2	28.60%	3	42.90%	0	0.00%	0	0.00%
Center 4	2	28.60%	3	42.90%	1	14.30%	0	0.00%	1	14.30%
Center 5	4	44.40%	3	33.30%	2	22.20%	0	0.00%	0	0.00%
Center 6	1	14.30%	0	0.00%	3	42.90%	1	14.30%	2	28.60%
Center 7	2	40.00%	0	0.00%	3	60.00%	0	0.00%	0	0.00%
Center 8	1	16.70%	1	16.70%	3	50.00%	1	16.70%	0	0.00%
Center 9	2	18.20%	2	18.20%	6	54.50%	0	0.00%	1	9.10%
Center 10	0	0.00%	2	50.00%	2	50.00%	0	0.00%	0	0.00%
Center 11	5	31.30%	5	31.30%	2	12.50%	3	18.80%	1	6.30%
Center 12	1	25.00%	1	25.00%	2	50.00%	0	0.00%	0	0.00%
Center 13	1	6.70%	5	33.30%	6	40.00%	1	6.70%	2	13.30%
Entire Riyadh city	25	23.80%	30	28.60%	37	35.20%	6	5.70%	7	6.70%

Table 19. Number of frontline EMS providers responding to a question of who debriefed them and how the debriefing was carried out after responding to an emergency in 2018 across the entire study area

		Type of frontline EMS provider		
		Paramedic	Paramedic technicians	Doctor
Debriefed by	Not applicable	13	0	0
	Medical reports committee	3	0	0
	Senior SRCA staff	82	3	2
	Colleague	0	1	1
How debriefing was conducted	Not applicable	13	0	0
	Face-to-face	63	4	3
	Filling form	4	0	0

Phone/radio call	4	0	0
SMS	14	0	0

Effectiveness

We used PCR data and senior SRCA staff survey data to measure five quality indicators for effectiveness of the Saudi EMS system: guidelines for actual medical problems (senior SRCA staff survey data), provision of advanced treatments (PCR data), involvement of EMS physicians in dispatching EMS response team (frontline EMS provider survey data), patients enrolled in research projects (senior SRCA staff survey data), patients arriving to the hospital alive (PCR data), and time-sensitive illnesses (PCR data).

Availability of treatment guidelines

Guidelines for actual medical problem was defined as percentage of available guidelines against the medical problems responded to. As shown in Table 13 under characteristics of patients using EMS services in Riyadh city, the chief patient complaints responded to by the EMS system were the following: cardiovascular conditions, neurological conditions, trauma related conditions, gastrointestinal emergencies, infectious emergencies, poisoning/intoxication, respiratory conditions, diabetes, musculoskeletal pain, allergy, minor burns, cold, mild fever, and other medical emergencies. Among the available general EMS guidelines were basic life support guidelines; airway, breathing, and circulation guidelines; Saudi heart association guidelines; prehospital trauma life support guidelines; and international trauma life support. The most commonly reported general guidelines were basic life support guidelines reported by 18 out of the 26 senior SRCA staff (Table 20). In addition to the general guidelines, 17 of the 26 senior RCA staff reported using advanced cardiac life support guidelines for caring for cardiovascular disease patients. However, two of the senior SRCA

staff reported using airway, breathing, and circulation guidelines, which are general guidelines to care for cardiovascular disease patients. All the reported guidelines were evidence-based, except in Center 7 EMS center where the guidelines were not available for assessment.

When compared against the chief patient complaints, the responses of the senior SRCA staff show that the Basic life support guidelines; Airway, Breathing, and Circulation; Saudi Heart Association guidelines; Prehospital Trauma Life Support; International Trauma Life Support; Advanced cardiac life support; Airway, Breathing, and Circulation are suitable for providing prehospital care to the patients. However, these guidelines are not available in some EMS centers. For example, Center 7 did not have any of these 7 guidelines. Centers 7 and 9 had some of the guidelines but they were not available for assessment on whether they are evidence-based. All the other Centers had less than 50% of these guidelines (Table 20). Based on Haugland et al. (11) benchmarks, none of the Centers had a high performance (more than 78%) or an average performance (45% to 78%). All the centers had a low performance (below 45%). Overall, all the sampled EMS centers in Riyadh city had a low performance (below 45%).

Table 20. Emergency medical service guidelines reported by senior Saudi Crescent Authority staff (two senior staff from each center: director and assistant director)

EMS center	General guidelines					CVD guidelines		Evidence-based?	Percentage of available evidence-based guidelines
	Basic life support guidelines	Airway, Breathing, and Circulation	Saudi Heart Association guidelines	Prehospital Trauma Life Support	International Trauma Life Support	Advanced cardiac life support	Airway, Breathing, and Circulation		
Center 1	2	0	0	0	0	2	0	Yes	28.6%
Center 2	2	0	0	0	0	1	0	Yes	28.6%
Center 3	2	0	0	0	2	2	0	Yes	42.6%
Center 4	2	0	0	2	0	2	0	Yes	42.6%
Center 5	2	0	0	0	0	2	0	Yes	28.6%
Center 6	0	0	0	0	0	0	0	Not applicable	0.0%
Center 7	0	0	2	0	0	2	0	Not assessed	0.0%
Center 8	0	2	0	0	0	0	2	Yes	28.6%
Center 9	0	0	0	0	0	0	0	Not applicable	0.0%
Center 10	2	0	0	0	0	2	0	Yes	28.6%
Center 11	2	0	0	0	0	2	0	Yes	28.6%
Center 12	2	0	0	0	0	2	0	Yes	28.6%
Center 13	2	0	0	1	0	2	0	Yes	42.6%
Number of EMS centers with each guideline	9	1	1	2	1	10	1	10	76.9%

CVD, cardiovascular disease

Provision of advanced treatments

Provision of advanced treatments was defined as percentage of EMS patients who received advanced treatments (specifically cardiac monitoring, intravenous cannulation, needle cricothyrotomy, advanced medications, advanced cardiac life support (ACLS), pre-hospital trauma life support, and multiple treatments) against total number of EMS patients. As shown in Table 14 under prehospital care services received by the patients, 347 patients (96.1%, 95% confidence interval = 93.6-97.7) received advanced life support among the 361 patients who received prehospital care treatments. Details regarding the number and percentage of EMS patients who received each treatment is shown in Table 14. Based on the Haugland et al. (11) benchmarks, in overall, all the sampled EMS centers in Riyadh city had a high performance (more than 59% provision of advanced treatments).

Involvement of EMS physicians in dispatching EMS response team

Involvement of EMS physicians in dispatching EMS response team was defined as percentage of frontline EMS providers reporting that EMS physicians were involved in dispatching them against total number of frontline EMS providers who completed the survey. Most of the surveyed frontline EMS providers (93 providers, 88.6%) reported that they were dispatched by EMS physicians. Among the frontline EMS providers who reported being dispatched by EMS physicians, 37 (39.8%) reported being dispatched by EMS physicians all the time, 35 (37.6%) most of the time, and 21 (22.6%) sometimes. Based on the Haugland et al. (11) benchmarks, the overall performance was average (more than 98% indicates high performance, 10% to 98% average performance, and below 10% low performance).

Patients enrolled in research projects

Patients enrolled in research projects was defined as percentage of senior SRCA staff acknowledging that they recruit patients into EMS studies against total number of senior SRCA staff who were surveyed. Only two out of the 26 surveyed senior SRCA staff (7.68%) acknowledged that they recruit patients into EMS studies. The two senior SRCA staff were from the same EMS center. The two senior SRCA staff quoted the study title as "The relation between response time and the outcome in cardiac patients" and reported to have recruited 300 EMS patents into the study by the time this study was conducted. Based on the Haugland et al. (11) benchmarks, the overall performance in Riyadh was high (7.7%; more than 4% indicates high performance, 1% to 4% average performance, and below 1% low performance).

Patients arriving to the hospital alive

Patients arriving to the hospital alive was defined as percentage of PCRs recording patients arriving to the hospital alive against total number of PCRs. Of the total 442 PCRs, 113 had missing data on whether the patient arrived to the hospital alive (111 of these were not transported and 2 were transported but had missing data) and were therefore excluded from the analysis (Figure 17). As shown in Table 21, a total of 318 patients (96.7%, 95% confidence interval = 94.1-98.1) arrived to the hospital alive. Five EMS centers (Centers 1, 5, 6, 10, and11) had all the patients arriving to the hospital alive while the remaining EMS centers had more than 88% of the patients arriving to the hospital alive. Based on the Haugland et al. (11) benchmarks, Centers 1, 3, 5, 6, 7, 8, 9, 10, 11, and 12 had a high performance (more than 94% of the patients arrived alive). Center 13 had an average performance (89% to 94% of the patients arrived alive), and Centers 2 and 4 had a low performance (below 89% of the of the patients arrived alive). Overall, all the sampled EMS centers in Riyadh city had a high performance (96.7%).

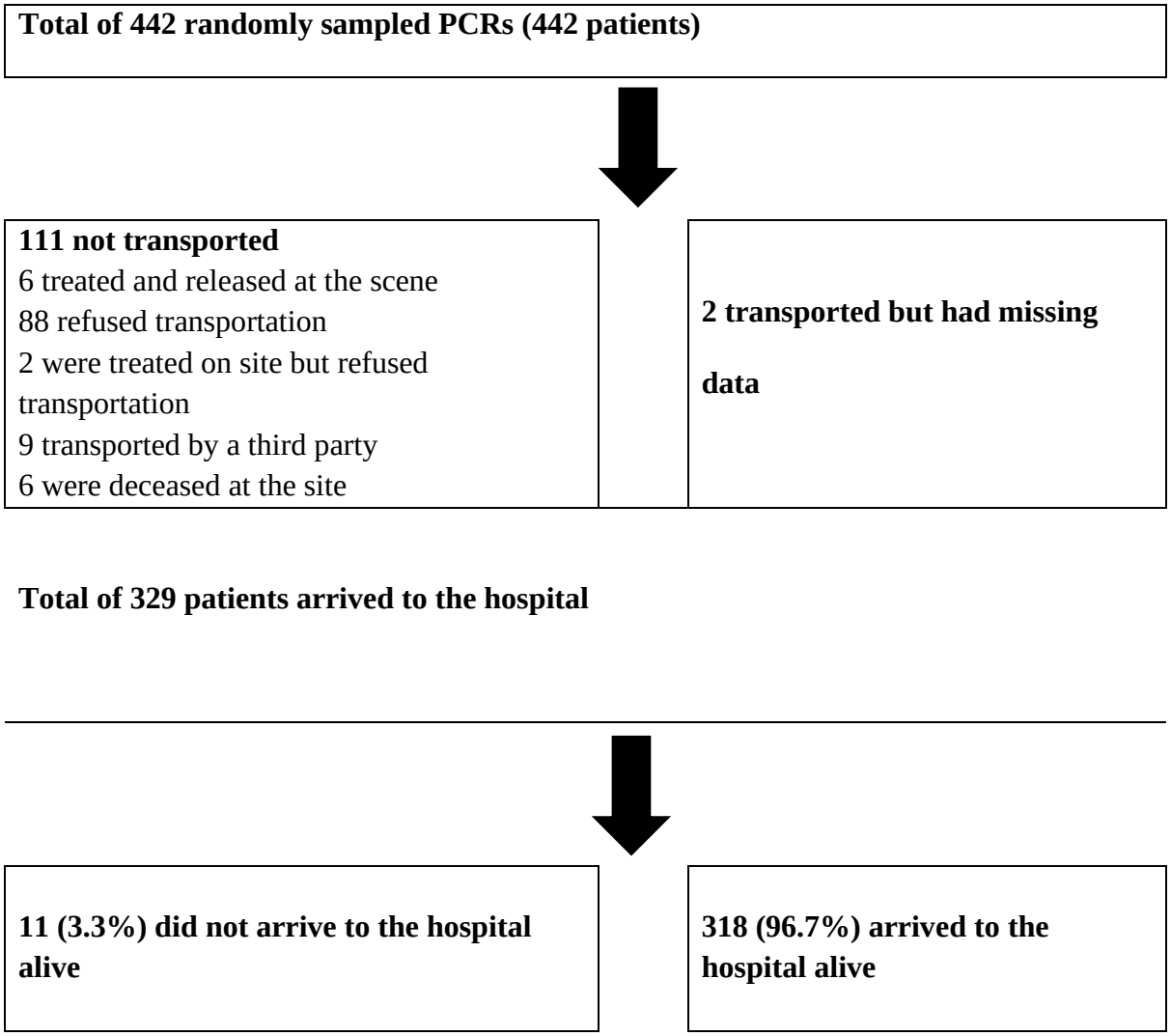


Figure 17. Patient flow chart of number of EMS patients transported, number who were not transported, number transported but with missing records on whether they arrived to the hospital alive, and the number of patients who arrived to the hospital arrive

Table 21. Number of patients arriving alive to the hospital based on the sampled prehospital care report data

	Patient arrived at the hospital alive			
	No		Yes	
	Number	%	Number	%
Center 1	0	0.00%	25	100.00%
Center 2	3	11.10%	24	88.90%
Center 3	1	3.40%	28	96.60%
Center 4	2	11.80%	15	88.20%
Center 5	0	0.00%	35	100.00%
Center 6	0	0.00%	21	100.00%
Center 7	1	3.00%	32	97.00%
Center 8	0	0.00%	9	100.00%
Center 9	1	3.20%	30	96.80%
Center 10	0	0.00%	36	100.00%

Center 11	0	0.00%	14	100.00%
Center 12	1	4.20%	23	95.80%
Center 13	2	7.10%	26	92.90%
Total	11	3.3%	318	96.7%

Time-sensitive illnesses

Time-sensitive illnesses was defined as percentage of patients with time-sensitive illnesses (specifically cardiovascular conditions, neurological conditions, trauma related conditions, gastrointestinal emergencies, infectious emergencies, poisoning/intoxication, respiratory conditions, and diabetes) who received prehospital emergency care against total number of patients. As already been presented under characteristics of patients using EMS services in Riyadh city and Table 13, most of the patients had time-sensitive illnesses compared with non-time-sensitive illnesses [277 patients (62.7%) Vs. 164 patients (37.1%)]. Details regarding the number and percentage of EMS patients under each time-sensitive illness are shown in Table 13. However, there are no benchmarks for interpreting measures of time-sensitive illnesses.

Patient-centeredness

We used frontline EMS provider survey data to measure one quality indicator for patient-centeredness: care for patient relatives. More information about patient-centeredness is in Chapter 5. This quality indicator was defined as percentage of frontline EMS providers acknowledging providing care for patient relatives directly or with collaborating services against total number of frontline EMS providers surveyed. Overall, 103 frontline EMS providers (98.1%, 95% confidence interval =93.3-99.5) acknowledged addressing the needs of patient relatives. In all the EMS centers, all the frontline EMS providers acknowledged addressing the needs of patient relatives except Center 2 where 18.2% said they didn't address needs of relatives. The frontline EMS providers reported using both own SRCA staff and

collaborating-services such as police to address the needs of patient relatives (Table 22). Overall, most of the frontline EMS providers reported using own SRC staff to address the needs of patient relatives than using collaborating services [60 (57.1%) Vs. 46 (43.8%)]. Based on the Haugland et al. (11) benchmarks, all the centers except Center 2 had a high performance (more than 97%). Center 2 had a low performance (below 93%) and none of the centers had an average performance (93% to 97%). Overall, all the sampled EMS centers in Riyadh city had a high performance (98.1%).

Table 22. Number of frontline EMS providers who acknowledged addressing the needs of patient relatives and how the needs were addressed

	Addressed needs of patient relatives?				Addressed by own SRCA staff						Addressed by collaborating-services such as police					
	No		Yes		No		Yes		Not applicable		No		Yes		Not applicable	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Center 1	0	0.00%	3	100.00%	0	0.00%	3	100.00%	0	0.00%	2	66.70%	1	33.30%	0	0.00%
Center 2	2	18.20%	9	81.80%	6	54.50%	3	27.30%	2	18.20%	4	36.40%	7	63.60%	0	0.00%
Center 3	0	0.00%	7	100.00%	2	28.60%	5	71.40%	0	0.00%	5	71.40%	2	28.60%	0	0.00%
Center 4	0	0.00%	7	100.00%	2	28.60%	5	71.40%	0	0.00%	4	57.10%	3	42.90%	0	0.00%
Center 5	0	0.00%	9	100.00%	4	44.40%	5	55.60%	0	0.00%	5	55.60%	4	44.40%	0	0.00%
Center 6	0	0.00%	7	100.00%	3	42.90%	4	57.10%	0	0.00%	4	57.10%	3	42.90%	0	0.00%
Center 7	0	0.00%	5	100.00%	4	80.00%	1	20.00%	0	0.00%	1	20.00%	4	80.00%	0	0.00%
Center 8	0	0.00%	6	100.00%	2	33.30%	4	66.70%	0	0.00%	4	66.70%	2	33.30%	0	0.00%
Center 9	0	0.00%	11	100.00%	5	45.50%	6	54.50%	0	0.00%	6	54.50%	5	45.50%	0	0.00%
Center 10	0	0.00%	4	100.00%	0	0.00%	4	100.00%	0	0.00%	4	100.00%	0	0.00%	0	0.00%
Center 11	0	0.00%	16	100.00%	5	31.30%	11	68.80%	0	0.00%	11	68.80%	5	31.30%	0	0.00%
Center 12	0	0.00%	4	100.00%	2	50.00%	2	50.00%	0	0.00%	2	50.00%	2	50.00%	0	0.00%
Center 13	0	0.00%	15	100.00%	8	53.30%	7	46.70%	0	0.00%	7	46.70%	8	53.30%	0	0.00%
Total	2	1.9%	103	98.1%	43	41.0%	60	57.1%	2	1.9%	59	56.2%	46	43.8%	0	0.0%

Equity

We used SRCA 2018 annual report and Saudi General Authority on Statistics (SGAS) population and area records to measure two quality indicators under this dimension: EMS centers per population and EMS units per area. These quality indicators were assessed for the entire Saudi Arabia, but with a focus on Riyadh city which is the study area. EMS centers per population was defined as the number of EMS centers per 100,000 population in each Saudi region. Riyadh region had 1.48 EMS centers per 100, 000 population, which was lower than that of Al-Madinah Al-Munawara, Asir, Al-Qassim, Tabuk, Jazan, Hail, AlBaha, AlJouf, Najran, and Northern regions (Figure 18, Table 23). Number of EMS units per area was defined as the number of EMS centers per area (km^2) of each Saudi region (Table 23). The number of EMS centers per 10,000 square kilometers was highest at Al-Qassim region (5.00) and the lowest was at Eastern region (0.70).

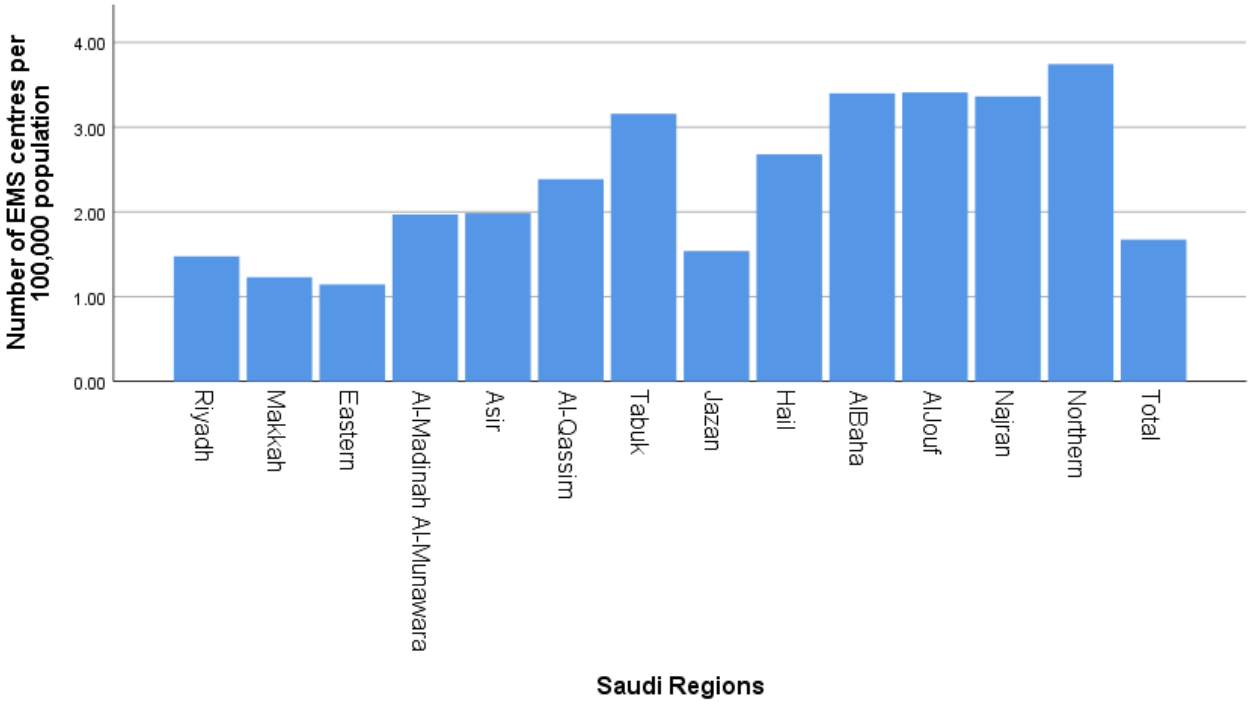


Figure 18. Number of EMS centers per 100,000 population of each Saudi Region

Table 23. Number of emergency medical service centers by population and area of each Saudi region

Saudi Region	EMS Centers	Population (2010 census)	Area	Number of EMS centres per 100,000 population	Number of EMS centres per 10,000 km^2
Riyadh	100	6,777,146	404,240	1.48	2.47
Makkah	85	6,915,006	153,128	1.23	5.55
Eastern	47	4,105,780	672,522	1.14	0.70
Al-Madinah Al-Munawara	35	1,777,933	151,990	1.97	2.30
Asir	38	1,913,392	76,693	1.99	4.95
Al-Qassim	29	1,215,858	58,046	2.39	5.00
Tabuk	25	791,535	146,072	3.16	1.71
Jazan	21	1,365,110	11,671	1.54	17.99
Hail	16	597,144	103,887	2.68	1.54
AlBaha	14	411,888	9,921	3.40	14.11
AlJouf	15	440,009	100,212	3.41	1.50
Najran	17	505,652	149,511	3.36	1.14
Northern	12	320,524	111,797	3.74	1.07
Total	454	27,136,977	2,149,690	1.67	2.11

Relationships Between Quality Indicators and Other Quality Indicators or Patient Characteristics

Relationship between timeliness quality indicators and patient arrival to hospital alive

We used Independent Samples T Test to test the relationship between patient arrival to hospital alive and timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination). As shown in Table 24, there was a statistically significant relationship between initial time to respond and arrival to the hospital alive whereby patient patients who arrived to the hospital alive had a shorter mean initial time to respond (0.42 mins Vs. 1.00 mins, $p < 0.05$). However, there were no statistically significant relationships between other timeliness quality indicators and patient arrival to hospital alive ($p > 0.05$).

Table 24. Relationship between timeliness quality indicators and patient arrival to hospital alive

Patient arrived at the hospital alive?		Mean	SD	*P* value
Initial time to respond (mins)	No	1.00	1.342	0.005*
	Yes	0.42	0.826	
Time to arrival of EMS response team (mins)	No	11.73	4.860	0.109
	Yes	14.50	9.228	
On-scene time (mins)	No	12.73	5.815	0.249
	Yes	15.08	9.217	
Time to preferred destination (mins)	No	48.17	19.354	0.693
	Yes	53.39	22.833	

Independent Samples T Test was used. *Statistically significant ($p < 0.05$)

Relationship between timeliness quality indicators and time-sensitive illnesses

We used Independent Samples T Test to test the relationship between time-sensitive illnesses and timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination). As shown in Table 25, there were no statistically significant relationships between timeliness quality indicators and time-sensitive illnesses ($p > 0.05$).

Table 25. Relationship between timeliness quality indicators and time-sensitive illnesses

		Mean	SD	*P* value
Time to dispatch (mins)	Not time-sensitive illness	0.51	1.206	0.261
	Time-sensitive illness	0.42	0.838	
Time to arrival of EMS response team (mins)	Not time-sensitive illness	13.91	9.221	0. 167
	Time-sensitive illness	14.07	8.519	
On-scene time (mins)	Not time-sensitive illness	14.72	9.394	0.95
	Time-sensitive illness	14.58	8.488	

Time to preferred destination (mins)	Not time-sensitive illness	57.97	25.369	0.574
	Time-sensitive illness	50.54	20.718	

Independent Samples T Test was used.

Relationship between timeliness quality indicators and time call received

We used analysis of variance (ANOVA) to test the relationship between time call received and timeliness quality indicators (initial time to respond, time to arrival of EMS response team, on-scene time, and time to preferred destination). As shown in Table 26, we found that mean time to arrival of EMS response team and on-scene time had a statistically significant relationship with the time call received whereby the time intervals were both high during middle parts of the day (06:01 to 12:00 and 12:01 to 18:00) and shorter times during the night (18:01 to 00:00 and 00:01 to 06:00) ($p < 0.05$). However, we found no statistically significant relationships between initial time to respond and time call received or between time to preferred destination and time call received ($p > 0.05$).

Table 26. Relationship between timeliness quality indicators and time-call received

Timeliness quality indicators		**Time-call received**				***P* value**
		00:01 to 06:00	06:01 to 12:00	12:01 to 18:00	18:01 to 00:00	
Initial time to respond	Mean (mins)	0.35	0.59	0.41	0.45	0.416
	SD	0.574	1.434	0.757	0.972	
Time to arrival of EMS response team	Mean (mins)	11.99	13.90	16.53	13.96	0.014*
	SD	7.910	7.727	9.505	9.429	
On-scene time	Mean (mins)	12.35	14.74	16.61	14.45	0.015*
	SD	7.947	7.868	9.423	9.219	
Time to preferred destination	Mean (mins)	47.34	52.77	58.30	52.04	0.142
	SD	16.985	25.212	26.412	18.510	

Analysis of variance (ANOVA) test was used. ‘Statistically significant ($p < 0.05$).

Relationship between patient arrival to hospital alive and time call received

We used Chi-Square test to test the relationship between time call received and arrival to hospital alive. As shown in Table 27, there were no statistically significant relationships between arrival to hospital alive and time call received ($p > 0.05$).

Table 27. Relationship between patient arrival to hospital alive and time call received

Time-call received	Patient arrived at the hospital alive		*P* value
	No	Yes	
00:01 to 06:00	2	67	0.714
06:01 to 12:00	2	67	
12:01 to 18:00	2	73	
18:01 to 00:00	5	85	

Chi-Square test was used

Comparison of timeliness quality indicators during Hajj and non-Hajj periods

Out of the total 442 PCRs sampled across all the months of 2018, 36 (8.1%) were those of patients who made EMS calls during Hajj period (the 2018 Hajj festival took place from August 13, 2018 to September 11, 2018). The remaining 406 PCRs (91.9%) were those of patients who made EMS calls during non-Hajj period. We found that mean initial response time, mean time to arrival of EMS response team, and mean time to preferred destination) were all lower during Hajj period compared with non-Hajj period (Table 28). In contrast, the mean on-scene time was higher during Hajj period compared with non-Hajj period (Table 28). However, Independent Samples T Test revealed that these differences were not statistically significant (*P*>0.05) (Table 28).

Table 28. Comparison of the measures of timeliness quality indicators during Hajj and non-Hajj periods

Call made during Hajj?		Mean	SD	*P* value
	No	0.46	1.004	0.771

Time to dispatch (mins)	Yes	0.38	0.833	
Time to arrival of EMS response team (mins)	No	14.04	8.849	0.859
	Yes	13.44	8.065	
On-scene time (mins)	No	14.58	8.889	0.886
	Yes	14.83	7.970	
Time to preferred destination (mins)	No	53.24	23.104	0.294
	Yes	49.18	15.808	

Independent Samples T Test was used.

Summary

A summary of the findings of the quality indicators for Riyadh city together with their interpretations are shown in Table 29.

Table 29. Findings of the timeliness, efficiency, effectiveness, patient-centeredness, and equity EMS quality indicators in Riyadh city

Quality dimension	Quality indicator	Definition	Finding	Interpretation
Timeliness	Initial time to respond	Percentage of immediate responses (responses in less than one minute) based on the difference between time call received and time response team is deployed.	66.5%	Low performance based on Haugland et al. (11) benchmarks
	Time to arrival of EMS response team	Mean time interval between time EMS response team is deployed to time of arrival at patient scene	11.13 mins; SD = 6.918	High performance based on Haugland et al. (11) benchmarks
	On scene time	Mean time interval between time call received to time of arrival at patient scene in minutes	14.6 mins; SD = 8.811	High performance based on Haugland et al. (11) benchmarks
	Time to preferred destination	Mean time interval between time call received to time patient is delivered to preferred destination in minutes	52.87 mins; SD = 22.536	High performance based on Haugland et al. (11) benchmarks
Efficiency	Complete documentation	Percentage of complete EMS records (PCRs with all mandatory fields filled; mandatory fields were name, gender, ambulance response times, people or individuals requesting the ambulance, patient location, and chief complaints of the patient).	36.9%	Average performance based on Haugland et al. (11) benchmarks
	Performance monitoring, audit, appraisal,	Percentage of frontline EMS providers reporting that EMS responses were monitored, debriefed, appraised, and/or	87.6%	Average performance based on Haugland et al. (11) benchmarks

	and/or debriefing	audited against the total number of frontline EMS providers.		
	EMS guidelines	Percentage of number of available guidelines against 7 expected guidelines: Basic life support guidelines; Airway, Breathing, and Circulation; Saudi Heart Association guidelines; Prehospital Trauma Life Support; International Trauma Life Support; Advanced cardiac life support; Airway, Breathing, and Circulation	Below 45% in all centers	Low performance based on Haugland et al. (11) benchmarks
	Provision of advanced treatments	Percentage of EMS patients who received advanced treatments (specifically cardiac monitoring, intravenous cannulation, needle cricothyrotomy, advanced medications, advanced cardiac life support (ACLS), pre-hospital trauma life support, and multiple treatments) against total number of EMS patients	96.1%	High performance based on Haugland et al. (11) benchmarks
Effectiveness	Involvement of EMS physicians in dispatching EMS response team	percentage of frontline EMS providers reporting that EMS physicians were involved in dispatching them against total number of frontline EMS providers who completed the survey	88.6%	Average performance based on Haugland et al. (11) benchmarks
	Patients enrolled in research projects	Percentage of senior SRCA staff acknowledging that they recruit patients into EMS studies against total number of senior SRCA staff who were surveyed.	7.7%	High performance based on Haugland et al. (11) benchmarks
	Patients arriving to the hospital alive	Percentage of PCRs recording patients arriving to the hospital alive against total number of PCRs.	96.7%	High performance based on Haugland et al. (11) benchmarks
	Time-sensitive illnesses	Percentage of patients with time-sensitive illnesses (specifically cardiovascular conditions, neurological conditions, trauma related conditions, gastrointestinal emergencies, infectious emergencies, poisoning/intoxication, respiratory conditions, and diabetes) who received prehospital emergency care against total number of patients	62.7%	No benchmarks
Patient-centeredness	Care for patient relatives	Percentage of frontline EMS providers acknowledging providing care for patient relatives directly or with collaborating services against total number of frontline EMS providers surveyed	98.1%	High performance based on Haugland et al. (11) benchmarks

	EMS centers per population	The number of EMS centers per 100,000 population in each Saudi region	1.48 for Riyadh region	Low performance[a]
Equity	EMS centers per area	The number of EMS centers per area (km^2) of each Saudi region.	<1 for all regions including Riyadh	Low performance[a]

[a] Measures of EMS centers per population and EMS centers per area were interpreted based on the standards set forth by the Saudi Red Crescent Authority. Details to be included after verification with SRCA. EMS, emergency medical center; SRCA, Saudi Red Crescent Authority

DISCUSSION

This is the first study to comprehensively evaluate the Saudi EMS system based on all the six quality domains (timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity) using data from both patient records and frontline EMS provider and senior SRCA staff questionnaires. These results are discussed below, but more detailed discussions of these results in the context of existing literature are provided in Chapter 6.

Characteristics of SRCA staff

In our study, we surveyed two groups of SRCA staff: senior SRCA staff (directors and assistant directors of each EMS center) and frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers). A previous study in Saudi Arabia found that that 6.6% of the providers are female (139), but our study found that all the frontline EMS providers are males. However, our study is consistent with the previous study (139) in showing that most of the providers had university education, and most were paramedics.

Timeliness quality indicators

We looked at four measures of timeliness of the service; we found that whilst on average there was a good performance in terms of getting to the scene of the emergency, and in time to get the patient to a hospital if relevant, there was a poor immediate response time from the time of

the initial call to get the team on the way to the patient – only 66% were immediate with delays of up to 0.96 mins.

Efficiency quality indicators

Efficiency tells us about the way in which the EMS system works (rather than its outputs). In this study we had two measures of efficiency relating to the completeness of documentation, especially patient records, and the monitoring and debriefing of EMS staff. In both cases we found that, using the Haughland benchmarks, the efficiency was average. Particularly, we found that the average performance in documentation of patient records were due to missing records on ambulance response times, type of emergency call, patient location, age, and chief complaints.

Effectiveness quality indicators

Our study results showed that the Saudi EMS system in Riyadh city had a high performance on four of the six QIs under this quality dimension (provision of advanced treatments, patients enrolled in research projects, patients arriving to the hospital alive, and time-sensitive illnesses). However, the EMS system had an average performance on one QI (involvement of EMS physicians in dispatching EMS response team) and low performance on one QI under this quality domain (EMS guidelines). According to the Haugland et al. (11) benchmarks, provision of advanced treatment to more than 59% of the patients indicates high performance, 39% to 59% average performance, and below 39% low performance. In this study, we found that advanced treatments were provided to 96.1% of the patients, indicating a high performance. According to Haugland et al. (11) benchmarks, enrolling more than 4% of patients into research projects indicates high performance, 1% to 4% average performance, and below 1% low performance. In this study, we found that patient enrollment into research

projects was at 7.68%, indicating a high performance. Similarly, the percentage of patients arriving to the hospital alive was 96.7%, indicating a high performance (Based on the Haugland et al. (11) benchmarks, more than 94% indicates high performance, 89% to 94% average performance, and below 89% low performance). Also, the percentage of patients with time-sensitive illnesses who received prehospital emergency care was 62.7%. Although there are no reported benchmarks for interpreting the measure of this QI, research has shown that a highly performing EMS system that attends to more patients with time-sensitive illnesses has a better patient survival (12). In our study, 62.7% of the patients had time-sensitive illnesses and this may indicate a high performance. However, this study found that the percentage of available EMS guidelines was below 45% in all EMS centers, indicating a low performance (Based on the Haugland et al. (11) benchmarks, more than 78% indicates high performance, 45% to 78% average performance, and below 45% low performance).

Patient-centeredness quality indicator

Our study results showed that the one QI that was assessed under this quality domain (care for patient relatives) indicated a high performance. In particular, we found that 98.1% of the surveyed frontline EMS providers acknowledged providing care for patient relatives directly or with collaborating services, indicating a high performance (Based on the Haugland et al. (11) benchmarks, more than 97% indicates high performance, 93% to 97% average performance, and below 93% low performance). Patient-centeredness is further explored in Chapter 5.

Equity quality indicators

In this study, we found that the number of EMS centers per 100,000 population in Riyadh city was 1.48. Although there are no benchmarks for interpreting this measure, it may indicate a

low performance. Similarly, the number of EMS centers per area (10,000 km^2) in Riyadh was 2.47, which may indicate a low performance.

Relationship between quality indicators and other quality indicators or patient characteristics

Our findings revealed that patients who arrived to the hospital alive had a significantly shorter mean initial time to respond compared with those who did not arrive to the hospital alive. Our results also showed that time to taken to dispatch EMS team and time taken to arrive at patient scene were both significantly longer during middle parts of the day (06:01 to 12:00 and 12:01 to 18:00) but shorter at night (18:01 to 00:00 and 00:01 to 06:00). However, our study revealed no significant relationship between three timeliness quality indicators (time to arrival of EMS response, on-scene time, and time to preferred destination) and patient arrival to hospital alive. Similarly, we did not find any significant differences between timeliness quality indicators and time-sensitive illnesses or between initial time to respond and time call received or between time to preferred destination and time call received. Also, our findings did not suggest any significant relationship between time call received and patient arrival to hospital alive. Although we found that initial response time, time to arrival of EMS response team, and time to preferred destination were all lower during Hajj period compared with non-Hajj period, these differences were not statistically significant.

How contextual factors may explain aspects of these findings

We used Haugland et al (125) benchmarks, which were developed for healthcare settings in Finland, Sweden, Denmark, and Norway, to rate quality of the Saudi EMS system. However, geographic, demographic, lifestyle, culture, and population health factors that are unique to Saudi Arabia could shape how the Saudi EMS system was rated. For example, some of the QIs

were assessed using survey data from frontline EMS providers who were all males, which may be different from the composition of frontline EMS providers in Finland, Sweden, Denmark, and Norway. Consequently, responses from the frontline EMS providers may have been different if some of the providers were males.

In addition, a previous study in Saudi Arabia reported that cultural factors such as language and family roles and commitment affect perceptions and attitudes of patients and care providers as well as one's understanding of a person's expressions and ways of communication (154). Therefore, such cultural factors may have influenced how frontline EMS providers responded to some of the survey questions, particularly how they responded to whether they cared for patient relatives.

Finally, Saudi Arabia has an annual Hajj festival, a religious pilgrimage characterized by mass gatherings of people visiting Mecca during which EMS centers outside Mecca send ambulances and frontline EMS providers to Mecca thereby affecting their capacity to provide quality EMS services in those locations (51). This contextual factor may have also affected rating of quantitative measures of Saudi EMS system using the Haugland et al (125) benchmarks. Detailed discussion about Hajj festival is included in Chapter 6.

Strengths and Limitations

One of the strengths of this study is that it used quality indicators reported in literature to comprehensively assess the structure, process and outcome of the Saudi EMS system. To the best of our knowledge, this is the first study in Saudi Arabia to comprehensively assess the country's EMS system. Secondly, this study considered the effects of Hajj festival, which is unique to Saudi Arabia, on the timeliness of EMS response and prehospital care treatments provided to patients in Saudi Arabia.

However, this study also had certain limitations. First, the study sample size was relatively small and this may have led to imprecise estimates and lack of power for testing differences between variables such as average time in different groups. Secondly, some of the data may have been reported as missing, yet they were simply not relevant to be recorded, but this was not indicated in the PCRs. For example, under injuries to different parts of the body, the data may have not been recorded hence interpreted as missing but maybe the patient did not have an injury to the particular part of the body. Also, the number of missing data is important to understanding the quality of service, and is one of the quality indicators measured in this study. Thirdly, some of the quality indicators (particularly performance monitoring, audit, appraisal, and/or debriefing; availability of EMS guidelines; patients enrolled in research projects; and care for patient relatives) could not be measured using pre-existing EMS data. These quality indicators were measured using electronic survey data from senior SRCA staff and frontline EMS providers. Therefore, these measurements may be subjective as some of the senior SRCA staff and frontline EMS providers may have not been sincere when completing the survey questionnaires due to response bias.

A broader examination of the strengths and weaknesses of the study as a whole and recommendations for further research are discussed in Chapter 7.

Chapter 5: Challenges faced when providing EMS services in Riyadh city, Saudi Arabia: A content analysis of responses from frontline EMS providers and senior Saudi Red Crescent Authority staff

INTRODUCTION

The previous chapter presented the quantitative results of the study including sample size, characteristics of patients using EMS services in Riyadh city and measures of process and outcome quality indicators (timeliness, patient safety, efficiency, effectiveness, patient-centeredness, and equity). In this chapter, the qualitative component of the study involving quantitative analysis of qualitative themes using content analysis methods is presented. According to Chafe (155) qualitative methods generate new information useful in understanding the processes, responses, and attitudes of study participants. In this study, qualitative methods were used to gain a deeper understanding into the challenges in providing EMS services in Riyadh, Saudi Arabia and solutions to these challenges from the perspective of frontline EMS providers and senior Saudi Red Crescent Authority staff.

Particularly, challenges faced by frontline EMS providers when communicating with patients and/or their relatives, when maintaining patient privacy, and when addressing the needs of patient relatives during emergency response in Riyadh city and proposed solutions to these challenges are presented. Communication challenges such as language barrier are largely reported in literature in other countries, including United States (81), Germany (82), Canada (83), South Africa (84), Minnesota (79), Kuwait (85), Iran (86). Similarly, challenges in maintaining patient privacy have also been reported in other countries: Finland (87), Australia (88), and Iran (89). Challenges in addressing the needs of patient relatives have also been reported in the United States (80).

In Saudi Arabia, however, no study has investigated or reported these challenges. Also, after a conversation with some of the senior SRCA staff and frontline EMS providers in Riyadh, Saudi Arabia prior to this study, the principal researcher noticed that issues in these three areas (communication, patient privacy, and relative needs) are perceived to be some of the most important challenges. However, due to lack of studies that have investigated these challenges in Saudi Arabia, we do not know what the problems are or the solutions. Therefore, a qualitative survey with open-ended questions was conducted to gain a deeper understanding of these challenges from the perspective of the frontline EMS providers.

The chapter also presents the results regarding the challenges faced in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival as reported by senior Saudi Red Crescent Authority (SRCA) staff. Saudi Arabia has unique events such as Hajj festival (pilgrimage to Makkah) during which EMS infrastructure and personnel are sent to Makkah to provide EMS services to millions of Muslims attending the religious festival (91). Most of the available studies have only focused on the healthcare challenges in Makkah where the festival takes place (156–158), but not in other Saudi regions whose healthcare infrastructure such as EMS is strained by the festival. Therefore, it was necessary to qualitatively survey senior SRCA staff to identify the EMS challenges in Riyadh.

METHODS

Study tools

We developed two semi-structured questionnaires: one for senior SRCA staff survey (survey of directors and assistant directors of SRCA EMS centres), and the other for frontline EMS provider survey (survey of SRCA EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers). The questionnaires also had other questions for collecting data used to measure quality outcomes in the quantitative component of the study.

The questionnaire for senior SRCA staff survey asked the staff to list the challenges faced in Riyadh city after sending EMS ambulances and staff to Makkah during Hajj festival (Appendix 5). Particularly, the questions were:

1. During the Hajj season, do you send your Riyadh EMS providers and ambulances to Makkah? If yes, do you do this each year?
2. What challenges do you face while providing EMS services in Riyadh during this time that you send your EMS providers and ambulances to Makkah?

The questionnaire for frontline EMS providers asked the providers to list the top three challenges they face when communicating with patients and/or their relatives, when maintaining patient privacy, and when addressing the needs of patient relatives during emergency response in Riyadh city and to propose solutions to the listed challenges (Appendix 6). Particularly, the questions were:

1. What do you consider to be the top three major challenges when communicating with patients and/or their relatives during EMS response in Riyadh city? How do you think the challenges you mentioned above can be addressed?
2. What do you consider to be the top three major challenges in maintaining the privacy of patients during EMS response in Riyadh city? How do you think the challenges you mentioned above can be addressed?
3. What do you consider to be the top three major challenges in addressing the needs of patients' relatives during EMS response in Riyadh city? How do you think the challenges you mentioned above can be addressed?

Data collection

Sampling

According to the SRCA 2018 annual report, there were a total of 77 EMS centres in Riyadh (97). Unpublished SRCA data shared by SRCA director for Riyadh region shows that out of the total 77 EMS centres in Riyadh, 40 centres (38 located in Riyadh city and 2 located in rural regions of Riyadh) attended to more than 1,000 medical emergencies in 2017 (Appendix 9), suggesting that these EMS centres in this region represent high-burden centres. Of the 36 EMS centers in Riyadh city, 12 were randomly sampled using online randomiser (www.random.org/lists; Randomness and Integrity Services Ltd, Dublin, Ireland). After sampling, the EMS center names and provider/senior staff names were masked.

For the survey of senior SRCA staff, the Director and Assistant Director of each of the 12 EMS centres together, the Director and Assistant Director at Muzahemeyya EMS center for pilot study, and the Director and Assistant Director for the entire Riyadh region were surveyed. Therefore, a total of 28 senior SRCA staffs (two from each EMS centre, one general director for Riyadh, and one assistant general director for Riyadh region). For the survey of the frontline EMS providers, all the frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) in the 12 EMS centres plus the additional Muzahemeyya EMS center were surveyed. The senior SRCA staff responded to different questions from those of the frontline EMS providers.

Survey of senior Saudi Red Crescent Authority staff

After obtaining the ethical approval and informed consent, we surveyed the 28 senior SCRA staff using the questionnaire for senior SRCA staff survey (Appendix 5). We only included directors and assistant directors who have worked for SRCA centres in Riyadh city for at least 2 years in the 12 EMS centres in order to obtain reliable estimate of performance. The senior

SRCA staff recorded their responses in the questionnaire. The survey was conducted from 1 May 2019 to 30 September 2019.

Survey of frontline EMS providers

We electronically sent the questionnaire for frontline EMS providers (Appendix 6) in Google form to all the frontline EMS providers in the 12 sampled EMS centres through the SRCA general director or assistant general director of each centre. The frontline EMS providers included EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers. The first page of the electronic questionnaire provided the study information and sought their informed consent before proceeding to respond to the questionnaire. We restricted the survey to frontline EMS providers who had responded to medical emergencies because they would be better placed to share their experiences and challenges. Therefore, the first question asked the frontline EMS providers if they responded to medical emergencies in 2018 and only accessed the other questions if their answer to this question was affirmative. To restrict access, the first question asked the frontline EMS providers if they provided EMS response to medical emergencies in 2018 and only accessed the other questions if their answer to this question was affirmative. The survey was conducted from 1 May 2019 to 30 September 2019.

Data analysis

We entered qualitative data in Microsoft Office Excel 2016 (Microsoft Corporation, Redmond, Washington, United States). We used quantitatively analyzed qualitative themes using content analysis method (159) to analyze the responses to the open-ended questions in the survey questionnaire from senior SRCA staff and frontline EMS providers. Content analysis was the preferred method of data analysis as it is recommended for qualitative descriptive studies like

the current one (159). Theoretically, content analysis is a qualitative data analysis that focuses on content and contextual meaning of text as the key characteristics of language (160).

In this study, the qualitative data including EMS center number of respondent number were exported to Microsoft Excel 2016 from Google forms by the principal researcher who was then joined by a member of the supervisory team (LJ) to identify themes and code the data to ensure accuracy and quality of data coding. We developed the themes using an inductive approach, "a process of coding the data without trying to fit it into a preexisting coding frame or the researcher's analytic preconceptions" (161). In this approach, the researcher and a member of the supervisory team with expertise in qualitative research first familiarized themselves with the data by going through each response and noting down emerging issues, then assigned preliminary codes to the data and searched for patterns in the codes to develop themes. Once we had established the themes, we counted the number of responses within each of these themes. Where there was a disagreement between the researcher and the member of the supervisory team on the emerging theme, we held a supervisory meeting with all members of the supervisory team where the themes were reviewed and defined after a critical discussion. Any differences in the cluster of the themes according to the EMS centers were also checked. Particularly, the data were coded by respondent number for each EMS center and then the themes for each EMS center was developed. We then determined whether specific themes seemed to appear just for some EMS centers and not others, or whether the same theme occurred across multiple EMS centers. We used selective quotes to support the themes. The same analysis method was used for qualitative data collected form senior SRCA staff.

RESULTS

Challenges faced by frontline EMS providers when communicating with patients and/or their relatives

The survey questionnaire was completed by 105 frontline EMS providers out of all the 185 frontline providers who received the survey (57.4% response rate), we identified 217 reported communication challenges with providers reporting more than one challenge. Fifty-seven frontline EMS providers (54.3%) reported three challenges each, 25 (23.8%) reported two challenges each, 23 (21.9%) reported one challenge each. No frontline EMS provider failed to report any challenge. The providers were coded with center number and provider number [e.g., Provider 3 (1) means provider 1 from center 3].

These challenges were grouped into five major themes: patient characteristics or condition, language barrier, lack of cooperation from patients and/or their relatives, difficult communication environment, and lack of public knowledge about EMS. Most of the reported challenges were about the patient characteristics or condition (71 challenges, 32.7%) (Figure 19). Five themes had less than 10 reported challenges each and were grouped under “Others”.

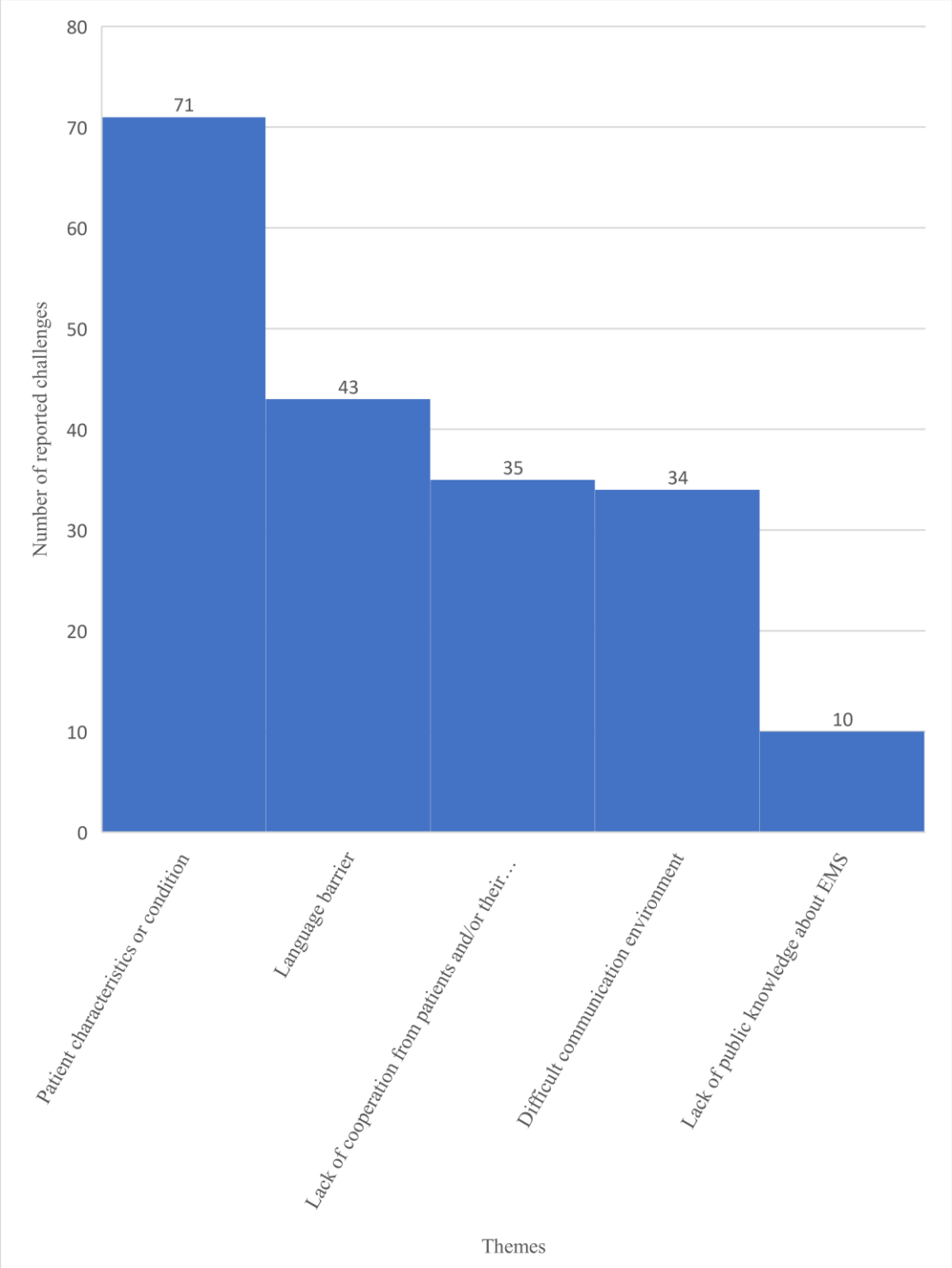


Figure 19. Themes of the challenges faced by frontline EMS providers when responding to medical emergencies in Riyadh city

Patient characteristics or condition

The most common group of reported challenges were about patient the patient characteristics or condition (mentioned in 71 challenges, 32.7%). Challenges under this theme were reported by frontline EMS providers across all the EMS centers. The challenges included patient demographic factors such as elderly and young patients who cannot communicate properly, and patient conditions such as drunkenness, anger/aggressiveness, and mental illnesses that compromises effective communication. Provider 5 at center 1 reported that "dealing with very old patients or children is always very challenging." The most commonly mentioned demographic factor was elderly patients (8 challenges), followed by elderly or young patients (3 challenges) and young patients (1 challenge). The most commonly mentioned patient condition was psychiatric patients (14 challenges) and the least was patients with agonizing pain (1 challenge). For example, provider 10 at center 11 reported that communicating with insane patients was a challenge. Some of the reported challenges are listed in Table 30 in the Discussion section.

Language barrier

The second most commonly reported challenge was about language barrier (mentioned in 43 challenges, 19.8%) and the challenges were reported across all the EMS centers. Some of the surveyed frontline EMS providers provided details of the causes of the language barrier as due to cultural differences [provider 3 at center 2], due to different Arabic dialects [provider 6 at center 9], and due to use of foreign languages by some EMS patients [provider 3 at center 10 and provider 3 at center 11].

Lack of cooperation from patients and/or their relatives

This was the third most common group of challenges reported by the surveyed frontline EMS providers (mentioned in 35 challenges, 16.1%), reported across all the EMS centers except centers 2, 8, and 12. Out of the 35 reported challenges in this theme, 14 of the challenges mentioned that lack of cooperation from patient relatives such as meddling with patient data, lack of awareness of patient condition, and unnecessary interventions by relatives posed a communication challenge during EMS response. The other 21 reported challenges mentioned lack of cooperation from patients such as refusal to disclose information, patients shouting, and refusal of transport and transfer options as important communication challenges.

Difficult communication environment

Thirty-four of the challenges reported by the surveyed frontline EMS providers (15.7%) mentioned difficult communication environment as a communication challenge during EMS response in Riyadh city. Challenges under this theme were reported by frontline EMS providers across all the EMS centers except center 2. The most commonly reported cause of difficult communication environment was crowding at site (mentioned in 16 reported challenges) followed by noise/nuisance at site (mentioned in 10 reported challenges) and location like factories and highways (mentioned in 4 reported challenges). Four of the reported challenges did not specify the cause or reason for the difficult communication environment.

Lack of public knowledge about EMS

Ten of the challenges reported by the surveyed EMS providers (4.6%) mentioned lack of public knowledge about EMS. These challenges were only reported by frontline EMS providers from EMS centers 1, 2, 3, 7, 8, 11, and 13. For instance, Provider 7 (6) reports that “Most of the public don’t respect and understand the nature of our work, teams are subjected to attack and

aggression," suggesting that patients or relative do not have enough knowledge about EMS thus do not cooperate in communications. Provider 7 (4) also reports that "Lack of understanding of the nature of EMS work" is a communication challenge when responding to medical emergencies in Riyadh city.

Others

Five themes were identified with less than 10 reported challenges each. These were: too many cases to deal with (8 reported challenges), cultural barrier (7 reported challenges), lack of trust (4 reported challenges), fast communication (3 reported challenges), and lack of guidelines (2 reported challenges). Ten of the challenges reported by the surveyed EMS providers could not be grouped into any of the themes (Table 30).

Solutions to the communication challenges as reported by frontline EMS providers

In addition to asking the frontline EMS providers to list the communication challenges they face when respond to EMS cases in Riyadh city, we also asked them to propose what they think would be the solutions to the challenges. We identified a total of 146 proposed solutions. We grouped these solutions into six themes: professionalism of response; use of translators; working with collaborating services such as police, civil defence, firefighters, and public; providing continuous education for EMS providers; increasing public awareness about EMS; and deploying a sufficient number of EMS providers. The most commonly proposed solutions were about professional EMS response (30 proposed solutions, 20.6%) (Figure 20). One theme had less than 10 proposed solutions.

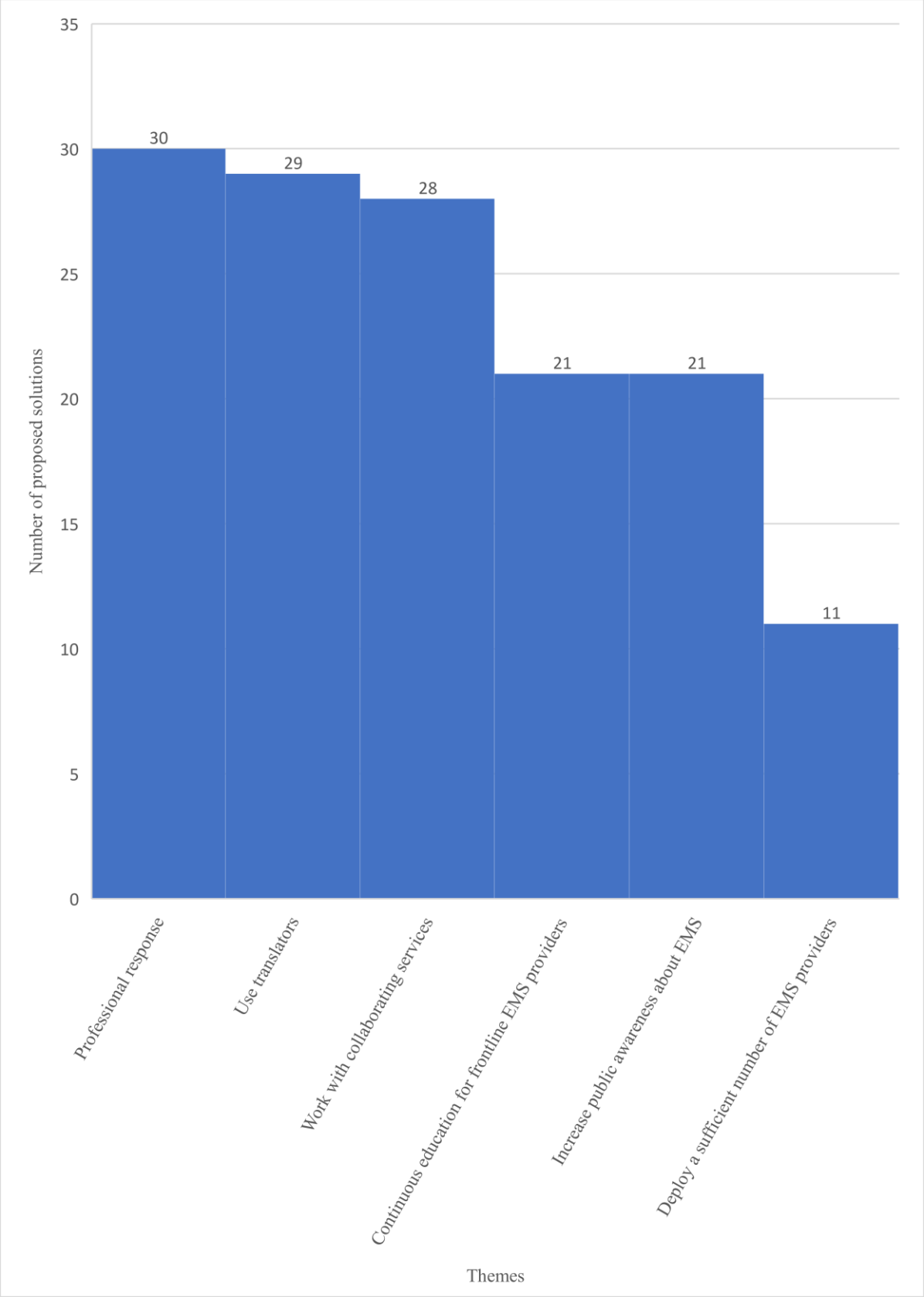


Figure 20. Themes for solutions to the communication challenges as reported by frontline EMS providers responding to EMS cases in Riyadh city

Professional EMS response

Professional EMS response was the most commonly proposed solution to the communication challenges (30 proposed solutions, 20.5%). Solutions under this theme were proposed across all the EMS centers. According to the surveyed frontline EMS providers who proposed solutions under this theme, professional EMS response requires creating a good relationship with patients and/or their relatives, creating confidence, and consulting with senior colleagues and supervisors where there are any doubts. Twelve providers proposed that a good relationship between providers and patients and/or their relatives can be created by remaining calm, by calming down aggressive patients, and by being kind and understanding to the patients and/or their relatives.

Eight of the providers also proposed that a professional EMS response can be maintained by creating confidence through diversification of communication methods, understanding cultural diversity and differences and assuring patients of your qualifications and abilities. Ten providers proposed that consulting with senior colleagues and supervisors where there are any doubts can also help maintain a professional EMS response (Table 30).

Use of translators

Use of translators to address language barrier as a communication challenge was the second most commonly proposed solution with a total of 29 proposed solutions (19.9%), and was proposed across all the EMS centers. This was a very straight forward solution and therefore most of the providers did not provide further details. However, Provider 8 (2) was of the opinion that translation should go beyond the language barrier and take into consideration any cultural differences: “Use translator and offer the idea to know about cultural differences.” Provider 8 (7) mentioned that sometimes a medical interpreter instead of a translator may be

enough to address the issue of language barrier. Two other providers clarified that translators should be part of the EMS response team.

Work with collaborating services

The third most commonly proposed solution was working with collaborating services such as the police and firefighters to address the challenge of difficult communication environment (28 proposed solutions, 19.2%). Solutions under this theme were proposed by frontline EMS providers in all EMS centers except centers 2, 4, 8, and 12. The providers proposed that EMS response team should work with other governmental agencies such as police, civil defense, firefighters, and public service providers to secure the scene, control intruders, and ensure safety of patients, by-standers, and EMS providers thus allowing effective communication.

Continuous education for EMS providers

Twenty-one of the proposed solutions (14.4%) mentioned continuous education of frontline EMS providers as a possible solution to communication challenges faced when responding to EMS cases in Riyadh city. Solutions under this theme were proposed by frontline EMS providers in all EMS centers except centers 2 and 7. In the proposed solutions, the providers mentioned specific training areas such as learning new languages, communicating with the elderly and young patients and understanding cultural diversity and differences.

Increase public awareness about EMS

Twenty-one of the proposed solutions (14.4%) mentioned increasing public awareness as a solution to communication problems during EMS response. Solutions under this theme were proposed by frontline EMS providers in all EMS centers except center 10. Areas of public awareness as proposed by the surveyed frontline EMS providers included EMS regulations,

duties and responsibilities of the Saudi Red Crescent Authority (SRCA), and qualifications of EMS providers.

Deploy a sufficient number of EMS providers

Eleven of the proposed solutions (7.5%) mentioned deployment of a sufficient number of EMS providers as a solution to address communication challenges when responding to EMS cases. Solutions under this theme were proposed by frontline EMS providers from EMS centers 2, 3, 5, 6, 9, 11, and 12 only. The providers proposed that sufficient number of EMS providers should be deployed to EMS cases, possibly to allow the providers adequate time to communicate with patients and/or their relatives and to address the problem of overwhelming number of EMS cases.

Others

One theme was identified with less than 10 proposed solutions. This was: development of communication protocols and guidelines as possible solution to addressing communication challenges during an EMS response. The other proposed solutions did not have any emerging themes (Table 30).

Challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response

Using data from electronic survey questionnaire, which was completed by 105 frontline EMS providers out of all the 185 frontline providers who received the survey (57.4% response rate), we identified 205 challenges with providers reporting more than one challenge. Forty-two frontline EMS providers (40.0%) reported three challenges each, 22 (21.0%) reported two challenges each, 41 (39.1%) reported one challenge each. No frontline EMS provider failed to

report any challenge. These challenges were grouped into five themes: intruders at patient scene, disclosure of information by patient or third parties, locations that compromise patient privacy; lack of patient cooperation; and unqualified or unprofessional EMS providers (Figure 21). Three themes had less than 10 reported challenges each and were grouped under "Others". Most of the reported challenges were about intruders (mentioned in 81 challenges, 39.5%) (Figure 21).

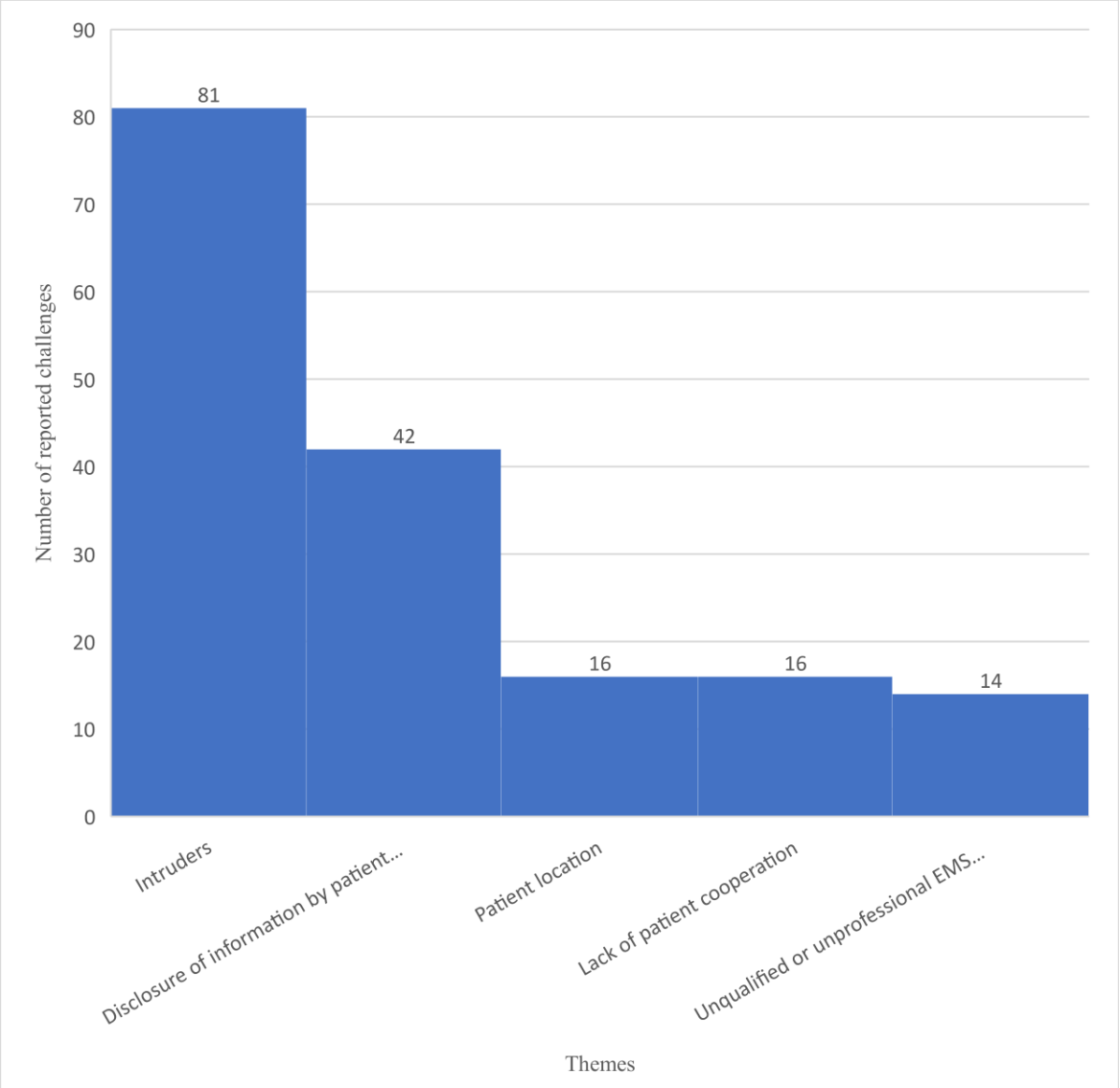


Figure 21. Themes of the challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response in Riyadh city

Intruders such as crowds, bystanders, criminals, meddling relatives, and media

The most common theme of reported challenges was about intruders such as crowds, bystanders, criminals, relatives, and large number of escorts (mentioned in 81 challenges; 39.5%). Challenges under this theme were reported by frontline EMS providers across all the 13 EMS centers. More than half of these reported challenges (44 challenges) mentioned that the intruders were in the form of crowds, which made it hard to preserve the privacy of the patients. For example, provider 3 (2) reported "crowding, which interferes with patient privacy" as a challenge in maintaining patient privacy. Similarly, provider 7 (3) reported that "preserving patient privacy during hard and multiple cases at crowded scene" is a challenge in maintaining patient privacy.

Three of the reported challenges mentioned bystanders as a form of intrusion, which presents a challenge in maintaining the privacy of patients during an EMS response. For example, provider 6 (4) reported that "intruder bystanders" while provider 11 (12) reported that "interference by bystanders" pose as challenges in maintaining patient privacy during an EMS response. Other forms of intrusion were criminals [mentioned by provider 1 (9)], meddling relatives [mentioned by providers 3 (5) and 3 (6)], media [mentioned by providers 9 (4) and 11 (4)]. Twenty-nine of the reported challenges under this theme did not include details of the form of intrusion, but mentioned intrusion in general as a challenge in maintaining patient privacy during EMS response in Riyadh.

Disclosure of information by patient or third parties

Disclosure of information by patient or third parties was the second most common theme of the reported challenges (mentioned in 42 challenges; 20.5%), reported across all the EMS centers except center 5. In two of the reported challenges, the providers mentioned that the patients can leak their own information to the public thus making it difficult to preserve patient

privacy during an EMS response. For example, provider 6 (5) reported that "Patients who are complaining and share his/her information" is a challenge in maintaining the privacy of patients during an EMS response. Provider 2 (3) also reported that "Patient leaking information" is a challenge. The remaining 40 challenges mentioned that private patient information can be leaked by third parties such as relatives (mentioned in 34 challenges), the police (mentioned in one challenge), public (mentioned in one challenge), and other unspecified third parties (mentioned in 4 challenges).

Patient location

Patient location was also mentioned in 16 challenges (7.8%) as a factor that makes it difficult to maintain patient privacy during an EMS response. Challenges under this theme were reported by frontline EMS providers across all centers except centers 5, 6, and 12. Particularly, the providers specified unsecured/violent scenes (mentioned in two challenges), public places (mentioned in five challenges), and noisy environments (mentioned in one challenge). In eight of the reported challenges, the specific type of patient location was not mentioned but the patient location was generally reported to present a challenge in maintaining the privacy of patients.

Lack of patient cooperation

Lack of patient cooperation was also reported as a challenge in maintain patient privacy during EMS response (mentioned in 16 challenges; 7.8%), reported by frontline EMS providers from centers 3, 4, 7, 8, 9, 10, 11, 12, and 13 only. For example, providers 3 (7), 9 (7), and 10 (2) mentioned that patients can sometimes speak loudly near bystanders and the public thus revealing confidential medical information. Providers 8 (7), 13 (12), and 13 (15) mentioned that the patient condition such as pain and nervousness may cause the patient to complain or

ask questions thus leaking their information to the public. Other providers did not mention specific details of how patients fail to cooperate in maintaining their privacy, but they reported that lack of patient cooperation poses a challenge to maintaining patient privacy during EMS response.

Unqualified or unprofessional EMS providers

Fourteen of the reported challenges (6.8%) mentioned unqualified or unprofessional EMS providers as a challenge in maintaining the privacy of patients during EMS response. The challenges under this theme were reported by frontline EMS providers from EMS centers 1, 3, 5, 6, 7, 8, 11, 12, and 13 only. For example, provider 3 (4) mentioned that some ambulance personnel (who are frontline EMS providers) lack awareness of how to maintain patient privacy during EMS response and may thus leak confidential patient information. The other surveyed providers reported that some EMS personnel conduct themselves unprofessionally by discussing confidential patient information with colleagues, giving verbal reports in public, disagrees with patients resulting into disclosure of private patient information, among other unprofessional conducts.

Others

Three themes were identified with less than 10 reported challenges each. These were: lack of cooperation between EMS team and collaborating services such as police, poor methods of data collection, and lack of public knowledge on the importance of patient privacy. Nine of these challenges were under the theme "lack of cooperation between EMS team and collaborating services such as police.". For instance, providers 1 (11), 2 (2), and 8 (8) mentioned that security teams sometimes fail to secure scenes thus it becomes difficult to secure patient privacy. Six of the challenges were under the theme "poor methods of data

collection" such as collection of data in hard copies, use of non-encrypted radio, poor methods of handling medical reports, improperly maintaining confidentiality of reports, and collecting information during an active accident as data collection methods. Five of the reported challenges were under the theme "lack of public knowledge on the importance of patient privacy. Sixteen of the reported challenges could not be grouped into any of themes.

Solutions to challenges in maintaining patient privacy as reported by frontline EMS providers

In addition to asking the frontline EMS providers to list the challenges they face in maintaining patient privacy when responding to EMS cases in Riyadh city, we also asked them to propose what they think would be the solutions to the challenges. We identified a total of 125 proposed solutions. We grouped these solutions into three themes: working with collaborating services such as police, rescue teams, civil defence, and other security agencies; developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy; and increasing public awareness of EMS. Three themes had less than 10 proposed solutions each and were grouped under "Others". The most commonly proposed solutions were about working with collaborating services (75 proposed solutions, 60.0%) (Figure 22).

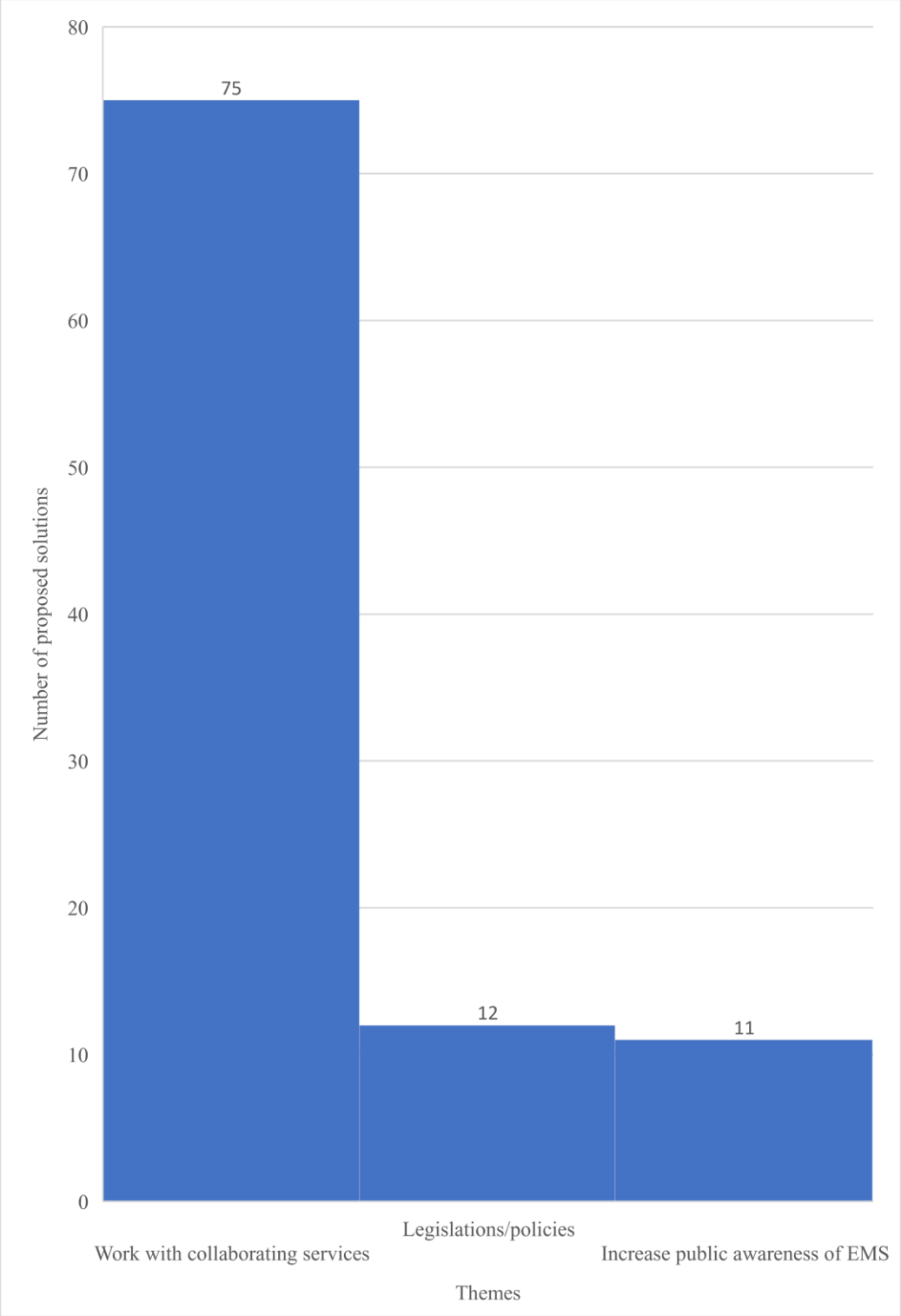


Figure 22. Themes for solutions to challenges in maintaining patient privacy as reported by frontline EMS providers responding to EMS cases in Riyadh city

Work with collaborating services

Most of the proposed solutions (75 proposed solutions, 60.0%) were about working with collaborating services such as police to maintain patient privacy during EMS response. The solutions under this theme were proposed by frontline EMS providers across all the 13 EMS centers. For instance, the providers proposed that police, rescue teams, civil defense, and other security agencies should work together with EMS teams to secure patient scenes, to control crowds and bystanders, to control patient relatives, and to offer general security at the scene. For example, provider 1 (11) proposed "secure environment by coordination of Ambulance and security teams" as a solution to challenges in maintaining patient privacy. Provider 2 (3) also proposed that "enhancing cooperation between security and EMS teams and secure patient's privacy by activating the role of security teams" would be a solution to challenges in maintaining patient privacy during EMS response.

Legislations/policies

Twelve of the proposed solutions (9.6%) suggested that legislations/policies should be developed for maintaining patient privacy during EMS response. The solutions under this theme were proposed by frontline EMS providers from EMS centers 1, 3, 7, 9, 11, 12, and 13 only. Eight of the proposed solutions under this theme mentioned that legislations or policies should be developed to punish offenders of patient privacy laws. For instance, 7 (4) proposed as follows: "Enact laws to penalize failure to preserve the patient's privacy and cooperation by other parties such as the police to preserve the patient's privacy." Similarly, provider 12 (2) proposed as follows: "There shall be penalties for failure to respect the privacy of the patient from the ambulance band or the public." Four of the proposed locutions under this theme mentioned that legislations/policies should be developed for preserving patients' privacy. For example, provider 3 (4) proposed as follows: "A strict law must be enacted for the EMS teams,

relatives and the public to preserve the privacy of the patient and activate this law." Provider 9 (4) as proposed that "A strict law to preserve patient's rights and privacy" would be a solution to addressing challenges faced in maintaining patient privacy during EMS response.

Increase public awareness of EMS

Eleven of the proposed solutions (8.8%) mentioned increasing public awareness about EMS as a solution to challenges in maintaining patient privacy during EMS response. The solutions under this theme were proposed by frontline EMS providers from EMS centers 1, 4, 7, 10, 11, 12, and 13 only. Although nine of the proposed solutions did not specify how the awareness should be increased, two of them mentioned that awareness about EMS should be increased through public education [provider 11 (11)] and through media campaigns and education in schools [provider 13 (15)].

Others

Three themes were identified with less than 10 proposed solutions each. These were: improve communication methods or approach, improve data collection methods by using protocols and guidelines, and continuous medical education for EMS providers. Seven of these proposed solutions were under the theme "improve communication methods or approach." In the proposed solutions, the providers explained that it is necessary to improve communication methods such as adopting electronics system in authentications [provider 13 (5)] and improving communication approach by building a good rapport with patients and/or their relatives [provider 9 (7)]. Six of the proposed solutions were under the theme "Improve data collection methods by using protocols and guidelines." Under this theme solutions, the providers proposed that data collection methods can be improved through developing protocols and

guidelines. Five of the proposed solutions were under the theme “continuous medical education for EMS providers.” Nine of the proposed solutions could not fit under any of the themes.

Challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response

Using data from electronic survey questionnaire, which was completed by 105 frontline EMS providers out of all the 185 frontline providers who received the survey (57.4% response rate), we identified 198 reported challenges with providers reporting more than one challenge. Thirty-six EMS providers (34.3%) reported three challenges each, 20 (19.1%) reported two challenges each, 49 (46.7%) reported one challenge each. No frontline EMS provider failed to report any challenge. These challenges were grouped into five themes: unnecessary demands from the relatives; relatives interfering in patient treatment and transfer plans; general interference by relatives; lack of cooperation with and rudeness to EMS team; and time constraints (Figure 23). Five themes had with less than 10 reported challenges each and were grouped under “Others”.

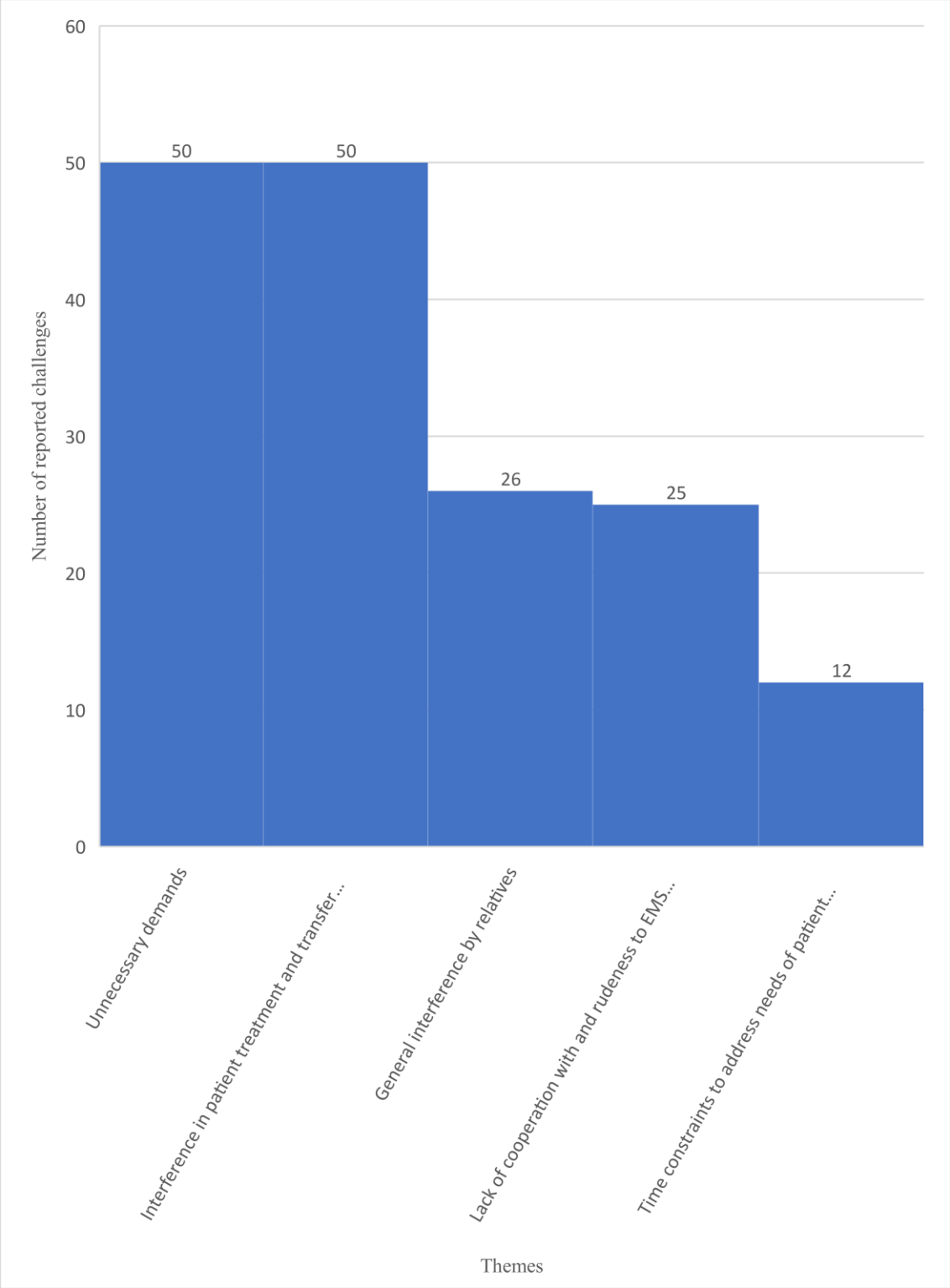


Figure 23. Themes of the challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response in Riyadh city

Most of the reported challenges were about unnecessary demands (50 challenges, 25.3%) and interference in patient treatment and transfer plans (50 challenges, 25.3%) (1 challenge, 0.5%) (Figure 23).

Unnecessary demands

Fifty of the reported challenges were about patients' relatives making unnecessary demands (50 challenges, 25.3%). The challenges under this theme were reported by frontline EMS providers from all the EMS centers except center 10. According to the frontline EMS providers who reported these challenges, some of the patients' relatives made requests that were beyond the scope of the EMS services. For example, provider 12 (2) reported that some of the patients' relatives made inappropriate demands while provider 3 (5) mentioned that relatives could request something out of the scope of the paramedic services. These unnecessary demands included demand for priority treatment, request for transfer to particular hospitals, personal requests, unrealistic demands, among others.

Interference in patient treatment and transfer plans

Fifty of the reported challenges were about patients' relatives interfering with patient treatment and transfer plans (50 challenges, 25.3%), reported across all the 13 EMS centers. Eleven of the reported challenges under this theme were about patients' relatives interfering with patient treatment plans. For example, provider 1 (9) reported that "interventions in the treatments provided to patients" is a challenge in addressing the needs of patients' relatives during an EMS response. Thirty-nine of the reported challenges under this theme were about patients' relatives interfering with patient transfer plans. For example, provider 2 (2) reported as follows: "Relatives interfering in where to transfer the patient." Provider 7 (1) also reported as follows: "Requesting faraway hospital whereas the case requires transferring to the nearest hospital."

General interference by relatives

Twenty-six of the reported challenges (13.1%) mentioned that general interference by patients' relatives is a challenge in addressing the needs of patients' relatives. The challenges under this theme were reported by frontline EMS providers from all the EMS centers except centers 4, 6, and 10. Five of the challenges under this theme were about the relatives not following regulations and instructions. For example, provider 1 (3) reported as follows: "Problems following regulations" and provider 13 (2) reported as follows: "Relative who are not following the instructions of the EMS team."

Seventeen of the reported challenges under this theme were about patients' relatives requesting information that can compromise patient privacy. For instance, provider 3 (1): reported that "relatives keep asking about the nature of the EMS service provided." Provider 13 (15) also reported that "asking questions regarding patient privacy" is a challenge in addressing the needs of patients' relatives. Four of the reported challenges under this theme were about large number of patients' relatives. For example, the providers reported that "large number of escorts" (provider 3 (2)" and "too many relatives" (provider 12 (12) are challenges in addressing the needs of patients' relatives.

Lack of cooperation with and rudeness to EMS team

Among the reported challenges in addressing the needs of patients' relatives, 25 (12.6%) mentioned lack of cooperation with and rudeness to EMS team by patients' relatives. The challenges under this theme were reported by frontline EMS providers from all the EMS centers except centers 1, 2, 3, and 4. Twenty of the reported challenges under this theme mentioned rudeness of patients' relatives to the EMS team. Particularly, providers 6 (3) and 11 (7) explained some relatives use bad words while communicating to providers 9 (4), 11 (16),

and 12 (3) mentioned that some patients' relatives shout, use aggressive language and are rude to EMS teams. Provider 13 (13) reported that some patients' relatives sometimes "verbally and physically assault the paramedics." Five of the reported challenges under this theme mentioned lack of cooperation of patients' relatives with EMS teams as a challenge in addressing the needs of patients' relatives. Particularly, providers explained that lack of cooperation can be in the form of relatives requesting information to be hidden from the patient [provider 4 at center 5], relatives requesting faster ambulance arrival [provider 6 at center 6], relatives requesting to answer questions on behalf of the patient [provider 3 at center 7], and relatives delaying in reporting EMS cases [provider 3 at center 12].

Time constraints to address needs of patient relatives

Among the reported challenges in addressing the needs of patients' relatives, 12 (6.1%) mentioned time constraints to address needs of patients' relatives. The challenges under this theme were reported by frontline EMS providers from all EMS centers except centers 2, 4, and 6. Particularly, the providers who reported challenges under this theme explained that time constraints were due to the need to transfer the patient quickly before addressing needs of patients' relatives [provider 1 (7)], time pressure [provider 3 (3)], many cases to deal with [provider 5 (3) and 11 (4)], high number of patients relatives [providers 7 (4) and 13 (13)], and lack of enough time [providers 8 (8), 9 (4), 9 (6), and 10 (4)].

Others

Five themes were identified with less than 10 reported challenges each. These were: lack of transport for patient relatives, lack of knowledge about EMS service, lack of collaborating services, interference with communication environment, and lack of guidelines. Five of these challenges were under the theme "lack of transport for patient relatives." According to the

providers who reported this challenge, this challenge arises when relatives request to accompany the patient or meddles in patient transport. Five of these challenges were under the theme "lack of knowledge about EMS service." Providers suggested that uneducated relatives [providers 4 at center 4, 5 at center 6, and 5 at center 6] and those with poor understanding of the roles of EMS pose a challenge in addressing their needs. Five of these challenges were under the theme "lack of collaborating services" where the providers mentioned that this was due to poor response from the government organizations [provider 3 at center 1], lack of collaboration from government agencies [providers 3 at center 2 and 5 at center 13], and circumstances of the scene such as where there has been a crime [provider 5 at center 3]. Four of these challenges were under the theme "interference with communication environment" where the providers reported that patients' relatives interfere with the communication environment by making noise [providers 3 at center 1 and 3 at center 9] and by distracting EMS providers [providers 6 at center 3) and 5 at center 5]. One of these challenges was under the theme "lack of guidelines" with the provider reporting "lack of guidelines on how to handle relatives" [provider 9 at center 8]. Fourteen of the challenges reported by the surveyed EMS providers could not be grouped into any of the themes.

Solutions to challenges in addressing the needs of patients' relatives as reported by frontline EMS providers

In addition to asking the frontline EMS providers to list the challenges they face in addressing the needs of patients' relatives when responding to EMS cases in Riyadh city, we also asked them to propose what they think would be the solutions to the challenges. We identified a total of 132 proposed solutions. We grouped these solutions into three themes: improving communication; increasing public awareness; and working with collaborating services. Two themes had less than 10 proposed solutions each and were grouped under "Others". The most

commonly proposed solutions were about improving communication (61 proposed solutions, 46.2%) (Figure 24).

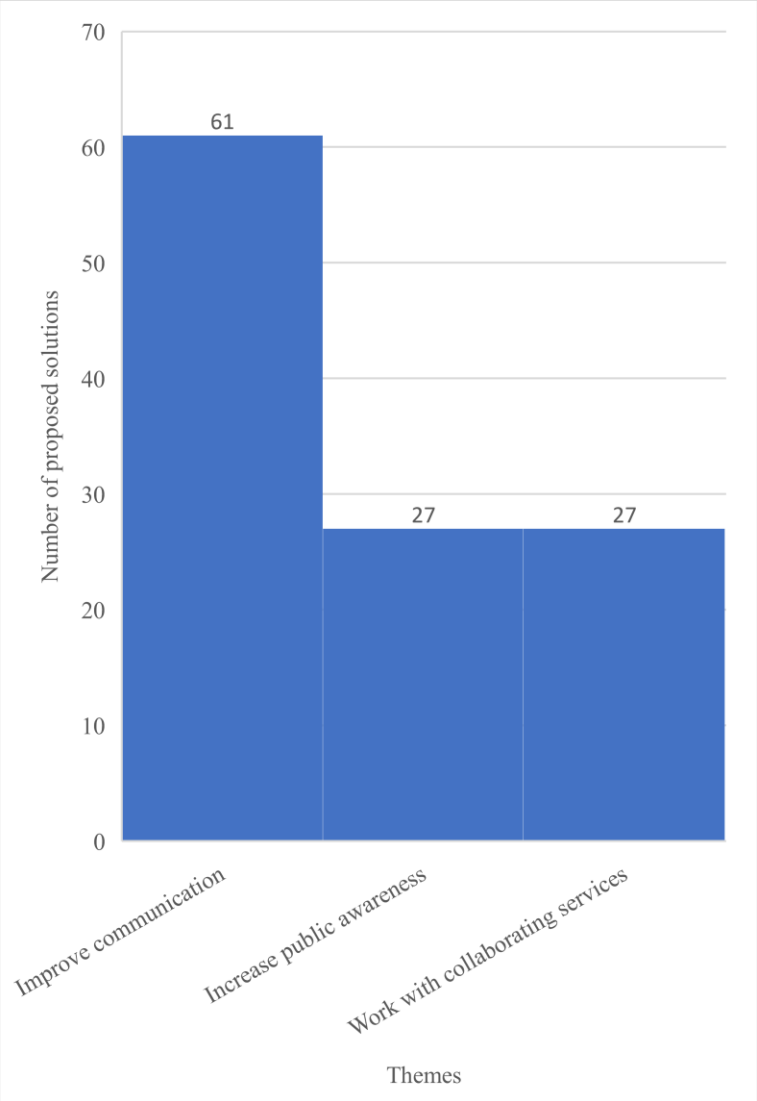


Figure 24. Themes for solutions to challenges in maintaining patient privacy as reported by frontline EMS providers responding to EMS cases in Riyadh city

Improve communication

Most of the proposed solutions (61 proposed solutions, 46.2%) mentioned improving communication as a solution to the challenges of addressing the needs of patient relatives. The solutions under this theme were proposed by frontline EMS providers from all the EMS centers except center 12. The providers who proposed solutions under this theme clarified that an

effective communication that supports the relatives [provider 8 at center 1], creates a good relationship with the relatives [provider 11 at center 1], understanding the needs of the relatives [provider 2 at center 7], and empathizes with the relatives [provider 8 at center 8] may be key to addressing the challenges faced when addressing the needs of patients' relatives.

Increase public awareness

Among the proposed solutions for challenges faced when addressing the needs of patients' relatives during EMS response, 27 (20.5%) were about increasing public awareness on EMS. The solutions under this theme were proposed by frontline EMS providers from all the EMS centers except centers 2 and 9. Some of the providers who proposed solutions under this theme clarified that increasing awareness about EMS should be done through national education system [provider 10 at center 1], through national campaigns [provider 1 at center 12], and through media outlets [provider 3 at center 13]. Some of the providers also clarified that the awareness should be about the scope of EMS [providers 3 at center 4, 5 at center 4, 1 at center 5, 9 at center 11, and 11 at center 11] and the role of EMS [providers 2 at center 10, 3 at center 12, 14 at center 11), and 2 at center 13]:

Work with collaborating services

Twenty-seven of the proposed solutions (20.5%) mention working with collaborating services such as police to control number of patients' relatives as a solution for challenges faced when addressing the needs of patients' relatives during EMS response. The solutions under this theme were proposed by frontline EMS providers from all the EMS centers except centers 4, 8, and 10. All the 27 providers who proposed solutions under this theme agreed that it is necessary to work with all government agencies such as police to control the number of patients' relatives in order to adequately address their needs. For example, provider 6 at center

1 proposed as follows: “avail collaborating services.” Provider 2 at center 12 also proposed as follows: “Coordination between the ambulance teams and other bodies such as police.”

Others

Two themes were identified with less than 10 proposed solutions each. These were: increase number of deployed EMS providers and follow guidelines and protocols. Four of these proposed solutions were under the theme “increase number of deployed EMS providers” where the providers proposed that the number of deployed EMS providers can be increased by providing sufficient ambulance teams [providers 4 at center 10, 2 at center 12, and 4 at center 12] and by increasing the number of EMS centers [provider 4 at center 11]. Three of the proposed solutions were under the theme “follow guidelines and protocols” where the providers proposed that guidelines and protocols on how to handle patients’ relatives should be developed ad follows during EMS response. Two of these proposed solutions were under the theme “develop guidelines and training programs.” Two were under the theme “legislation” where the providers proposed that legislations should be developed to protect the rights of rescuers, the patient and patient relatives. Six of the proposed solutions could not fit under any of the themes.

Challenges faced in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival

Using data from electronic survey questionnaire, which was completed by all the 28 senior SRCA staff who received the survey (one director and one assistant director from each of the 13 sampled EMS centers and the general director and assistant director for the entire Riyadh region, we identified 52 reported challenges with each senior SRCA staff reporting more than one challenge. The senior SRCA staff were the individuals best placed to talk about the broad

issues related to the Hajj festival. These challenges were grouped into 6 major themes: shortage of staff, long shift hours, shortage of equipment such as ambulances, increased number of EMS calls, and challenges in arranging work schedule. Two of the reported challenges could not fit in any of these themes and were therefore grouped under "Others". The most common challenge was shortage of staff (mentioned in 19 challenges, 36.5%) and the least was increased number of EMS calls (mentioned in 4 challenges, 7.7%) (Figure 25).

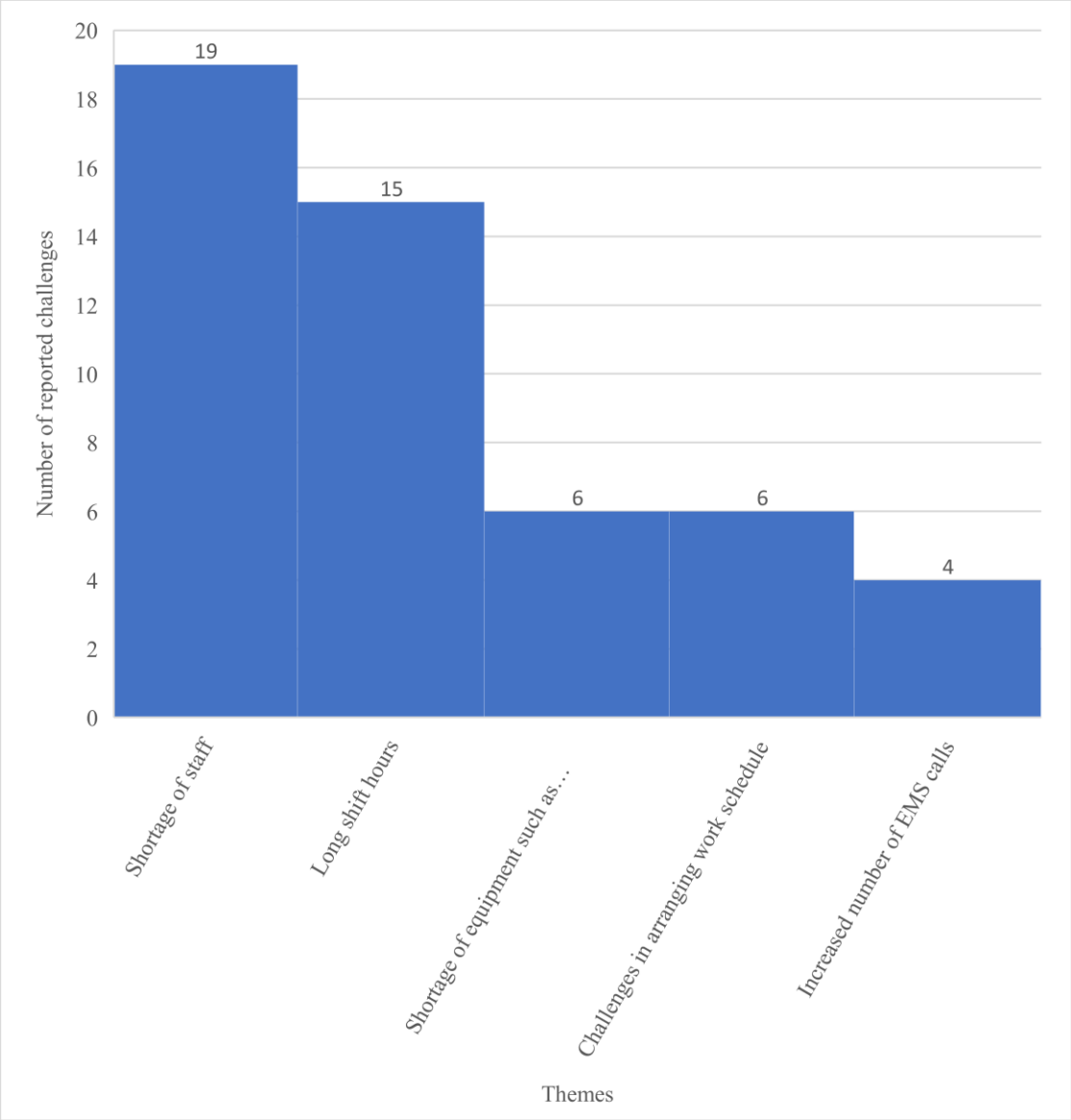


Figure 25. Themes of the challenges faced in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival

Shortage of staff

Among the reported challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival, 19 (36.5%) were about shortage of staff. All the 19 senior SRCA staff who reported this challenge all agreed that shortage of staff is a major challenge in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj. For instance, 1 Director (Director for EMS center 1) reported that "shortage of EMS staff in each station" is a major challenge in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival. Similarly, 14 Director, reported as follows: "Lack of the number of paramedics in Riyadh"

Long shift hours

Fifteen of the reported challenges (28.9%) mentioned that long shift hours for EMS personnel is challenge in Riyadh after EMS personnel and ambulance are sent to Makkah during Hajj festival. For instance, the director for the entire Riyadh region (14 Director) explained that sometimes work hours increase. Similarly, the assistant director of center 2 (2 Ass. Director) explained that "prolonged working hours" is a challenge in Riyadh after EMS personnel and ambulance are sent to Makkah during Hajj festival.

Shortage of equipment such as ambulances

Among the reported challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival, 6 (11.5%) were about shortage of EMS equipment such as ambulances. For example, the senior SRCA staff reported as follows "shortage of medical equipment" (2 Director); "lack of vehicles" (4 Ass. Director); "lack of vehicles & some supply" (7 Director).

Challenges in arranging work schedule

Among the reported challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival, 6 (11.5%) were about challenges in arranging work schedule. All the 6 senior SRCA staff reported that arranging work schedule with the reduce number of EMS personnel is a challenge. For instance, 10 Ass. Director reported that "The most common challenge about the schedule. Arranging providers to new shifts."

Increased number of EMS calls

Four of the reported challenges (7.7%) were about increased number of EMS calls. The director of center 9 (9 Director) explained as follows: "The most important challenge is that the pressure of calls increases which negatively affects the ability of the centre to cover its needs. For example, we are 11 in our center and we send yearly or every other year at least three EMS providers." The other three senior SRCA staff also reported increased number of EMS calls as a challenge under this theme, as follows: "increased volume of calls" (4 Director); "more call & increase patients" (7 Ass. Director); and "heavy volume of calls" (9 Ass. Director).

Others

Two of the challenges reported by the senior SRCA staff (3.9%) could not be grouped into any of the themes.

Summary of results

The summary of the results of the content analysis is shown in Table 30.

Table 30. Summary of the qualitative results

	Themes	**Some of the responses**
Challenges faced by frontline EMS providers when communicating with patients and/or their relatives during EMS response in Riyadh city **Question**: What do you consider to be the top three major challenges when communicating with patients and/or their relatives during EMS response in Riyadh city?	Patient characteristics or condition (71 reported challenges)	• Provider 1 (5): "Dealing with very old patients or children is always very challenging" • Provider 10 (2): "Uncooperative elderly patient" • Provider 12 (2): "The patient is too old or too young age" • Provider 12 (1): "Patient with contagious diseases" • Provider 12 (1): "Insane patient is or under the influence of drugs" • Provider 13 (12): "Some categories of patients such as the deaf, dumb or the mad" • Provider 13 (13): "The patient complained of agonizing pain"
	Language barrier (43 reported challenges)	• Provider 4 (6): "If patient is foreigner, not speak Arabic, like English Speaker" • Provider: 4 (7): "Local dialects or incomprehensible languages" • Provider 9 (4): "Incomprehensible language and translation problem"
	Lack of cooperation from patients and/or their relatives (35 reported challenges)	• Provider 5 (4): "Meddling of the relative with patient information" • Provider 13 (1): "Patients who don't want to share full information of their cases" • Provider 4 (1): "Relatives' unawareness of the condition of the patient"
	Difficult communication environment (34 reported challenges)	• Provider 3 (3): "Crowd meddling while attending the case" • Provider 8 (7): "Site inconvenience" • Provider 10 (2): "Uncooperative bystanders who make noise" • Provider 10 (2): "Crowd creating chaos in the scene making things difficult for teams" • Provider 13 (13): "Nuisance or noise at the scene"
	Lack of public knowledge about EMS (10 reported challenges)	• Provider 1 (5): "To inquire about his medical condition and about details conditions of the scene" • Provider 2 (1): "Too much talk more than what the EMS team needs." • Provider 7 (6): "Unawareness of the public about the role of SRCA and its services"

	Others (24 reported challenges)	• Provider 7 (6): “Most of the public don’t respect and understand the nature of our work, teams are subjected to attack and aggression” • Provider 2 (3): “Many emergency cases at the same time” • Provider 9 (2): “Dealing with more than one case that will affect the quality of communications” • Provider 7 (7): “Cultural Diversity” • Provider 13 (13): “Birth cases with different cultures” • Provider 7 (5): “Lack of trust of the EMS team capability” • Provider 1 (3): “Quick responses” • Provider 3 (2): “Lack of guidelines on how to transfer the patient” • Provider 1 (5): “To inquire about his medical condition and about details conditions of the scene”
Solutions to the communication challenges as reported by frontline EMS providers responding to EMS cases in Riyadh city **Question**: How do you think the challenges you mentioned above can be addressed?	Professional response by creating a good relationship with patients and/or their relatives by creating confidence and consulting with senior colleagues and supervisors where there are any doubts (30 proposed solutions)	• Provider 2 (2): “Handle the patient with due care and kindness, explain the case to the relatives and explain to them on how to transfer the patient according to his case” • Provider 8 (7): “Calm down the patient” • Provider 11 (12): “Communicate with patient and relatives in a friendly and that the patient should be transported to the most appropriate facility based on the patient's case” • Provider 3 (8): “Understanding the cultural diversity” • Provider 8(4); “Discussing with senior colleagues or now to proceed” • Provider 10 (4): “Have a plan to deal with old patients and children by consulting senior colleagues”
	Using translators (29 proposed solutions)	• Provider 12 (3): “The translator has to be available in the EMS system” • Provider 13 (2): “The Authority system should have translators of different languages ready to serve as needed”

Working with collaborating services as police, civil defence, firefighters, and public (28 proposed solutions)	• Provider 3 (3): “Coordinating with other governmental public service sectors” • Provider 6 (2): “Secure the scene by police and civil defense” • Provider 11 (6): “Secure the scene and Work with police and civil defense” • Provider 11 (17): “Police should secure the scene to allow good communication with patient and relatives”
Providing continuous education for EMS providers (21 proposed solutions)	• Provider 4 (7): “Rehabilitation to master another language and courses for developing communicative skills with the elderly and young people.” • Provider 6 (6): “Continuous education for EMS providers and improving their performance by attending training courses” • Provider 9 (6): Develop communication skill of the EMS team for better communication with patients and relatives”
Increasing public awareness about EMS (21 proposed solutions)	• Provider 1 (1): “Their knowledge about the regulations and medical service provision” • Provider 7 (6): “Raise awareness of the public about the role of SRCA through the social media platforms and imposing fines and punishment in case of verbal or physical aggression and publish this in the media” • Provider 11 (2): “Awareness and guidance through media”
Deploying a sufficient number of EMS providers (11 proposed solutions)	• Provider 9 (2): “Provide the ambulance team with a sufficient number of EMS crew” • Provider 11 (4): “Increase number of EMS staff and offer one to one support” • Provider 11 (15): “Increase size of response team” • Provider 12 (1): “Adequate ambulance teams” • Provider 12 (3): “There should be enough team member to deal with critical patients”
Others (6 proposed solutions)	• Provider 2 (2): “Guidelines on protective clothing, washing hands and applying safety precautions” • Provider 12 (1): “Guidelines on how to deal with people with special needs, such as the insane or ones who were under the influence of drugs” • Provider 13 (5): “Enacting laws that oblige relative to disclose patient history”

Challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response in Riyadh city **Question**: What do you consider to be the top three major challenges in maintaining the privacy of patients during EMS response in Riyadh city?	Intruders at patient scene (81 reported challenges)	• Provider 3 (2): “Crowding, which interferes with patient privacy” • Provider 7 (3): “Preserving patient privacy during hard and multiple cases at crowded scene” • Provider 6 (4): “Intruder bystanders” • Provider 7 (3): “Bystanders” • Provider 11 (12): “Interference by bystanders”
	Disclosure of information by patient or third parties (42 reported challenges)	• Provider 8 (2): “Relatives asking for confidential information” • Provider 11 (6): “Inference y relative's questions” • Provider 3 (4): “Lack of cooperation by relatives of the patient in preserving the privacy of the patient” • Provider 2 (2): “Ignorant and uncooperative relatives” • Provider 13 (15): “Leakage of private information by police, public, patient or relatives”
	Locations that compromise patient privacy (16 reported challenges)	• Provider 4 (6): “Maintaining patient privacy in unsecured scene” • Provider 1 (2): “Invade of confidentiality because of the scene circumstances” • Provider 4 (7): “The location of the patient or the injured such as being in a public place” • Provider 11 (11): “Communicatons in noisy environments may leak information” • Provider 11 (17): “Public places, like malls and streets”
	Lack of patient cooperation (16 reported challenges)	• Provider 3 (7): “Patient talking in front of the public about condition” • Provider 9 (7): “Patients talking too much about what they are suffering from” • Provider 10 (2): “Patients releases his information in front of bystanders because of his high or low spirit” • Provider 13 (12): “Severe pain causing him to reveal his conditions” • Provider 13 (15): “Nervous adults’ patient who leaks private information” • Provider 3 (5): “Uncooperative patient” • Provider 12 (1): “Lack of cooperation from some patients”
	Unqualified or unprofessional EMS	• Provider 3 (4): “Lack of awareness and leniency of some ambulance personnel in disclosing patient information”

	providers (14 reported challenges)	• Provider 8 (3): “Conflicts between patient and medical response team” • Provider 11 (16): “Some team members are not preserving patient privacy” • Provider 12 (3): “Some EMS providers who are not serious when doing their job” • Provider 13 (1): “EMS team sharing patient report with ED team in front of public”
	Others (36 reported challenges)	• Provider 2 (2): “Security teams not doing their best to preserve the privacy of the patient” • Provider 3 (3): “Interference of other sectors such as police” • Provider 9 (6): “Insufficient number of supporting team during service provision” • Provider 13 (7): Improperly maintaining confidentiality of the report” • Provider 13 (11): “Public looking forward to know more information about cases” • Provider 13 (3): “The nature and complication of the case” • Provider 13 (4): “Different cultures” • Provider 8 (7): “Relatives of the patient”
Solutions to challenges in maintaining patient privacy as reported by frontline EMS providers responding to EMS cases in Riyadh city **Question**: How do you think the challenges you mentioned above can be addressed?	Working with collaborating services such as police, rescue teams, civil defence, and other security agencies (78 proposed solutions)	• Provider 1 (11): “Secure environment by coordination of Ambulance and security teams” • Provider 2 (1): “Use collaborating services to control crowds” • Provider 2 (2): “Availability of security teams, spreading awareness through the media and schools and enact laws” • Provider 4 (7): “Sufficient security teams to secure the scene to preserve the privacy of the patient” • Provider 12 (2): “Coordination between rescue teams, defense, civil and police” • Provider 13 (14): “The police shouldn’t allow for crowds; Sending away relatives and intruders”
	Developing legislations/policies to punish offenders of patient privacy laws and to preserve	• Provider 1 (3): “Assessments and activate legal penalties” • Provider 7 (4): “Enact laws to penalize failure to preserve the patient's privacy and cooperation by other parties such as the police to preserve the patient's privacy” • Provider 7 (5): “Enact laws to penalize intruders” • Provider 12 (2): “There shall be penalties for failure to respect the privacy of the patient from the ambulance band or the public”

	patients' privacy (12 proposed solutions)	• Provider 13 (12): "Enact laws that deter disclosing privacy"
	Increasing public awareness of EMS (11 proposed solutions)	• Provider 7 (3): "Raising the awareness of the public" • Provider 10 (2): "There should be plans to educate public" • Provider 11 (6): "Public awareness" • Provider 13 (13): "Raising awareness about preserving patient privacy" • Provider 13 (15): "Raise awareness to respect patient privacy in the media and schools"
	Others (27 proposed solutions)	• Provider 13 (4): "Understand differences and be supportive and nice when dealing with elderly" • Provider 6 (2): "Use guidelines to improve data collection" • Provider 6 (1): "Develop guidelines to improve data collection methods and make crew discussion private" • Provider 11 (18): "Train providers and have protocols for that" • Provider 13 (2): "Train EMS providers and have guidelines" • Provider 7 (3): "Providing the EMS team the authority to modify the patient history in the app" • Provider 11 (2): "Protective gears"
Challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response in Riyadh city **Question**: What do you consider to be	Unnecessary demands from the relatives (50 reported challenges)	• Provider 3 (7): "Relative requesting different treatment not suitable for the patient" • Provider 3 (5): "If relatives requested something out of the scope of the paramedic services" • Provider 4 (6): "Relative demanding non-available things" • Provider 9 (4): "Requesting things that are not in the interest of the patient or may harm the patient" • Provider 12 (2): "Unawareness of relatives of the patient in what their requests such as the inappropriate requests compared to the patient's condition"
	Relatives interfering in patient treatment and	• Provider 1 (9): "Interventions in the treatments provided to patients"

the top three major challenges in addressing the needs of patients' relatives during EMS response in Riyadh city?	transfer plans (50 reported challenges)	• Provider 4 (1): "Treat patient at the scene in case they refuse and advise them to transfer him to hospital" • Provider 4 (7): "Interference as of the quality of medical service provided to the patient" • Provider 2 (2): "Relatives interfering in where to transfer the patient" • Provider 7 (1): "Requesting • Provider 10 (2): "Relatives insist on the way the patient should be moved or transported"
	General interference by relatives (26 reported challenges)	• Provider 1 (1): "Do not follow regulations" • Provider 13 (2): "Relative who are not following the instructions of the EMS team" • Provider 13 (13): "Stubborn relatives who don't obey instructions" • Provider 3 (7): "Requesting some personal information about the patient" • Provider 9 (1): "Requesting confidential information about the patient" • Provider 3 (2): "Large number of escorts" • Provider 12 (12): "Too many relatives"
	Lack of cooperation with and rudeness to EMS team (25 reported challenges)	• Provider 5 (5): "Relatives' bad words and manners" • Provider 8 (2): "Relatives shouting when they offer their needs" • Provider 13 (3): "Relative who make fun of the paramedics" • Provider 13 (13): "Relatives try to verbally and physically assault the paramedics" • Provider 5 (3): "Uncooperative relatives" • Provider 7 (3): "Asking to answer the questions to the patients while patient can do so" • Provider 12 (3): "Relatives delay reporting"
	Time constraints (12 reported challenges)	• Provider 1 (7): "Quick transfer before addressing needs of relatives" • Provider 3 (3): "Time pressure in the field to address all the needs for relatives" • Provider 5 (3): "Dealing with more than one case at a time" • Provider 13 (13): "More than one relative to join the patient in the ambulance" • Provider 13 (14): "Difficulty in dealing with them during the active accident"
	Others (35 reported challenges)	• Provider 3 (7): "Relatives requesting to accompany the patient on the scene and the ambulance"

		• Provider 10 (1): “Some relatives ask to accompany the patient in the ambulance” • Provider 13 (1): “Unavailability of transportation means for the relative” • Provider 6 (5): “Ignorance of the relatives” • Provider 1 (3): “Poor response from government teams” • Provider 3 (5): “Circumstances of the scene such as whether or crime” • Provider 9 (3): “Relatives who make noise” • provider 8 (9): “lack of guidelines on how to handle relatives” • Provider 1 (5): “Relatives to be convinced if they were not admitted”
Solutions to challenges in addressing the needs of patients’ privacy as reported by frontline EMS providers responding to EMS cases in Riyadh city **Question**: How do you think the challenges you mentioned above can be addressed?	Improving communication (61 proposed solutions)	• Provider 1 (11): “Good relationship with the relatives. Be firm with requests of serving the interest of patient” • Provider 7 (7): “Explain what is possible and not possible to the patient in a polite way” • Provider 13 (14): “Explain the situation and inform them about what we can do, calming them down” • Provider 13 (15): “Politely inform the relatives about the privacy of the patient, Reassure the patient by giving him/her correct info about his/her case”
	Increasing public awareness (21 proposed solutions)	• Provider 1 (10): “There should be awareness and national education system” • Provider 12 (1): “Intensify awareness campaigns” • Provider 13 (3): “Raising awareness in media and schools” • Provider 12 (3): “More information and awareness regarding the role of ambulatory service” • Provider 11 (14): “Raising awareness about SRCA role and transportation” • Provider 13 (2): “Educating the relatives about role of EM services”
	Working with collaborating services (27 proposed solutions)	• Provider 5 (3): “Cooperation and coordination between EMS team and security” • Provider 11 (16): “Availability of security and other supporting teams” • Provider 11 (18): “Communicate with team supervisors and get help from the participating agencies”

	Others (17 proposed solutions)	• Provider 12 (2): “Coordination between the ambulance teams and other bodies such as police” • Provider 12 (2): “Provide an adequate response team” • Provider 11 (17): “Following regulations and protocol” • Provider 4 (6): “Increase training courses on how to deal with the public” • Provider 8 (9): “Develop guidelines” • Provider 11 (13): “Enact laws that protect the rights of both the patient and medical team” • Provider 3 (9): “Well-equipped EMS team to meet all patients/relatives’ needs” • Provider 13 (2): “The EMS team knows best about the interest of the patient
Challenges faced in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival During the Hajj season, do you send your Riyadh EMS providers and ambulances to Makkah? If yes, do you do this each year? What challenges do you face while providing EMS services in Riyadh	Shortage of staff (19 reported challenges)	• 1 Director: “Shortage of EMS staff in each station” • 3 Director: “The most challenge is the deficiency in man power in Riyadh” • 5 Ass. Director: “The main challenges is that number of EMS providers decreases” • 10 Director: “In addition, trying to cover any shortage for the providers from other centre” • 11 Ass. Director: “shortage in EMS employees in all the station” • 13 Ass. Director: “Few of EMS providers in Riyadh City” • 14 Director: “Lack of the number of paramedics in Riyadh”
	Long shift hours (15 reported challenges)	• 2 Ass. Director: “Prolonged working hours” • 4 Director: “Shift hours changed some times” • 5 Ass. Director: “Working hours increases” • 7 Ass. Director: “Shift hours changed” • 14 Director: “Sometimes work hours increase”
	Shortage of equipment such as ambulances (6 reported challenges)	• 2 Director: “Shortage of medical equipment” • 4 Ass. Director: “Lack of Vehicles” • 7 Director: “Lack of Vehicles & some supply” • 8 Director: “Shortage of the number of ambulances” • 11 Director: “Shortage of ambulance in some stations” • 14 Ass. Director: “Lack of Vehicles & some supply”

during this time that you send your EMS providers and ambulances to Makkah?	Challenges in arranging work schedule (6 reported challenges)	• 5 Ass. Director: “The other challenge is that the shifts system in our centre changes as well” • 8 Director: “Changing of the shifts system in our center” • 9 Ass. Director: “Difficulty to manage the cases in some years when we send at least three of our 11-member center” • 10 Director: “The most common challenge is that for arranging new schedule” • 10 Ass. Director: “The most common challenge about the schedule. Arranging providers to new shifts” • 13 Director: “Compression in working times”
	Increased number of EMS calls (4 reported challenges)	• 9 Director: The most important challenge is that the pressure of calls increases which negatively affects the ability of the centre to cover its needs. For example, we are 11 in our center and we send yearly or every other year at least three EMS providers.” • 4 Director: “Increased volume of calls” • 7 Ass. Director: “More call & increase patients” • 9 Ass. Director: “Heavy volume of calls”
	Others (2 reported challenges)	• 2 Director: “Communications problems” • 3 Ass. Director: “Always difficult reachable for patient and victims on scene which is delay our services; hospital occupancy is most of the challenges (always busy and 0 bed available)”

DISCUSSION

Challenges faced by frontline EMS providers when communicating with patients and/or their relatives during EMS response in Riyadh city and proposed solutions

When communicating with patients and/or their relatives during an EMS response, we found that frontline EMS providers face the following challenges: patient characteristics or condition that compromise communication, language barrier, lack of cooperation from patients and/or their relatives, difficult communication environment, lack of public knowledge about EMS, and too many cases to deal with. The providers proposed the following solutions to these challenges: deploying a sufficient number of EMS providers; developing communication protocols and guidelines; increasing public awareness about EMS; professional response by creating a good relationship with patients and/or their relatives by creating confidence and consulting with senior colleagues and supervisors where there are any doubts; providing continuous education for EMS providers; using translators; and working with collaborating agencies such as police, civil defense, and firefighters.

When maintaining the privacy of patients during EMS response, we found that frontline EMS providers face the following challenges: intruders at patient scene, disclosure of information by patient or third parties, locations that compromise patient privacy, lack of patient cooperation, unqualified or unprofessional EMS providers, lack of cooperation between EMS team and collaborating services, poor methods of data collection, and lack of public knowledge on the importance of patient privacy. The providers proposed the following solutions to these challenges: continuous medical education for EMS providers; developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy; improving data collection methods; increasing public awareness of EMS; and working with collaborating services such as police, rescue teams, civil defense, and other security agencies.

When addressing the needs of patients' relatives during EMS response, we found that frontline EMS providers face the following challenges: unnecessary demands from the relatives, relatives interfering in patient treatment and transfer plans, general interference by relatives, lack of cooperation with and rudeness to EMS team, time constraints, lack of transport for patient relatives, lack of knowledge about EMS service, lack of collaborating services, interference with communication environment, and lack of guidelines. The providers proposed the following solutions to these challenges: developing guidelines and training programs, developing legislations, following EMS guidelines and protocols for addressing the needs of patient relatives, improving communication, increasing number of deployed EMS providers, increasing public awareness, and working with collaborating services.

The challenges faced by frontline EMS providers when communicating with patients and/or their relatives during EMS response in Riyadh city and proposed solutions are shown in Table 31.

Table 31. Analysis of the reported challenges faced by frontline EMS providers when communicating with patients and/or their relatives during EMS response against the proposed solutions

Challenges	Proposed solutions
• Patient characteristics or condition • Language barrier • Lack of cooperation from patients and/or their relatives • Difficult communication environment • Lack of public knowledge about EMS • Too many cases to deal with	• Deploying a sufficient number of EMS providers • Developing communication protocols and guidelines • Increasing public awareness about EMS • Professional response by creating a good relationship with patients and/or their relatives by creating confidence and consulting with senior colleagues and supervisors where there are any doubts • Providing continuous education for EMS providers • Using translators • Working with collaborating services as police, civil defence, firefighters, and public

In this study, we found that patient demographic factors such as age (elderly and young patients) and patient conditions (such as drunkenness, anger/aggressiveness, unconsciousness, and mental illnesses) that compromise effective communication is the most commonly reported communication challenge during EMS response. In similar studies conducted elsewhere, it has been reported that frontline EMS providers report communication as a challenge in caring for elderly patients (162–164) and young patients (165). Similarly, communication with drunk, unconscious, deaf, and aggressive patients has also been reported to be a challenge during EMS response (166,167).

In our study, the surveyed frontline EMS providers proposed providing continuous education for EMS providers and developing communication protocols and guidelines as solutions to addressing the challenge of patient characteristics or condition during prehospital care. In another study, Peterson et al. (162) recommended further continuous geriatric education for paramedics to improve their communication skills of when caring for elderly patients. Literature reviews have also appreciated a challenge in communicating with patients with certain characteristics such as deaf and unconscious patients and recommended use of EMS guidelines and protocols to address this challenge (168,169). Therefore, the results of our study are consistent with those of previous studies in identifying patient age and conditions that can compromise effective communication during EMS response and in recommending developing communication protocols and guidelines as a solution to this challenge.

We also found that language barrier is the second most common communication challenge reported by frontline EMS providers. The challenge of language barrier during prehospital care has also been reported by previous studies conducted elsewhere. For instance, Tate (81) reported that language barrier is a common challenge during prehospital care in the United States (81). Similarly, language barrier has also been reported to be a challenge during

EMS response in several other countries including Germany (82), Canada (83), South Africa (84), Minnesota (79), and Kuwait (85).

Researchers have also conducted studies to investigate the possible solutions to language barrier as a communication challenge during EMS response. In a study among EMS providers at seven dispatch centers (three in New Mexico and four in Western Cape), Tate et al. (170) identified the following strategies that can be used to overcome the challenge of language barrier: using of telephonic interpreter service, relying on interpretations and translation by bystanders, using the services of multilingual coworkers, and using non-verbal communication approaches. Noack et al. (82) also reported that a mobile app can be used by paramedic as a digital communication tool to translate and overcome language barriers during EMS response. In our study, the surveyed frontline EMS providers proposed use of translators as a solution to addressing the challenge of language barrier. This proposal is consistent with the solutions reported in literature. For example, strategies identified by Tate et al. (170) revolved around using of translators but provided examples of who can be used as translators. Particularly, the study identified translators as telephonic interpreter service, bystanders, and multilingual coworkers. Similarly, the digital communication app reported by Noack et al. (82) is also a form of translation. Therefore, our study findings are consistent with those of previous studies that language barrier is a significant challenge faced by frontline EMS providers during EMS response and that this challenge can be addressed by using translators such as telephonic interpreter service, bystanders, multilingual coworkers, and mobile apps. Use of translators is particularly important to Saudi Arabia where, although Arabic is the main language, differences in language due to cultural and Islamic influence has been reported (171). In Saudi Arabia, culture is known to affect the perception and attitudes of people during communication. For example, cultural factors affect one's understanding of a person's expressions and ways of

communicating (154). Also, cultural misunderstanding between patients and healthcare providers has been reported to be a significant factor in effective communication (171).

Other communication challenges identified in this study include lack of cooperation from patients and/or their relatives, difficult communication environment, lack of public knowledge about EMS, and too many cases to deal with. These challenges have also been reported in other studies. For example, in Denmark, Hansen et al. (172) reported that frontline EMS provider often mention noisy patient scenes as a significant challenge during prehospital care. Several studies have also reported lack of public awareness about EMS services to be a challenge in communicating with patients or their relatives during prehospital care in India and Japan (173,174). It has also been reported that time constraint due to too many EMS cases in scenes such as mass casualty incidents can also compromise effective communication during an EMS response (175). Although we did not come across any study that has recommended solutions to these challenges, the solutions proposed in this study are practical and presents the novelty of our research. The solutions include: professional response by creating a good relationship with patients and/or their relatives by creating confidence and consulting with senior colleagues and supervisors where there are any doubts; working with collaborating services such as police, civil defense, and firefighters; developing communication protocols and guidelines; increasing public awareness about EMS; and deploying a sufficient number of EMS providers. Working with collaborating services such as police, civil defense, and firefighters is particularly important in keeping intruders away from patient scenes. Indeed, this study found that intrusion was one of the issues that compromised the communication environment at patient scenes; therefore, working with the police to keep intruders away from patient scenes is a solution to effective communication. However, there are no such guidelines or frameworks in Saudi Arabia. Also, collaborating services such as civil defense and

firefighters may help secure the scene thus allowing frontline EMS providers enough time to communicate with patients while providing prehospital care services.

Challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response in Riyadh city and proposed solutions

The challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response in Riyadh city and proposed solutions are shown in Table 32.

Table 32. Analysis of the reported challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response against the proposed solutions

Challenges	Proposed solutions
• Intruders at patient scene • Disclosure of information by patient or third parties • Locations that compromise patient privacy • Lack of patient cooperation • Unqualified or unprofessional EMS providers • Lack of cooperation between EMS team and collaborating services • Poor methods of data collection • Lack of public knowledge on the importance of patient privacy	• Continuous medical education for EMS providers • Developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy • Improving data collection methods • Increasing public awareness of EMS • Working with collaborating services such as police, rescue teams, civil defence, and other security agencies

We found that intrusion at patient scene was the most commonly reported challenge by the frontline EMS providers (81 challenges, 39.5%). Our findings further revealed that the intrusion was due to bystanders, criminals, interfering relatives, and media. Our study also found that most of the proposed solutions (75, 60.0%) were about working with collaborating services such as police to secure the scene and control intruders. These findings may indicate that EMS personnel arrive at patient scenes earlier than other services such as police, firefighters, and civil defense; therefore, they find intruders at the scene. Indeed, our study also

found that lack of cooperation between EMS team and collaborating services was one of the reported challenges in maintaining patient privacy, further suggesting that EMS personnel arrive earlier at patient scene than collaborating services.

Few studies have previously investigated challenges faced by frontline EMS providers in maintaining the privacy of patients during EMS response. In one study in Finland, Koskimies et al. (87) reported that paramedics mentioned attitudes of paramedic and lack of knowledge among frontline EMS providers as some of the challenges in maintaining patient privacy during EMS response. The challenges reported by Koskimies et al. (87) are similar to one challenge reported in this study (unqualified or unprofessional EMS providers). In a qualitative study in Iran, Torabi (86) found that some of the privacy challenges reported by frontline EMS providers included maintain patient privacy in the street and examination of the patient in a public area. In this study, we also found that patient locations such as unsecured/violent scenes, public places, and noisy environments can also compromise patient privacy during EMS response. Our study also revealed additional challenges that have not been reported in literature with practical solutions as shown in Table 32. The challenges include lack of patient cooperation, unqualified or unprofessional EMS providers, lack of cooperation between EMS team and collaborating services, poor methods of data collection, and lack of public knowledge on the importance of patient privacy.

Among the proposed solutions to these challenges were continuous medical education for EMS providers; increasing public awareness of EMS; developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy; and working with collaborating services such as police, rescue teams, civil defence, and other security agencies; and improving data collection methods. Continuous medical education for frontline EMS providers is particularly important in developing the capacity of the providers to maintain patient privacy in the midst of the challenges. Developing policies legislations/policies to

punish offenders of patient privacy laws and to preserve patients' privacy are equally important in ensuring that frontline EMS providers, the patient, and the public maintain patient's privacy during an EMS response.

Challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response in Riyadh city and proposed solutions

The challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response in Riyadh city and proposed solutions are shown in Table 33.

To the best of our knowledge, no study has investigated the challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response. We found that the main challenges in addressing the needs of patient relatives is unnecessary demands (50 challenges, 25.3%), interference in patient treatment and transfer plans (50 challenges, 25.3%) and general interference by relatives (26 challenges, 13.1%). While these unnecessary demands and interferences by relatives may be true challenges, it is also possible that it is just a perception of the frontline EMS providers due to lack of proper training about their roles, which includes addressing the needs of the relatives. Indeed, a study by Hsiao et al. (176) in in-hospital EMS setting found that patient relatives put more importance on the need for effective communication than EMS nurses. The findings by Hsiao et al. (176) study suggest that what is perceived by healthcare providers as unnecessary or interference may be essential demands and needs from the viewpoint of the relatives.

Previous studies have only investigated challenges in addressing the needs of patients' relatives in in-hospital care settings not prehospital care settings (177,178). Therefore, our study is novel in revealing the challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response with practical solutions as shown in Table

33. Details of how frontline EMS providers address the needs of patients' relatives are presented in Chapter 4.

Table 33. Analysis of the reported challenges faced by frontline EMS providers in addressing the needs of patients' relatives during EMS response against the proposed solutions

Challenges	Proposed solutions
• Unnecessary demands from the relatives • Relatives interfering in patient treatment and transfer plans • General interference by relatives • Lack of cooperation with and rudeness to EMS team • Time constraints • Lack of transport for patient relatives • Lack of knowledge about EMS service • Lack of collaborating services • Interference with communication environment • Lack of guidelines	• Developing guidelines and training programs • Developing legislations • Following EMS guidelines and protocols for addressing the needs of patient relatives • Improving communication • Increasing number of deployed EMS providers • Increasing public awareness • Working with collaborating services

Challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival

The surveyed senior SRCA staff reported that they face the following challenges in Riyadh after sending EMS personnel and ambulance to Makkah during Hajj festival: shortage of staff; long shift hours; shortage of equipment such as ambulances; challenges in arranging work schedule; and increased number of EMS calls. As these challenges were collected from the perspectives of the senior SRCA staff, they may actually represent broader problems facing provision of EMS in Riyadh during Hajj festival.

During Hajj festival, there is a mass gathering of Muslim pilgrims in Makkah. The festival has been reported as one of the largest annually recurring mass religious gatherings

worldwide with approximately 3 million pilgrims attending the festival each year (156). As the large gathering of people in Makkah puts a strain in the existing healthcare infrastructure including EMS in Makkah, the other regions of Saudi Arabia such as Riyadh are usually required to send EMS ambulances and personally to Makkah. To the best of our knowledge, our study is the first to investigate the challenges faced in Riyadh city after EMS personnel and ambulances are sent to Makkah during Hajj festival. Most of the available studies have only focused on the healthcare challenges in Makkah where the festival takes place (156–158). These studies found that health challenges in Makkah where the festival takes place include risk of infectious diseases such as pneumonia and other communicable diseases among pilgrims (156–158). Therefore, our study may serve as a background for investigating the consequences of Hajj festival in other Saudi regions where Hajj festival does not take place. Also, our study has identified EMS resources (both human and non-human) as a major challenge in Riyadh city during the time that Hajj festival is taking place in Makkah. This finding can be used to recommended proper resource allocation for EMS responses both in Makkah and other regions where the festival does not take place.

Strengths and Limitations

The strength of the frontline EMS provider survey is that it investigated both the challenges by frontline EMS providers during EMS responses as well as the solutions of these challenges. This allowed the researcher to get a deeper understanding into what the frontline EMS providers view as the main challenges during EMS response and what they think are practical solutions to the challenges. In both surveys, this study had the strength of a rigorous process of theme development and content analysis - the researcher and a member of the supervisory team with expertise in qualitative research developed the themes and carried out content analysis

and any disagreements were discussed and settled in a general supervisory meeting with all members of the supervisory team.

The strength of the senior SRCA staff survey is that it investigated an aspect of EMS that it unique to Saudi Arabia: the challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival. While most studies have focused in the health challenges in the city where the Hajj festival is held, our study is the first to investigate health challenges in another city where the festival is not held. Also, in our study, none of the frontline EMS providers or senior SRCA staff failed to report any challenge or solution. This demonstrates that the respondents perceived the challenges and solutions to be important. However, this study also had certain limitations. First, both the frontline EMS provider survey and senior SRCA staff survey were conducted using electronic surveys and therefore some of the responses were not detailed. For example, some of the respondents did not give full responses and there was no option to ask them to provide more details. This compromised the depth of the information gathered. We recommend that face-to-face interviews be conducted with the frontline EMS providers and senior SRCA staff to get more detailed responses regarding the challenges faced in providing EMS services. Secondly, both the frontline EMS providers and senior SRCA staff surveys were only limited to one Saudi region (Riyadh city); therefore, caution should be taken when transferring the results to other Saudi regions. We therefore recommend a nationwide survey of frontline EMS providers and senior SRCA staff to get information data for the entire Saudi Arabia. Thirdly, the survey questionnaire had limited questions as the qualitative data was only required to provide a further understanding to quantitative data, that were also collected in this study. For example, the survey questionnaire for senior staff did not include questions on what the senior SRCA staff thought would be solutions to the problems face din Riyadh after sending EMS ambulances and staff

to Makkah during Hajj. A more in-depth qualitative study on the Saudi EMS system is thus recommended.

CONCLUSION

In conclusion, our survey of frontline EMS providers and senior SRCA staff revealed that there are significant challenges facing the provision of EMS services in Riyadh city. In particular, the frontline EMS provider survey revealed that the providers face significant challenges when communicating with patients and/or their relatives, when maintaining patient privacy, and when addressing the needs of patients' relatives during an EMS response. Triangulation of these challenges against the study objectives and the proposed solutions revealed that the main challenges across all the three areas are due to:

1. Barriers in communication (such as language barrier, lack of translators and lack of adequate communication skills)
2. Lack of collaborating services such as police, firefighters and civil defence.
3. Poor public knowledge about EMS
4. Lack of continuous education for frontline EMS providers.

On the other hand, the senior SRCA staff survey revealed that the challenges faced in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival can be categorised into two: challenges affecting human resources (shortage of staff, long shift hours, challenges in arranging work schedule, and increased number of EMS calls) and challenges affecting non-human resources (shortage of equipment such as ambulances). Therefore, we recommend that during Hajj festival, SRCA should work with private EMS providers to supplement EMS services in Makkah without moving human and non-human EMS resources from Riyadh city.

Chapter 6: Review of study results in the context of other recent work in Saudi Arabia, and recommendations for service provision

INTRODUCTION

In the previous two chapters, the quantitative and qualitative results of the study are presented. In this chapter, these results are discussed. The study methods and findings for each objective are summarized below.

Objective 1. To conduct a scoping review of tools and indicators that have been used to evaluate EMS systems

We first conducted a narrative review of previous systematic or scoping reviews published in 2015 to 2020 to identify synthesized quality indicators (QIs) for evaluating emergency medical service (EMS) systems (first part). Secondly, the researcher reviewed both primary research articles and review articles published in 2010 to 2020 to identify tools for collecting data to measure the identified EMS QIs (second part). In the first part of the review, we identified two clinical QIs (proportion of patients with time-sensitive illnesses who received prehospital emergency care and proportion of patients who received advanced treatments) and 15 non-clinical QIs (initial time to respond immediately, time to arrival of EMS response, on scene time, time to preferred destination, proportion of positive patient feedbacks, proportion of available materials and resources, proportion of EMS patients recruited into EMS studies, proportion of EMS patients arriving alive to health facilities, proportion of EMS responses are debriefed, proportion of expenses against the total budget, number of EMS physicians providers, proportion of complete EMS records, availability of communication guidelines, proportion of adverse events, and availability of safety guidelines and materials for frontline).

In the second part of the review, we did not identify any standard tool (a generally acceptable or approved tool that produces precise, consistent, reliable, and valid measures when used in different contexts) for evaluating EMS systems. However, we identified four non-standard tools that have been developed to evaluate EMS systems: Haugland et al. (58) EMS questionnaire, Dantas et al. (126) QA-PHC instrument, Mehmood et al. (124), Comprehensive EMS assessment tool, and Sund (127) EMS simulation model. Among these tools, the Haugland et al. (58) EMS questionnaire was identified as the most comprehensive and relevant because: (1) it has all the 15 non-clinical QIs identified in the first part and two additional non-clinical QIs (number of EMS units per population and number of EMS units per area); (2) it has been used in a largely successful prospective observational study in Finland, Sweden, Denmark and Norway that demonstrated its feasibility, rankability, variability, actionability and documentation (125); (3) it has proposed benchmarks to interpret the QI measures; and (4) it was developed by a multidisciplinary team consisting of three general practitioners, two EMS medical directors, a director of a public health institute, a specialist in community medicine, a patient-organization leader and ten physicians working in EMS.

Objective 2: To map out the structure of the Saudi EMS system to identify aspects of the Saudi EMS system for EMS evaluation and develop a structure, process, and outcome-based tool for evaluating the country's EMS system

We first mapped out the structure, process, and outcome of the Saudi EMS system by reviewing reported literature and data by the Saudi Red Crescent Authority (SRCA) to identify potential sources of data for measuring the 17 QIs identified in objective 1 (first part). Secondly, we used the identified sources of EMS data in Saudi Arabia to assess whether all the 17 QIs in the Haugland et al. (58) EMS questionnaire could be measured in Saudi Arabia and modified the questionnaire to evaluate the Saudi EMS system (second part). We found that the existing EMS

data in prehospital care reports could be used to measure the following nine QIs: initial time to respond, time to arrival of EMS response team, on scene time, time to preferred destination using, adverse events, complete documentation, provision of advanced treatments, patients arriving to the hospital alive, and time-sensitive illnesses. We also found that existing EMS data in the SCRA annual report could be used to measure the following two QIs: number of EMS units per population and number of EMS units per area. However, the remaining six QIs could not be measured using the pre-existing EMS data. Therefore, we considered relevant SRCA personnel who are best placed to provide information required to measure the remaining six QIs. Consequently, we found that frontline EMS providers (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) could be surveyed to provide information required to measure the following three QIs: performance monitoring, audit, appraisal, and/or debriefing; involvement of EMS physicians in dispatching EMS response team; and care for relatives. We also found that senior SRCA staff (directors and assistant directors of each EMS center) could be surveyed to provide information required to measure the following two QIs: guidelines for actual medical problems and patients enrolled in research projects.

Cumulatively, we found that 15 out of the 17 QIs in the Haugland et al. (58) EMS questionnaire could be measured in Saudi Arabia using secondary data (prehospital care reports, SRCA annual reports, and SGAS records) and primary data (data obtained from a survey of senior SRCA staff and frontline EMS providers). Two QIs (necessity of EMS physicians in providing appropriate care and significant logistical contributions of EMS physicians) could not be measured. The QIs could not be measured in this study because the study only focused on prehospital care without looking at patient outcome data in hospitals, which are required to measure these QIs. Therefore, we used the 15 QIs and their sources of data to develop a three-part tool for evaluating the Saudi EMS system: data extraction tool,

questionnaire for a survey of senior SRCA staff, and questionnaire for a survey of frontline EMS providers.

Objective 3: To describe the characteristics and medical needs of patients using EMS based on sampled PCRs in Riyadh city

We extracted the following patient data from the randomly sampled PCRs: (1) patient characteristics before prehospital care (gender, age, and pre-existing patient conditions); and (2) patient characteristics during prehospital care (location, type of emergency call, injuries to different parts of the body, chief patient complaint). We found that the characteristics of the patients who used EMS services were as follows: more males used the EMS services compared to females, most of the patients were older, aged 60 years and above; the most common pre-existing patient condition was comorbid diabetes mellitus and hypertension; most of the patients who made the alarm calls were located at home; most commonly recorded chief complaint was trauma (28.7%), though most of the calls were due to other medical conditions other than trauma or motor vehicle accidents; most of the calls were made from 1801 to 0000 hrs; most of the patients (361; 81.7%) received some kind of pre-hospital treatment, and most of the treatments provided were categorized as advanced life support rather than basic life support; and most of the patients were transported to healthcare facilities.

Objective 4: To describe the characteristics of staff employed in the Saudi EMS system in Riyadh city

We surveyed frontline EMS providers in the 13 sampled EMS centers in Riyadh, Saudi Arabia. We found that all the frontline EMS providers were males; majority (85.71%) had university education; and most of them were paramedics (93.33%) while others were EMS technicians (4, 3.81%) and doctors (3, 2.86%). We also found that the all the frontline EMS providers who

completed the survey had responded to an EMS case in 2018 and had worked for SRCA for an average of 5.87 years (SD = 3.57; minimum 1 year and maximum 17 years) as of 2018 when this study was conducted thus meeting the inclusion criteria. For the senior SRCA staff survey, a total of 28 senior staff were included: one director and one assistant director from each of the 13 sampled EMS centers and the general director and assistant director for the entire Riyadh region.

Objective 5: To use the "developed" tool to evaluate the Saudi EMS system in Riyadh city

We used the tool developed under objective 2 to collect data from PCRs, senior SRCA staff, and frontline EMS providers to measure the 17 QIs under the following six quality dimensions: (1) timeliness (initial time to respond, time to arrival of EMS response team, on scene time, time to preferred destination using data from PCRs); (2) patient safety (adverse events using data from PCRs); (3) efficiency (complete documentation using data from PCRs and performance monitoring, audit, appraisal, and/or debriefing using survey data from frontline EMS providers); (4) effectiveness (guidelines for actual medical problems using survey data from senior SRCA staff, provision of advanced treatments using data from PCRs, involvement of EMS physicians in dispatching EMS response team, patients enrolled in research projects using survey data from senior SRCA staff, patients arriving to the hospital alive, and time-sensitive illnesses using data from PCRs); (5) patient-centeredness (care for patient relatives using survey data from frontline EMS providers); and (6) equity (number of EMS units per population and number of EMS units per area using data from SRCA annual report). We interpreted measures of these QIs using the Haugland et al.(125) benchmarks.

Under the timeliness quality domain, we found that the Saudi EMS system had a low performance on initial time to respond, but high performances on time to arrival of EMS

response team, on-scene time, and on time to preferred destination. We also looked at each of these measures within each of the centers, and we observed that whilst there appeared to be variability in timeliness indicators between centers, the confidence intervals for these indicators did not reveal any significant differences between centers, indicating consistency in service delivery across the EMS centers.

Under the efficiency quality domain, we found that the Saudi EMS system in Riyadh city had an average performance for all the two QIs (complete documentation and performance monitoring, audit, appraisal, and/or debriefing). Particularly, we found that not all frontline EMS providers are debriefed after an EMS response. Also, the average performance in documentation of patient records were due to missing records on ambulance response times, type of emergency call, patient location, age, and chief complaints.

Under the effectiveness quality domain, we found that the Saudi EMS system in Riyadh city had a high performance on provision of advanced treatments, patients enrolled in research projects, and patients arriving to the hospital alive, but an average performance on involvement of EMS physicians in dispatching EMS response team and a low performance on availability of guidelines for actual medical condition. Particularly, the available guidelines were basic life support guidelines; airway, breathing, and circulation; guidelines; Saudi heart association guidelines; prehospital trauma life support; international trauma life support; advanced cardiac life support; and airway, breathing, and circulation. However, no EMS center had all the guidelines; number of the EMS centers only had two of these guidelines while some of them lacked any of the guidelines.

We also found that most of the EMS cases (62.7%) were time-sensitive illness, but there are no benchmarks for interpreting measures of time-sensitive illnesses. Under the patient centeredness quality domain, we only had one measure which was of whether the needs of patients' relatives were met and if so how. We found that all but one centre reported meeting

the needs of relatives, sometimes in collaboration with other services such as the police. Under the equity quality domain, we found that Riyadh region had 1.48 EMS centers per 100, 000 population, which was lower than that of Al-Madinah Al-Munawara, Asir, Al-Qassim, Tabuk, Jazan, Hail, AlBaha, AlJouf, Najran, and Northern regions. We also found that the number of EMS centers per square kilometer of each Saudi region, including Riyadh was <1. However, there are no benchmarks to interpret these findings, but according to Mishra et al. (179), international standards recommend provision of one EMS center with at least one ambulance for every 50,000 people. Therefore, our findings of 1.48 EMS centers per 100,000 population is below international standards.

Overall, the Saudi emergency medical system (EMS) system had a high performance in eight QIs (time to arrival of EMS response team, on scene time, time to preferred destination, provision of advanced treatments, patients enrolled in research projects, patients arriving to the hospital alive, time-sensitive illnesses, and care for patient relatives); average performance in three QIs (complete documentation; performance monitoring, audit, appraisal, and/or debriefing; and involvement of EMS physicians in dispatching EMS response team); and a low performance in four QIs (initial time to respond, EMS guidelines, EMS centers per population and EMS centers per area).

We looked at a number of factors which might be expected to affect the timeliness of the service. We found no evidence that the timeliness of the service depended upon whether the patient had a time sensitive illness or not. However, we found that time taken to dispatch EMS team and time taken to arrive at patient scene were both significantly longer during middle parts of the day but shorter at night. Our findings also showed that patients who had significantly shorter initial ambulance response times were more likely to arrive to the hospital alive than those who had longer initial response time. We also hypothesized that quality of service delivery might be affected during the Hajj season. We found that, although initial

response time, time to arrival of EMS response team, and time to preferred destination were all lower during Hajj period compared with non-Hajj period, these differences were not statistically significant.

Under patient safety quality domain, were not able to measure adverse events as data regarding this QI were missing in the PCRs. We expected to find records of any patient adverse events in the PCRs, but all the sampled PCRs lacked records of adverse events.

As described in Chapter 4, certain contextual factors unique to Saudi Arabia such as gender composition of frontline EMS providers, language and family roles and commitment, and Hajj festival may explain aspects of these findings. For instance, while the quantitative results were rated using Haugland et al (125) benchmarks, which was developed for healthcare settings in Finland, Sweden, Denmark, and Norway where it is likely that there are female frontline EMS providers, there were no female frontline EMS providers surveyed in Saudi Arabia. Therefore, the benchmarks may not directly show the appropriate estimate measure of some of the Saudi EMS quality indicators, especially those measured using frontline EMS provider survey data.

Objective 6: To explore from staff perspective their perceptions of the challenges of providing EMS services and opportunities for improvement in Riyadh city

We qualitatively and separately surveyed both frontline EMS providers and senior SRCA staff to explore their perceptions of the challenges of providing EMS services and opportunities for improvement in Riyadh city. Particularly, we surveyed frontline EMS providers in the sampled 13 EMS centers to identify the problems they face when communicating with patients and/or their relatives, when maintaining the privacy of patients, and when addressing the needs of patients' relatives during EMS response in Riyadh and what their propose as solutions to these

challenges. We surveyed senior SRCA staff to determine the challenges they face in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj.

Communication was one of the biggest issues that emerged from the survey of frontline EMS providers. In particular, the survey revealed that frontline EMS providers find it difficult to communicate with patients or patients' relatives who speak a different language or dialect and those who have conditions that compromise their ability to communicate. The frontline EMS providers also highlighted difficult communication environments due to noise, lack of cooperation from patients and/or their relatives, and lack of public knowledge about EMS. According to the surveyed providers, these challenges can be addressed by deploying a sufficient number of EMS providers; developing communication protocols and guidelines; increasing public awareness about EMS; professional response by creating a good relationship with patients and/or their relatives by creating confidence and consulting with senior colleagues and supervisors where there are any doubts; providing continuous education for EMS providers; using translators; and working with collaborating agencies such as police, civil defense, and firefighters.

Frontline EMS providers also highlighted several challenges in maintaining the privacy of patients during EMS response, including intruders at patient scene, disclosure of information by patient or third parties, locations that compromise patient privacy, lack of patient cooperation, unqualified or unprofessional EMS providers, lack of cooperation between EMS team and collaborating services, poor methods of data collection, and lack of public knowledge on the importance of patient privacy. The providers proposed the following solutions to these challenges: continuous medical education for EMS providers; developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy; improving data collection methods; increasing public awareness of EMS; and working with collaborating services such as police, rescue teams, civil defense, and other security agencies.

When addressing the needs of patients' relatives during EMS response, we found that frontline EMS providers face the following challenges: unnecessary demands from the relatives, relatives interfering in patient treatment and transfer plans, general interference by relatives, lack of cooperation with and rudeness to EMS team, time constraints, lack of transport for patient relatives, lack of knowledge about EMS service, lack of collaborating services, interference with communication environment, and lack of guidelines. The providers proposed the following solutions to these challenges: developing guidelines and training programs, developing legislations, following EMS guidelines and protocols for addressing the needs of patient relatives, improving communication, increasing number of deployed EMS providers, increasing public awareness, and working with collaborating services.

For senior SRCA staff survey, we found that after sending EMS personnel and ambulances to Makkah during Hajj festival, senior SRCA staff reported that they face the following challenges in Riyadh city: shortage of staff, long shift hours, shortage of equipment such as ambulances, challenges in arranging work schedule, and increased number of EMS calls.

OVERVIEW OF RECENT FINDINGS FROM OTHER EMS STUDIES IN SAUDI ARABIA

In this section, the above findings will be set in context of the literature from Saud Arabia and the wider context. Since there have been a number of contemporary studies conducted in KSA during the same timescales as the work of this thesis (since 2018), this section starts by briefly summarizing the findings of other studies that have been taking place, so that conclusions can be drawn from all of the available literature.

Moafa et al. (50) **EMS disparities study**

A population-based registry study, by Moafa et al. (50) investigated the disparities in the timeliness and number of ambulances of the Saudi EMS system in Riyadh province and other rural provinces. Using data kept by the SRCA, the researchers found that the median general response time (defined as the time elapsed starting from receiving a call in the EMS center and ended by the arrival of the ambulance's crew to the scene) was higher in rural areas (20.2 mins) than in urban area (15.2 mins). Similarly, the study found that EMS response time within 20 mins was higher in urban areas (62.3%) than in rural areas (56.5%). In terms of number of ambulances, the study found six times more ambulance crews were available for rural areas compared to urban areas.

This study had the strength of being the first population-based study Saudi Arabia and compare timeliness and utilization between urban and rural areas of the countries, and was a very large study using data for all EMS responses in Riyadh city from 1 January 2018 to 31 December 2018 (146,639 EMS responses). However, unlike the work of this thesis, the Moafa study only looked at two quality domains (timeliness and equity) and the differences between urban and rural areas of Saudi Arabia reported in this study may have been due to other confounding factors such as better road network in urban areas which were not considered or reported in this study.

Alanazy et al. (180) **EMS personnel experience study**

In a very recent qualitative study using semi-structured interviews from 2021, Alanazy et al. (180) investigated lived experiences of frontline EMS providers and middle-level station managers in Saudi Arabia regarding the key issues they face when providing EMS service. Using data from 20 face to face interviews (10 in rural areas and 10 in urban areas), the researcher found that in both rural and urban area, EMS personnel face a myriad of issues

affecting the delivery of EMS services including EMS personnel factors such as poor work conditions, stress, lack of education and training especially in rural areas, and lack of female EMS providers; patient factors such as patient refusal of treatments when EMS provider is a man, unrealistic expectations, lack of awareness, poor patient locations, and patient/family violence; and organizational factors such as lack of both human and material resources and lack of coordination with other collaborating services.

This study had the strength of using a robust qualitative study method: face-to-face interviews with online follow-up meetings on Zoom (an online video conference technology). This ensured detailed collection of qualitative data and allowed further clarifications by the respondents when it was needed. However, the study had a limitation of only investigating the challenges faced in the provision of EMS service, but unlike our study, failed to ask the frontline EMS providers how they think the challenges can be addressed. Unlike in our study where electronic surveys of frontline EMS providers were conducted, the Alanazy et al. (180) used face to face interviews. Despite the slightly different methodology, the study also found challenges with patients and relatives in their understanding of the service, poor education and training of staff, lack of resources, and lack of co-ordination with other collaborating services.

Alotaibi and Khan (181) **EMS preparedness for mass causalities study**

In a cross-sectional descriptive quantitative study, Alotaibi and Khan (181) investigated the preparedness of EMS providers to respond to mass casualty incidents (MCIs) by identifying their strengths and weaknesses when responding to MCIs. The study included all the SRCA general administration branches in the 13 Saudi regions. The study used the EMS Incident Response and Readiness Assessment (EIRRA) tool, which was developed by the United States National Association of State Emergency Medical Service Officials. The study found that Makkah region, which have the largest number of ambulances and medics vehicles and

Madinah region had median scores of in the 4 each in the EIRRA tool, showing substantial preparedness for MCIs. Madinah region was found to have a statistically significant higher levels of preparedness than Makkah. However, the study found that the Riyadh and the Eastern region had limited MCI preparedness. Riyadh, North borders, Eastern, Tabuk, Jazan, Hail, and Qasim regions had a median score of 3 while all the other remaining regions had a median score of 2, indicating they are less prepared for MCIs.

While this study had the strength of large sample size across the whole of Saudi Arabia and was the first study to assess the preparedness of the Saudi EMS system to MCIs, it did not comprehensively assess the quality of the Saudi EMS system; it only focused on its preparedness for mass causalities. (91)

Other studies

There have been other recent studies involving SRCA services, including a study by Ghazal et al. (182), which explored knowledge and awareness of sepsis, finding better knowledge and awareness among paramedics than technicians. Another study by Alhusain et al. (183) compared patient outcomes from sepsis between those transported by EMS and those transported to hospital by other means. It was a large but single centre study and found better outcomes for those transported by EMS. Both of these studies provide information specific to sepsis and suggest that, whilst there is a need for more training in relation to sepsis, EMS providers are enabling better outcomes for people with sepsis but they do not provide any broader information on the quality of EMS service provision. Another study by Alsofayan et al. (184) looked at the impact of COVID-19 on emergency services.

TRIANGULATION OF STUDY FINDINGS

Data

In the quantitative component of our study, we found that there were missing data in the PCRs, which are kept by SRCA. Some of the missing data were on important aspects of EMS such as time records: time call received, time EMS team is deployed, time of arrival at patient scene, and time patient is delivered at patient scenes. We also did not find records on any adverse events in the PCRs and therefore we were not able to measure any QI under patient safety domain. In particular, we found the following missing data in the PCRs: ambulance response times (188 records), type of emergency call (40 records), patient location (36 records), age (14 records), and chief complaints (1 record). However, some of PCR data may have not been recorded but they were simply not relevant to be recorded, but the irrelevant data were not indicated in the PCRs. For example, under injuries to different parts of the body, the data may have not been recorded hence interpreted as missing but maybe the patient did not have an injury to the particular part of the body.

Nonetheless, missing time data affected calculation of timeliness quality indicators in some of the cases (initial time to dispatch, time to arrival of EMS response team, on-scene time, and time to preferred destination). Lack of data may also affect future EMS evaluations in Saudi Arabia. Indeed, Moafa et al. (50) also reported that some data were missing in the SRCA database and this may have compromised the validity of the study findings. Consequently, this may have negative implications for both patient care and the ability to evaluate the EMS system. Therefore, it is necessary to train frontline EMS providers on proper recording and keeping of EMS data.

The qualitative component of this study revealed challenges in ensuring privacy of patient data due to intruders at patient scene, disclosure of information by patient or third parties, locations that compromise patient privacy, lack of patient cooperation, unqualified or

unprofessional EMS providers, lack of cooperation between EMS team and collaborating services, poor methods of data collection, and lack of public knowledge on the importance of patient privacy. Particularly, we found that intruders at patient scene are majorly crowds, bystanders, criminals, relatives, and large number of escorts. To avoid negative implications for patient care, these intruders can be controlled by collaborating services such as police, rescue teams, civil defense, and other security agencies when there is a proper coordination between the EMS response team and these collaborating agencies. Indeed, the frontline EMS providers who were surveyed proposed working with these collaborating agencies as a solution to the challenge of securing patient data.

Despite the possibility of using collaborating services to ensure safety of patient data, we also found that patient data can also be leaked by patients themselves or third parties such as relatives, the police, the public, and other unspecified third parties. Therefore, carrying out public awareness campaigns to educate the general public about the importance of maintaining patient privacy is highly recommended. Indeed, other studies in Saudi Arabia found that there is poor EMS knowledge in Saudi Arabia (91,182). These studies were conducted by interviewing the general public (91) and EMS personnel (182); both interviewers found low EMS knowledge in the general public and among EMS personnel. Other alternative solutions, as proposed by the surveyed frontline EMS providers include developing legislations/policies to punish offenders of patient privacy laws and to preserve patients' privacy and improving data collection methods.

As data become increasingly computerized, this is likely to impact on the availability of data for studying EMS services on large numbers of patients, but potentially increases the problems of accuracy of the data, depending on how that data are entered. It may also increase problems of security of the data, as computerized data is more vulnerable to access by unauthorized parties. This increases the need to consider how data are entered, stored and

accessed in Saudi Arabia. However, it may also mean that there are more opportunities in the future for looking at quality of service on much larger numbers of individuals.

Organisation of services

When looking at the structure of the Saudi EMS system, we found that after receiving an emergency call, a call center uses Saudi Red Crescent Computer Aid Dispatching System (SRCCAD) to dispatch ambulances and EMS response team at different urgency levels to patient scene through nearest EMS centers or hospitals (50).

In the quantitative component of our study, we found that in overall, the Saudi EMS system performed averagely in complete documentation of EMS data and in performance monitoring, audit, appraisal, and/or debriefing), and performed poorly in initial time to respond, availability of EMS guidelines, and number of EMS centers per population, and number of EMS centers per area.

The complex EMS response process whereby a call is first received by a call center before the nearest EMS center or hospital is notified to dispatch EMS response team and ambulances may be responsible for the average performance in initial response time. The average and low performances may also be tied to challenges that were revealed in the qualitative survey of frontline EMS providers. In particular, we found that provision of EMS service in Riyadh city is faced by a myriad of challenges when communicating with patients and/or their relatives, when maintaining patient privacy, and when addressing the needs of patients' relatives. One of the challenges that was reported across all the three areas was lack of cooperation between EMS team and collaborating agencies, suggesting lack of proper organization of the EMS service. Taken together, both the quantitative findings on the average and low performance of the Saudi EMS system and qualitative findings on challenges faced during EMS response points out to a necessity of properly organizing the EMS service by

proper coordination between the EMS team and collaborating agencies to improve quality of its service delivery.

Service provision by SRCA is organized in a manner that can accommodate dispatch of collaborating services such as police and fire-fighters together with and/or alongside EMS response team and ambulances. Specifically, once a call center receives an emergency call, they can also dispatch nearest and relevant collaborating services in addition to dispatching ambulances with EMS response team. In a previous study, Nordberg et al. (185) found that dual dispatch of collaborating service of fire-fighters and EMS response team reduced response times in all studied regions of Stockholm area, Sweden. The findings of this study demonstrates that use of collaborating services during EMS response can help reduce response time.

According to the Saudi Red Crescent Authority (96), the Saudi EMS system is based on a hybrid model of both Franco-German and Anglo-American models (1). In this hybrid model, the EMS system "stays and stabilizes" patients with the main aim of bringing hospitals close to the patients with many pre-hospital care treatments provided by many paramedics including physicians with an extensive scope of practice (Franco-German model) (1). At the same time, the EMS system rapidly transports patients to the hospital with few pre-hospital care treatments (Anglo-American model) (33). Indeed, our study found that most of the patients (81.7%) received some kind of pre-hospital treatment, and most of the treatments provided were categorized as advanced life support rather than basic life support demonstrating that the Saudi EMS system, is based on the Franco-German model. We also found that 3 (2.86%) of the frontline EMS providers were doctors, which is a key feature of EMS systems based on the Franco-German model. We also found that 14 (3.9%) of the patients received basic life support and that most of the patients (74.4%) were transported to healthcare facilities thus demonstrating that the EMS system is also based on the Anglo-American model. In addition to providing EMS services, SRCA also carries out other duties and responsibilities as outlined in

Chapter 3. Key among these additional duties are the preparedness and response for crisis and provision relief services in Saudi Arabia according to the accredited national plan. However, this study only focused on provision of EMS services.

Outcomes of EMS

In this study, we only measured one outcome quality indicator (arriving to the hospital alive) as the study focused on prehospital care component of EMS service. We found that the Saudi EMS system had a high performance on arriving to the hospital alive. In addition, we found that most of the patients (347 patients, 96.1%) received advanced life support: cardiac monitoring, intravenous cannulation, needle cricothyrotomy, advanced medications, advanced cardiac life support (ACLS), pre-hospital trauma life support, and other forms of advanced life support. Taken together, the findings demonstrate that most patients arrived alive to the hospital due to the advanced life support that they received. Indeed, we found that 318 patients (96.7%) arrived to the hospital alive and only 11 patients (3.3%) did not arrive to the hospital alive. The other patients were not transported (111 patients) and were transported but had missing data (2 patients).

Alhusain et al. (183) also found that transport by EMS methods is associated with better clinical outcomes for sepsis/septic shock patients compared with transport by non-EMS methods. The study found that among patients transported by EMS method, adherence to intravenous fluid was 91.4% compared with 87% for the non-EMS group ($p = 0.19$), "antibiotics (EMS 50.7% vs non-EMS 52%, $p = 0.81$), blood cultures before antibiotics (EMS 53% vs non-EMS 47.4%, $p = 0.21$), and measuring lactate levels (EMS 73.1% vs non-EMS 57%, $p = <0.01$)." The study also found that the mortality rate was lower among patients transported by EMS methods (48.5%) compared with non-EMS method (54%), but the difference was not statistically significant. The findings of our study is consistent with those of

the Alhusain et al. (183) study in demonstrating the role of prehospital care treatments in improving patient outcomes including patient survival. Therefore, focus should be placed in the provision of advanced life support during prehospital care. To achieve high quality advanced life support, it is necessary to provide continuous medical education to frontline EMS providers. Also, it is necessary to carefully choose the response team based on the patient condition and clearly established guidelines.

The need for guidelines

In this study, we found that the percentage of available EMS guidelines was below 45% in all EMS centers, indicating a low performance based on the Haugland et al. (125) benchmarks. We also found that most centers had basic life support guidelines and most had the advanced cardiac support, but very few had other guidelines including airway, breathing, and circulation guidelines; Saudi heart association guidelines; prehospital trauma life support guidelines; international trauma life support; and airway, breathing, and circulation guideline. The Prehospital Guidelines Consortium, a consortium of 57 American stakeholder organizations (186) lists EMS or prehospital care guidelines for clinical aspects of EMS medicine (guidelines for all EMS conditions such as time/life critical conditions, trauma, medical emergencies, special clinical considerations, and special considerations for evaluation, treatment, transport, and destinations); medical oversight of EMS; quality management and research; and special operations of EMS system. Although the required EMS guidelines for Saudi Arabia have not been listed by SRCA, other government agencies, or previous studies, it is clear that the guidelines identified in this study are not adequate when compared to those listed by the Prehospital Guidelines Consortium (186). Indeed, when we surveyed frontline EMS providers, they proposed the need for additional EMS guidelines for both clinical care and non-clinical care such as guidelines for addressing the needs of patient's relatives during EMS response.

In particular, the surveyed frontline EMS providers proposed developing communication protocols and guidelines as a solution to the challenges they face when communicating with patients and/or their relatives during EMS response. The providers also proposed guidelines for addressing the needs of patients' relatives as a solution to challenges they face when addressing the needs of patients' relatives during EMS response. Taken together, our findings reveal that EMS guidelines should go beyond the actual medical conditions to also include guidelines on the complexities of an EMS response, such as guidelines for communicating with patients and/or their relatives and guidelines for addressing the needs of patients' relative.

Care for/communication with patients' relatives

Quantitatively, we found that 103 frontline EMS providers (98.1%) acknowledged addressing the needs of patient relatives during EMS response, indicating a high performance of the Saudi EMS system based on the Haugland et al. (125) benchmarks. However, our qualitative data revealed that these frontline EMS providers face several challenges when communicating with or caring for patient relatives. Of these challenges, some of the challenges that stood out were lack of cooperation from relatives who the providers said make unnecessary demands, interfere with communication environment, and interfere with patient transfer probably due to poor public knowledge about EMS, which was also reported as a challenge. In addition, lack of guidelines on how to deal with patient relatives also stood out as a problem faced by frontline EMS providers in addressing the needs of patient's relatives. These challenges demonstrate high expectations among patients' relatives on EMS service as well as general lack of public knowledge about EMS. However, it is also possible that it is just a perception of frontline EMS providers that the relative demands are unnecessary due to lack of proper training and guidelines for providers. Indeed, the surveyed frontline EMS providers mentioned lack of

guidelines as a challenge in addressing the needs of patient relatives. Consequently, there is a need to educate both the public about the roles and limits of EMS and frontline EMS providers about their responsibilities to patient relatives during EMS response. Also, EMS guidelines on addressing the needs of patient relatives should be developed. Finally, the Saudi EMS system should work with collaborating agencies such as police, civil defense, and firefighters as well as translators or interpreters to care for and communicate patient relatives during EMS response.

Adequacy of resources

Both the quantitative and qualitative findings of this study revealed lack of adequate material and human resources in the Saudi EMS system. Similarly, a previous study by Moafa et al. (50) in Saudi Arabia also reported inadequate EMS resources with disparities in EMS providers between rural and urban areas—the study found six times more ambulance crews for rural areas compared to urban areas. We also found that SRCA has a total of 185 frontline EMS providers among the 13 sampled EMS centers. Among the frontline EMS providers who completed the survey, we found that most of the EMS providers were paramedics (98, 93.33%); 4 (3.81%) were EMS technicians; and 3 (2.86%) were doctors. These findings suggest inadequate number of EMS doctors, who have been reported to play a significant role in improving quality of prehospital care and the consequent patient outcomes (187). Also, we found that all the surveyed frontline EMS providers were males. Previously, it was reported that female patients were not happy to be treated by male paramedics (91). This finding may explain why we found more male patients to have used the EMS services. Similarly, a previous study in Saudi Arabia by Moafa et al. (72) also reported that more male patients than female patients utilized EMS services and they attributed this finding to lack of female EMS providers.

We also found a myriad of problems faced by frontline EMS providers that may be attributed to lack of adequate resources. For instance, challenges such as language barrier when communicating with patients and/or their relatives can be addressed by inclusion of translators as a collaborating service or within EMS response team. The challenge of intrusion by by-standers and relatives, which presents a challenge to the communication environment and to patient privacy, can be addressed by availability of police as a collaborating service to secure patient scene.

Qualitatively, some of the surveyed frontline EMS providers mentioned time constraints as a challenge in addressing the needs of patient relatives. The providers also mentioned lack of transport for patient relatives as a challenge and proposed that adequate number of frontline EMS providers should be deployed to address the needs of patient relatives. These findings indicate lack of adequate frontline EMS providers. Similarly, surveyed SRCA staff reported shortage of staff, long shift hours, shortage of equipment such as ambulances, challenges in arranging work schedule, and increased number of EMS calls as challenges they face in Riyadh after sending EMS personnel and ambulances to Makkah during Hajj festival. These findings also indicate that there are inadequate material and human resources in the EMS system in Riyadh such that sending them to Makkah during Hajj compromises the operations and efficiency of the EMS system in Riyadh city. The inadequate material and human resources may be due to inadequate funding by the governments, which fully funds the operations of the SRCA. However, there are no information from SRCA or other government agencies regarding SRCA budget. Nevertheless, more funding for purchase of additional material and human resources is highly recommended.

Comparisons of findings across different EMS centers

Both the qualitative and quantitative findings of our study did not find significant differences in quality of service and challenges of services across different EMS centers, possibly indicating equity across the centers. However, other studies in Saudi Arabia have found significant differences across EMS centers (50,180)**.** Moafa et al. (50) found that median general response time was higher in EMS centers in rural areas than in EMS centers in urban area. The study also found six times more ambulance crews were available in EMS centers in rural areas compared to those in urban areas. Similarly, Alanazy et al. (180) reported significant differences in issues affecting the delivery of EMS services at EMS centers in rural areas and those in urban areas. The differences in results across different EMS centers in these two studies (50,180) may be due to the fact that the two studies included EMS centers in different regions of Saudi Arabia (rural and urban areas). However, our study was conducted in one region (Riyadh city) hence lack of significant differences across different EMS centers. Also, we did not originally aim to assess differences across EMS centers; therefore, the study may not have been powered to detect such differences.

Hajj season

Hajj season, a duration whereby there are mass gatherings of people visiting Makkah annually for religious proposes, which can affect access to and quality of EMS services (51). In this study, we quantitatively compared timeliness quality indicators and provided prehospital care treatments during Hajj and non-Hajj seasons. Although we found no statistically significant differences in the measures of timeliness quality indicators during Hajj and non-Hajj seasons, which may be due to small numbers and low study power, in contrast, our qualitative data from the survey of senior SCRA staff revealed that there are challenges faced in Riyadh city and after sending EMS personnel and ambulances to Makkah during Hajj festival.These challenges

include: shortage of staff, long shift hours, shortage of equipment such as ambulances, challenges in arranging work schedule, and increased number of EMS calls. Consequently, it is highly recommended that additional EMS providers should be hired and more ambulances purchased for provision of EMS services in Makkah during Hajj season. The contradicting qualitative and quantitative results of our study demonstrates the need for further qualitative and quantitative studies to investigate the challenges faced in Riyadh during Hajj and non-Hajj seasons.

RECOMMENDATIONS/IMPLICATIONS FOR POLICY AND PRACTICE

Based on the findings of this study, we would like to make the following recommendations to the government, public health specialists/safety teams, senior SRCA staff, and SRCA frontline EMS providers.

Recommendations to the government

We found challenges in ensuring privacy of patient data due to, among other reasons, lack of public knowledge on the importance of patient privacy and lack of cooperation between EMS team and collaborating services. However, our study did not obtain patient perspectives on these issues. Consequently, we recommend that the government should get additional information from all stakeholders including patients before carrying out public health campaigns to educate the general public about EMS systems and forming an inter-agency team comprising of SRCA officials and other relevant government agencies such as police, civil defense, and firefighters to properly coordinate EMS response, as was proposed by the surveyed EMS providers. Indeed, Reid et al. (52) reported that provision of EMS is often inter-disciplinary, involving collaboration of frontline EMS providers with other agencies such as police, civil defense, and firefighters. Civil defense and firefighters also carry out several roles

at patient scene including managing incidents, enforcing fire safety and investigation, carrying out firefighting and rescue operations, and detecting and containing hazardous chemicals and toxins (53). If implemented, these recommendations will also be important in addressing our findings that the Saudi EMS system has average and low performances on some of the QIs and frontline EMS providers also face a myriad of challenges during EMS response. Also, we found that SRCA lacks adequate material and human resources especially during Hajj season when EMS personnel and ambulances are sent to Makkah. Therefore, we recommend that more funding for purchase of additional material and human resources, especially during Hajj season when partnerships with the private sector can also be used to provide additional material and human resources for the provision of EMS services in Makkah. However, as our study findings may be tentative, the government should carefully consider these findings and collect additional information where necessary before implementing our recommendation on budgetary allocation.

Recommendations to public health specialists/safety teams

We found challenges in ensuring privacy of patient data due to, among other reasons, lack of cooperation between EMS team and collaborating agencies such as police, civil defense, and firefighters. Based on these findings, we recommend that public health specialists/safety teams should work together with EMS providers in providing EMS services. We also found that some of the challenges faced by frontline EMS providers are due to lack of guidelines necessitating the need to develop safety guidelines for patients' scenes. We also found that PCRs lack records of adverse events. Therefore, we recommend that a proper mechanism for reporting and recording adverse events experienced during prehospital care should be developed with adequate training of frontline EMS providers. However, more information about these

challenges from patient perspective should be obtained before implementing any of these recommendations.

Recommendations to the senior SRCA staff

We found that there were missing data in the PCRs. Particularly, we were not able to measure the QI under patient safety domain as records of adverse events were missing in the PCRs. Therefore, we highly recommend that senior SRCA staff should organize frequent continuous in-service training for frontline EMS providers on accurate recording and storing of EMS data. We also recommend that SRCA staff should involve professionals in designing better methods of data collection. We also found challenges in ensuring privacy of patient data due to, among other reasons, unqualified or unprofessional EMS providers, lack of cooperation between EMS team and collaborating services, and poor methods of data collection. We therefore recommend that senior SRCA staff should only hire professional frontline EMS providers and carry out frequent performance appraisals/debriefings to determine their professionalism and suitability to continue providing the EMS response. Also, senior SRCA staff should work together with collaborating agencies such as police, civil defense, and firefighters to properly coordinate an EMS response.

Based on our findings that provisions of advanced prehospital care treatments are associated with better patient outcomes, we recommend that continuous medical education should be provided to frontline EMS providers on provisions of these prehospital care treatments. It is necessary to carefully choose the members of an EMS response team based on the patient condition and clearly established guidelines. Also, the available EMS guidelines should go beyond the actual medical conditions to also include guidelines on the complexities of an EMS response, such as guidelines for communicating with patients and/or their relatives and guidelines for addressing the needs of patients' relative as those listed by the Prehospital

Guidelines Consortium (186). However, our study findings may be tentative, and therefore additional information need to be collected by senior SRCA staff before implementing any of these recommendations.

Recommendations to SRCA frontline EMS providers

We found challenges in ensuring privacy of patient data due to, among other reasons, unqualified or unprofessional EMS providers. Therefore, we recommend that frontline EMS providers should frequently participate in continuous in-service medical education and performance appraisals/debriefings to improve their expertise, knowledge, and ethical conduct in the delivery of EMS services. In addressing challenges faced at patient scenes such as noise and intrusion, we recommend that frontline EMS providers should work with collaborating services and strictly adhere to EMS guidelines. To address the challenges faced when addressing the needs of patient relatives such as unnecessary demands and interferences, we recommend that frontline EMS providers should understand their role in providing service to patient's relatives and work with collaborating service such as police if available to ensure that their needs are adequately addressed. However, frontline EMS providers should consider these recommendations in the context of other similar reports published in literature as well as their own internal quality practices.

CONCLUSION

In this chapter, we reviewed and discussed our study results in the context of other recent work in Saudi Arabia, and recommendations for service provision. In the next chapter, an overview of strengths and limitations of the thesis, and what worked and what did not work is provided, with recommendations for future evaluations and further research.

Chapter 7: Recommendations for future evaluation and research

INTRODUCTION

In the previous chapter, we provided a critical discussion of the study results and recommendations for policy and practice. In this chapter, an overview of strengths and limitations of the thesis, and what worked and what did not work is provided, with recommendations for future evaluations and further research.

STUDY STRENGTHS AND LIMITATIONS

In this study, we developed a structure, process, and outcome-based tool and use it to assess the quality of the Saudi EMS system under six domains: timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity. The structure of an EMS system is made up of EMS facilities, EMS equipment, staffing, provider knowledgebase, ambulance deployment, ambulance response times, and credentials of EMS providers. The process of an EMS system is made up of protocols and guidelines, prehospital care treatments, and transportation of patients to appropriate health facilities. The outcome of an EMS system is made up of patient mortality rates, patient morbidity rates, and patient disabilities (57,58,126,131). In this study, we conducted a scoping review of tools and indicators that have been used to evaluate EMS systems, mapped out the structure of the Saudi EMS system to identify aspects of the Saudi EMS system for EMS evaluation and developed a structure, process, and outcome-based tool for evaluating the country's EMS system. We used the the tool to collect data to measure the following QIs:

- Structure: number of EMS units per population and number of EMS units per area using data, initial time to respond, time to arrival of EMS response team, on scene time; time to preferred destination, adverse events using data, complete documentation

- Process: performance monitoring, audit, appraisal, and/or debriefing using survey data; guidelines for actual medical problems; provision of advanced treatments; involvement of EMS physicians in dispatching EMS response team; patients enrolled in research projects using survey data; time-sensitive illnesses; and care for patient relatives using survey data from frontline EMS providers
- Outcome: patients arriving to the hospital alive

Strengths

As described above, we successfully assessed the structure, process, and outcome of the Saudi EMS system using the Haugland et al. (58) EMS questionnaire. To the best of our knowledge, this is the first study to comprehensively evaluate the Saudi EMS system based on all the six quality domains: timeliness, safety, efficiency, effectiveness, patient-centeredness, and equity. We modified the Haugland et al. (58) EMS questionnaire to develop a three-part tool for evaluating the Saudi EMS system: data extraction tool, questionnaire for a survey of senior SRCA staff, and questionnaire for a survey of frontline EMS providers. Before modifying the EMS questionnaire, we first carried out a robust literature review to ensure to identify all measures that have been used in EMS evaluation. This ensured that the developed tool all the appropriate measures required to comprehensively assess EMS systems. To the best of our understanding, this is the first study to develop a tool for the comprehensive evaluation of the Saudi EMS systems. The tool is based on EMS questionnaire that was developed by a multidisciplinary team consisting of general practitioners, EMS medical directors, health institute directors, community medicine specialist, patient-organization leaders, and physicians. Also, the tool had several strengths including the demonstration of its feasibility, rankability, variability, actionability and documentation of the QI measurements in a study (125); availability of benchmarks to interpret its measurements, and contains all the non-

clinical QIs that were identified through a literature review (Chapter 2). We piloted the tool where its feasibility, rankability, variability, actionability and documentation were further confirmed. However, we did not assess the validity of the tool as there was no standard EMS evaluation tool to be used for comparison with our tool. The three-part tool developed for the assessment of the Saudi EMS system is evidence-based and can comprehensively assess the quality of the Saudi EMS system. This tool may help in future evaluations of the Saudi EMS system or similar EMS systems in the Arabic Gulf States. Our quantitative results can be generalized to other areas of the Saudi regions as EMS is provided by Saudi Red Crescent Authority.

In addition to these strengths, the qualitative survey of the frontline EMS providers had a large sample size whereby the survey questionnaire was sent to all the providers in the 13 EMS centres that were randomly selected. Also, the random selection of the EMS centres in Riyadh city makes the findings of this study transferable to all the EMS centres in Riyadh city. In addition, this study considered the effects of Hajj festival, which is unique to Saudi Arabia, on the timeliness of EMS response and prehospital care treatments provided to patients in Saudi Arabia. While most studies investigated the effect of Hajj festival on health outcomes in Makkah where the festival takes place, this study looked at the effects of the Hajj festival in Riyadh where although the festival does not take place there, it puts strains on its EMS infrastructure. Also, the qualitative part of the study had the strength of a rigorous process of theme development and content analysis - the researcher and a member of the supervisory team with expertise in qualitative research developed the themes and carried out content analysis and any disagreements were discussed and settled in a general supervisory meeting with all members of the supervisory team.

Limitations

This study had certain limitations. First, only one quality indicator (arrival to hospital alive) was used to assess the outcome of the Saudi EMS system. Other outcome QIs such as length of hospital stay and patient outcomes (mortalities and discharge) could not be measured in this study because the study only focused on prehospital care without looking at patient outcome data in hospitals. Only one outcome quality indicator was assessed because this study only focused on prehospital care component of EMS yet hospital data are required to measure other outcome quality indicators. Secondly, although this study measured many structure quality indicators, it did not measure ambulance features and equipment required for efficient EMS response such as native ambulance features including siren, power supply, GPs system etc.); materials for patient transfer; materials for patient monitoring; search and rescue devices; oxygen and airway devices; safety and hygiene materials, and materials for patient treatment. Future studies should be conducted to physically assess ambulances for these materials and equipment.

Also, this study only focused on one region of Saudi Arabia with a relatively small sample size. For the quantitative component of this study, a total of 442 prehospital care reports were sampled from randomly selected 12 EMS centers in Riyadh city and one EMS center outside Riyadh city for pilot study. This sample represented 36 PCRs randomly sampled from each EMS center: a convenient number of 3 PCRs from each month of 2018 (from January to December, 2018). A convenient sample is known to have a high internal validity, but limited external validity—results may not be easily generalized to populations with characteristics that differ from the population that was conveniently accessed and results from a convenient sample can only be generalized to its population only if the sample was randomly drawn from that population (188). Also, convenient samples may not be representative of the study population (188). In our study, PCRs were indeed randomly sampled from each EMS centre. However,

the convenient sample size of three PCRs for each month, which was used to be able to complete the study within the PhD program timelines, may have not been appropriately representative of all the PCRs. Also, due to the small sample size, the results may have given imprecise estimates of parameters, as shown by wide confidence intervals. In addition, the small sample size led to low power for determining statistical significance between variables. As the original study protocol did not intend to test relationships between patient characteristics and QIs or between QIs and other QIs, the sample size was not intended to test for these effects. Consequently, some of the tests may have been insignificant because of low power. In the qualitative study, convenient sampling was not used. Instead, we sent survey questionnaires to all frontline EMS providers and senior SRCA staff in the randomly sampled 12 EMS centers and the pilot EMS center.

In addition, we were not able to measure the QI under patient safety domain as records of adverse events were missing in the PCRs; we expected to find records of any patient adverse events in the PCRs. Also, some of the quality indicators (particularly performance monitoring, audit, appraisal, and/or debriefing; availability of EMS guidelines; patients enrolled in research projects; and care for patient relatives) could not be measured using pre-existing EMS data. These quality indicators were measured using electronic survey data from senior SRCA staff and frontline EMS providers. Therefore, these measurements may be subjective as some of the senior SRCA staff and frontline EMS providers may have not been sincere when completing the survey questionnaires. In addition, only the number the patients transported to hospitals was used to assess whether patients arrived to the hospital alive yet some of the patients were not transported because: 1) they were treated and released at the scene; 2) they refused transportation; 3) they were treated on site but refused transportation; 4) they were transported by a third party; and 5) they were deceased at the site. Furthermore, there may have been measurement errors (the difference between a measured quantity and its true value) in the

quantitative data. For instance, in our study, we found that most of the initial response time was 0, suggesting that the time intervals may have not been accurately recorded in the PCRs. These limitations may have affected the precision of the study results. Finally, our results regarding the association between quality indicators and other quality indicators or patient characteristics may have been influenced by other confounding factors. For example, we found that time taken to dispatch EMS team and time taken to arrive at patient scene were both significantly longer during middle parts of the day but shorter at night, but this relationship may be due to other confounding factors such as availability of ambulances and EMS personnel.

There were additional limitations in the qualitative components of the study. First, both the frontline EMS provider survey and senior SRCA staff survey were conducted using electronic surveys and therefore some of the responses were not detailed. For example, some of the respondents did not give full responses and there was no option to ask them to provide more details. This compromised the depth of the information gathered. Secondly, the survey questionnaire had limited questions as the qualitative data was only required to provide a further understanding to quantitative data, that were also collected in this study. For example, the survey questionnaire for senior staff did not include questions on what the senior SRCA staff thought would be solutions to the problems faced in Riyadh after sending EMS ambulances and staff to Makkah during Hajj.

Thirdly, for frontline EMS provider survey we had a response rate of 56.8% after electronically sending the survey questionnaire to all the frontline EMS providers in the sampled 13 EMS centres. This means that 43.2% of the frontline EMS providers did not complete the survey possibly introducing non-response bias to the survey data– the people who take part in a study tend to be different to those who don’t take part – it is possible people who did not respond would have given different answers.

Lastly, we did not look at inequalities in accessing EMS in Riyadh, Saudi Arabia. Previous studies in Saudi Arabia have reported inequalities in access to healthcare between rural and urban areas (50), between citizens and non-citizens (or migrant/expatriate workforce) populations (189), and between men and women (190). Although we could not consider health inequalities between rural and urban areas as the current study was conducted in an urban area only (in Riyadh city), it may have been possible to consider inequalities in EMS access between citizens and non-citizens as well as between men and women. Future evaluation of the Saudi EMS system should consider these inequalities when assessing quality of the country's EMS system.

Reflexive statement

The researcher's background, own judgments, practices, and belief systems may have affected the process of data collection and analysis. The researcher was born, lived, and studied in Riyadh city, Saudi Arabia where he attained a diploma in EMS. With the diploma, the researcher worked for a specialist hospital in Riyadh city and SRCA as an EMS technician where he performed several duties including responding to emergencies and keeping EMS records. Following in-service training, the researcher became a paramedic with several duties including provision of advanced pre-hospital care during EMS response. In 2009, the researcher moved to the United States for further studies — he attained a Bachelors of Science degree in Paramedical Sciences in 2013 and a Masters of Science degree in Disaster Medicine and Management in 2016. After attaining these degrees, the researcher returned to Riyadh, Saudi Arabia and worked as a lecturer in the department of EMS at an EMS college where he trained frontline EMS providers. Later on in 2018, the researcher moved to the United Kingdom for a PhD program focusing on EMS in University of Nottingham Division of Epidemiology and Public Health. Based on this background, the researcher has some

similarities with some of the respondents. For example, the researcher previously worked as a frontline EMS provider in Riyadh city, as a colleague to some of the surveyed frontline EMS providers. Also, the researcher trained some of the frontline EMS providers — some of these EMS providers may have participated in the survey. Although the researcher did not work in the rank of a senior SRCA staff (director or assistant director of EMS centres), he earlier worked under these senior staff as an EMS technician and paramedic and some of them may have recognized him. Consequently, the relationship of the researcher with the frontline EMS providers and senior SRCA staff may have affected the number of respondents who completed the surveys and may have also altered responses of the respondents in the survey questionnaire. The researcher's understanding of the Saudi EMS system also helped in successfully completing, organising, navigating, and collecting data in this setting and within the limited PhD timelines.

In terms of own judgments, practices, and belief systems, the researcher believes that the qualitative aspect of the study should be conducted through face-to-face interviews or focus group discussions to obtain detailed information and to address any emerging questions for further clarifications. However, in this study, face-to-face interviews or focus group discussions were not possible due to the large geographical area of Riyadh city and limited PhD timelines; therefore, some of the qualitative data collected were not detailed and emerging issues could not be clarified and/or explored. The researcher also believes that open-ended questions in a qualitative research gives respondents an opportunity to give detailed responses with extensive discussion of the issues emerging from the question. Although most of the questions were indeed open-ended, most responses were not detailed. Consequently, the collected qualitative data were analysed using content analysis method as opposed to detailed thematic analysis as was originally planned in the study protocol. Having lived and studied in the United States and the United Kingdom where women also provide EMS services, the

researcher believes that the Saudi EMS system should also have female EMS providers. Therefore, we sent the survey questionnaires to all frontline EMS providers and all senior SRCA staff in the sampled EMS centres to ensure that female providers and staff also completed the survey. Also, as a Muslim, the researcher believes in the honesty of every respondent. Therefore, for senior SCRA staff survey, the researcher independently surveyed directors and assistant directors of the same EMS centre and reported the responses of each.

In addition to how the researcher's background, own judgments, practices, and belief systems affected the process of qualitative data collection and analysis, the researcher was also anxious and confused about certain emerging issues. A major confusion arose on how different responses from director and assistant director of the same EMS centre should be reported. However, based on the researcher's beliefs in honesty as discussed earlier and discussions with members of the supervisory team, we decided to report both responses from each EMS centre. The researcher was also anxious and confused on how to handle brief qualitative data as opposed to detailed data that were expected considering use of open-ended questions in the survey questionnaires. However, this confusion was addressed by resorting to using content analysis after a discussion with all members of the supervisory team. Particularly, one of the members of the supervisory team who is an expert in qualitative research and who had no prior knowledge or experience of the Saudi EMS system also coded the data and any emerging disagreements in coding were addressed with the other members of the supervisory team. Therefore, the researcher made meaning of the qualitative data by use of content analysis method and by triangulating qualitative data with quantitative data as this was a mixed-method study. In addition, the researcher made key procedural decisions including training research assistants to help him collect data within the limited timelines, training additional data entry clerks to help him organize raw qualitative data, and comparing own translations of Arabic

responses to English responses with translations provided by hired certified translators in Riyadh to ensure accuracy.

RECOMMENDATIONS FOR FURTHER STUDIES

Although this study attempted to comprehensively assess the quality of the Saudi EMS system, there are some aspects of EMS quality that were not assessed: outcome quality indicators (only one outcome quality indicator was assessed i.e, arrival to hospital alive) and ambulance features and equipment that are required for efficient EMS response. Consequently, we recommend that a further study should be conducted to investigate other clinical patient outcomes such as in-hospital mortality, complications, length of hospital stay, laboratory findings among others, and to measure ambulance features and equipment that are required for efficient EMS response.

Secondly, our study population was EMS providers (frontline EMS providers and senior SRCA staff), but other populations such as patients who receive EMS service, the general public, and agencies such as police and firefighters who provide collaborating services during EMS response can also be studied. Particularly, we found poor public knowledge about EMS; therefore, assessing public knowledge about EMS and their perceptions of the quality of EMS their receive should be explored in a future study. We also found that poor coordination between EMS providers and collaborating services compromises the quality of EMS deliver. Therefore, we recommend that studies should be conducted among agencies such as police and firefighters who provide collaborating services during EMS response to determine the role in EMS delivery and how this affects quality of EMS.

Thirdly, this study only focused on Riyadh city; therefore, a nation-wide study that assess the quality of the Saudi EMS systems in all the regions is highly recommended. Also, the quantitative component of our study used physical PCRs as some of the required data were not electronically available. However, other studies such as the Moafa et al. (50) EMS

disparities study used electronic data, but this study only focused on disparities in the timeliness and number of ambulances of the Saudi EMS system in Riyadh province and other rural provinces. As EMS data recorded by SRCA become increasingly computerized, it is likely to impact on the availability of data for studying EMS services on large numbers of patients. Therefore, future studies using electronic data recorded by SRCA can be used in future studies for looking at quality of service on much larger numbers of patients in different Saudi regions and country wide.

Fourth, our study only focused on provision of EMS services, yet SRCA has additional duties and responsibilities including preparedness and response for crisis and provision relief services in Saudi Arabia according to the accredited national plan. Therefore, future studies should investigate the quality of other services provided by SRCA. Fifth, there is only one QI available for assessments of EMS systems under patient-centeredness quality domain: care for patient relatives. Further research should be conducted to identify other QIs under this quality domain. Finally, we recommend that that the tool we developed in this study can be further improved through consensus building with EMS stakeholders and used to assess EMS quality in Saudi Arabia and other Arabia Gulf states.

The qualitative component of this study was conducted using electronic questionnaires; consequently, some of the responses from senior SRCA staff and frontline EMS providers were not detailed. Therefore, we recommend that face-to-face interviews be conducted with frontline EMS providers and senior SRCA staff to get more detailed responses regarding the challenges faced in providing EMS services. Also, this study provided qualitative data regarding the challenges facing provision of EMS services in Riyadh city. Key among these challenges were issues involving patients (such as patient condition or location that compromise communication and/or privacy); patients' relatives and by-standers (such as intrusion, lack of knowledge about EMS, and lack of cooperation); EMS providers (such as language barrier,

unethical conduct, and inadequate number of EMS providers), and Hajj festival (such as shortage of staff, long shift hours, shortage of equipment in Riyadh city). Therefore, further qualitative studies are recommended to determine whether these challenges are also experienced in the prevision of EMS in other Saudi regions. Similarly, further quantitative studies are recommended to investigate the impact of these issues on the overall quality of EMS in Riyadh city.

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Appendices

Appendix 1. Quality indicators reported by previous reviews

A. Clinical domain quality indicators reported by Howard et al. (128)

Quality indicator	Definition	Available benchmark
1. Time-sensitive illnesses	Number of patients with time-sensitive illnesses such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction who received prehospital emergency care	Not provided
2. Provision of advanced treatments during prehospital care	Number of patients who received airway management interventions during prehospital care	Not reported
	Number of patients who received general interventions and medications during prehospital care	Not reported

B. Non-clinical domain quality indicators reported by Howard et al. (128)

Quality indicator	Definition	Available benchmark
1. Time intervals	Mean EMS response time (different from the time an alarm call is received to the time the ambulance arrives at the patient scene)	Proposed benchmarks by Haugland et al. (125)
2. Service user satisfaction	Proportion of positive patient feedbacks	Not reported
3. Deployment of resources	Proportion of available materials and resources versus required ones	Not reported
4. EMS research	Proportion of EMS patients recruited into EMS studies	Proposed benchmarks by Haugland et al. (125)
5. Interaction with receiving facilities	Proportion of EMS patients arriving alive to health facilities	Proposed benchmarks by Haugland et al. (125)
6. Performance monitoring, audit, appraisal, or debriefing	Proportion of EMS responses that are monitored, debriefed, appraised, and/or audited	Proposed benchmarks by Haugland et al. (125)
7. Financial resources and management	Proportion of expenses against total budget	Not reported

8. Employee and other human resources	Number of MS physicians, doctors, paramedics, nurses, EMS technicians, and other EMS providers	Not reported
9. Documentation and record keeping	Proportion of complete EMS records	Proposed benchmarks by Haugland et al. (125)
10. Communication and EMS dispatch	Availability of guidelines for communication among the response team, communication with patients and their relatives, and availability of criteria for dispatching response team	Not reported
11. Adverse events	Proportion of adverse events during prehospital care	Proposed benchmarks by Haugland et al. (125)

C. Clinical quality indicators reported by Pap et al. (129)

Quality indicator	Definition	Available benchmark
1. Provision of advanced treatments during prehospital care	Number of patients who received airway management and oxygenation Number of patients who received pain management during prehospital care	Not reported
2. Time-sensitive illnesses	Number of patients with time-sensitive illnesses such as asthma, acute coronary syndrome, out-of-hospital cardiac arrest, seizures, stroke, trauma, and glycemia who received prehospital emergency care	Not reported

D. System or organizational quality indicators reported by Pap et al. (129)

Quality indicator	Definition	Available benchmark
1. Communication and dispatch	Availability of communication guidelines among the response team, communication with patients and their relatives, and availability of criteria for dispatching response team	Not reported

2. Documentation and record keeping	Proportion of complete medical records	Proposed benchmarks by Haugland et al. (125)
3. Staff training and education	Number of EMS staff with particular qualifications; number of in-service trainings completed	Not reported
4. Financial resources and management	Proportion of expenses against total budget	Not reported
5. Hospital notification	Number of EMS cases notified to the hospitals and receiving health facilities	Not reported
6. Safety and health of frontline EMS providers	Availability of safety guidelines and materials for frontline EMS providers	Not reported
7. Patient safety	Availability of safety guidelines and materials for patients	Not reported
8. Patient satisfaction levels	Proportion of positive patient feedbacks	Noted reported
9. Personnel performance evaluation and audit	Proportion of EMS responses that are monitored, debriefed, appraised, and/or audited	Proposed benchmarks by Haugland et al. (125)
10. EMS research	Proportion of EMS patients recruited into EMS studies	Proposed benchmarks by Haugland et al. (125)
11. Resources and deployment	Proportion of available materials and resources versus required ones	Not reported
12. Time intervals	Mean time intervals: call received to deploy response team, call received to arrival at patient scene, arrival at patient scene to initiate transportation, call received to deliver of patient to preferred destination	Proposed benchmarks by Haugland et al. (125)

E. Clinical quality indicators reported by Poulsen et al. (130)

Quality indicator	Definition	Available benchmark
1. Time-sensitive illnesses	Number of patients with time-sensitive illnesses such as trauma, cardiac arrest, and chest pain who received prehospital care	

F. Non-clinical quality indicators reported by Poulsen et al. (130)

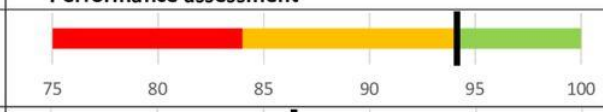
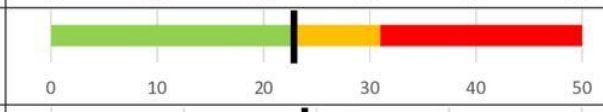
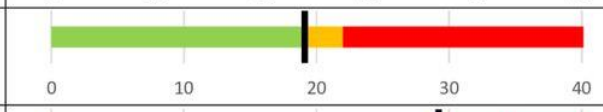
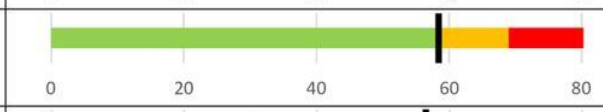
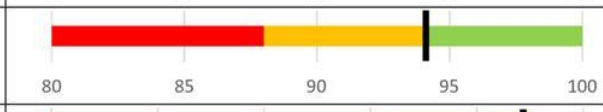
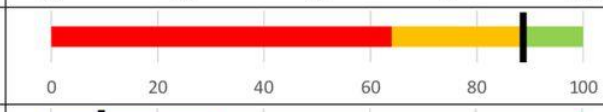
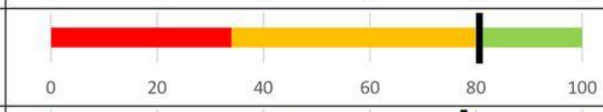
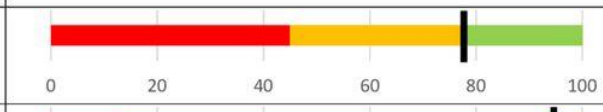
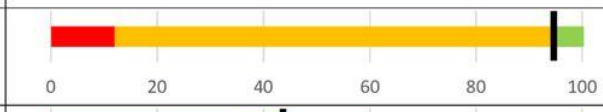
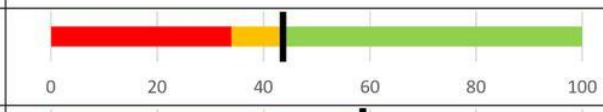
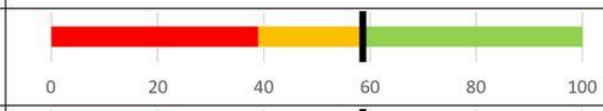
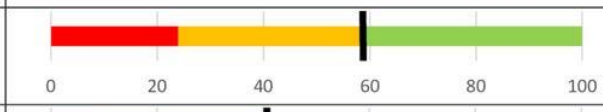
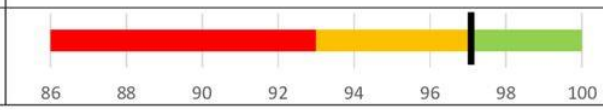
Quality indicator	Definition	Available benchmark
1. Time intervals	Mean time intervals: call received to deploy response team, call received to arrival at patient scene, arrival at patient scene to initiate transportation, call received to deliver of patient to preferred destination	Proposed benchmarks by Haugland et al. (125)
2. Resources	Proportion of available materials and resources versus required ones	Not reported
3. Adverse events	Proportion of adverse events during prehospital care	Proposed benchmarks by Haugland et al. (125)

G. Quality indicators reported by Moafa et al. (72)

Category	Quality indicator	Definition	Available benchmark
Safety	Transportation of patients to appropriate medical facilities	Proportion of patients transported to appropriate medical facilities	Not reported
	Availability of safety materials and guidelines	Availability of safety guidelines and materials for frontline EMS providers, patients, and by-standers	Not reported
Timeliness	Time intervals	Mean time intervals: call received to deploy response team, call received to arrival at patient scene, arrival at patient scene to initiate transportation, call received to deliver of patient to preferred destination	Proposed benchmarks by Haugland et al. (125)
	Patients with life-threatening conditions	Number of patients with life-threatening conditions transported to medical facilities via EMS	Not reported
Effectiveness	Provision of advanced prehospital care and treatment	Number of prehospital care procedures and treatments provided	Proposed benchmarks by Haugland et al. (125)
	Mortality	Proportion of patients arriving to the hospital alive	Proposed benchmarks by Haugland et al. (125)

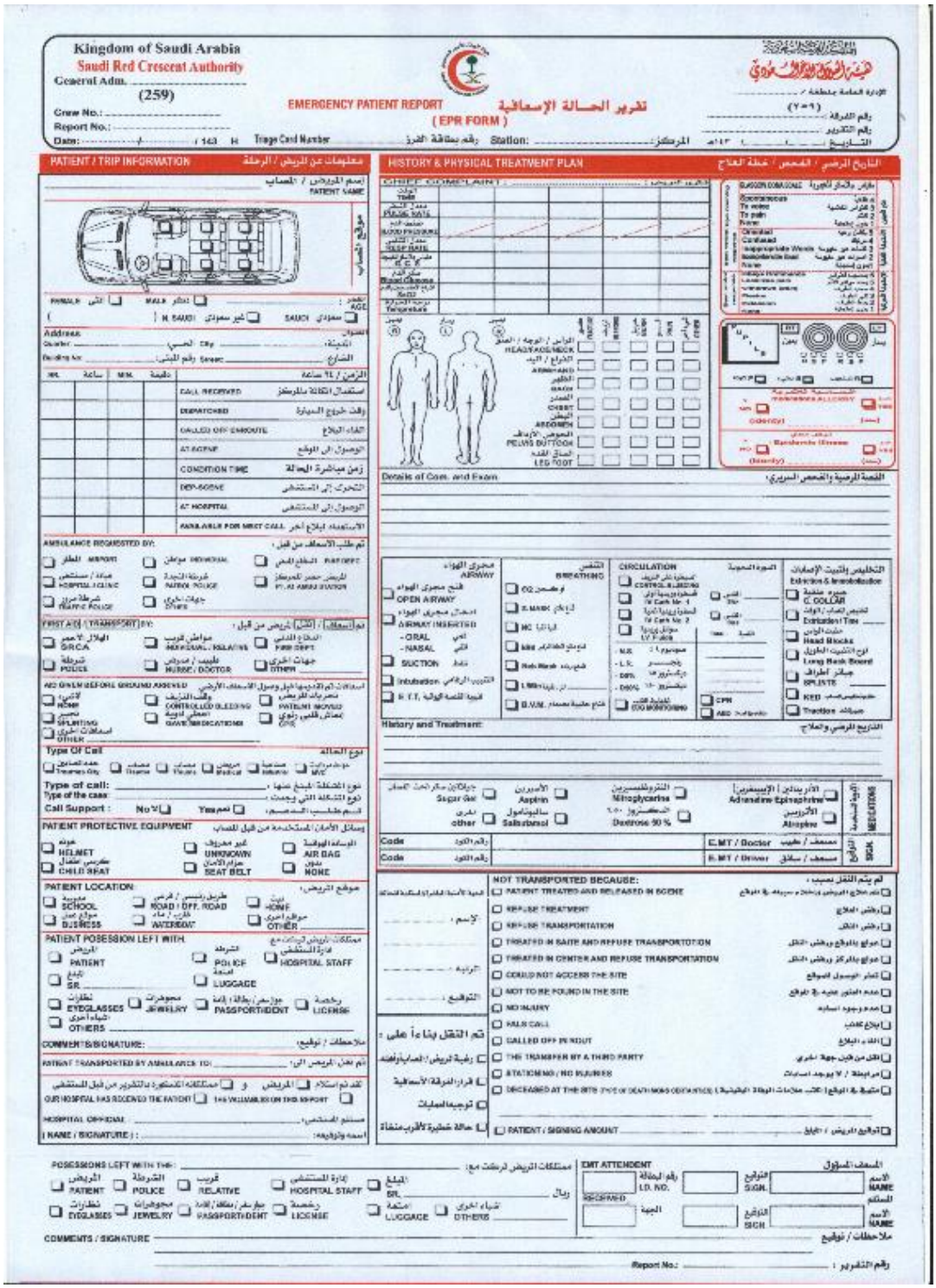
	Disease-related outcomes	Proportion of positive patient outcomes such as discharge and recoveries	Not reported
	Qualifications of EMS technicians	Number of EMS technicians with particular qualifications	Not reported
	Knowledge about EMS contact numbers	Proportion of patients/members of the general public who know about EMS phone numbers	Not reported
Patient-centeredness	Patient impression and satisfaction	Proportion of positive patient feedback	Not reported
	Availability of both male and female EMS providers	Proportions of male and female EMS providers	Not reported
Equity	Socioeconomic status	Proportion of patients who can afford and access prehospital care	Not reported

Appendix 2. Proposed benchmarking of EMS quality indicators, by Haugland et al. (125)

Quality indicator	Unit of QI	Performance assessment
Able to respond immediately when alarmed	%	
Time to arrival of P-EMS	minutes	
On scene time	minutes	
Time to preferred destination	minutes	
Patients arriving hospital alive	%	
Debriefed responses	%	
Adverse events	%	
Complete documentation	%	
Guidelines for actual medical problem	%	
P-EMS involvement in dispatch	%	
P-EMS necessary to provide appropriate care	%	
Provision of advanced treatment	%	
Significant logistical contribution	%	
Patients enrolled in research projects	%	
Care for relatives	%	
		

Green zone, high performance; yellow zone, average performance; red zone, low performance. The benchmark is set at the transition between green and yellow zones (at the lower end of the fourth quartile where higher values reflect better performance) and marked with a black and fat vertical line.

Appendix 3. Sample SRCA prehospital care report



Appendix 4. Pre-existing Saudi Red Crescent Authority data extraction tool

Section 1: Data from annual report The following data will be extracted from the Saudi Red Crescent Authority annual report			
Data	Methods	Findings	
1. Number of EMS centres per Saudi Region	Directly extract from the annual report	Riyadh: _____ Medinah: _____ Eastern: _____ Tabouk: _____ Northern: _____ Najran: _____ Al-Jouf: _____	Makkah: _____ Qaseem: _____ Aseer: _____ Ha'il: _____ Jazan: _____ All-Bahah: _____
2. Number of EMS cases attended by land ambulance in 2018	Directly extract from the annual report	Riyadh: _____ Medinah: _____ Eastern: _____ Tabouk: _____ Northern: _____ Najran: _____ Al-Jouf: _____	Makkah: _____ Qaseem: _____ Aseer: _____ Ha'il: _____ Jazan: _____ All-Bahah: _____
3. Number of EMS cases attended by air ambulance in 2018	Directly extract from the annual report	Riyadh: _____ Medinah: _____ Eastern: _____ Tabouk: _____ Northern: _____ Najran: _____ Al-Jouf: _____	Makkah: _____ Qaseem: _____ Aseer: _____ Ha'il: _____ Jazan: _____ All-Bahah: _____
4. Number of EMS centres per 100,000 population in each Saudi region	$\frac{No.\ of\ EMS\ centers\ in\ the\ region}{Population\ of\ the\ region} \times 100{,}000$	Riyadh: _____ Medinah: _____	Makkah: _____ Qaseem: _____

		Eastern: _____	Aseer: _____
	EMS centres in each region obtained from SRCA annual report. Population of each region obtained from SGAS	Tabouk: _____	Ha'il: _____
		Northern: _____	Jazan: _____
		Najran: _____	All-Bahah: _____
		Al-Jouf: _____	
5. Number of EMS centres per km^2 of each Saudi region	$\frac{No.\ of\ EMS\ centers\ in\ the\ region}{Area\ of\ the\ region}$ EMS centres in each region obtained from SRCA annual report. Area of each region obtained from SGAS	Riyadh: _____	Makkah: _____
		Medinah: _____	Qaseem: _____
		Eastern: _____	Aseer: _____
		Tabouk: _____	Ha'il: _____
		Northern: _____	Jazan: _____
		Najran: _____	All-Bahah: _____
		Al-Jouf: _____	
6. Percentage of patients with time-sensitive illnesses (such as seizures, stroke, trauma, hypoglycemia, non-trauma chest pains, and asthma/airway obstruction)	$\frac{Number\ with\ time\ sensitive\ illnesses}{Total\ number\ of\ EMS\ patients} \times 100,000$	_____	
7. List of medical problems attended in 2018	Obtain medal problems	1. _____	
		2. _____	
		3. _____	

Section 2: Data from prehospital care reports

432 prehospital care reports (PCR) sampled from 12 EMS centres in Riyadh city, Saudi Arabia

Patient ID: _____ **EMS centre**: _____

Data	Methods	Findings
8. Initial time to respond (percentage of immediate response based on the	$Time\ of\ dispatch - Time\ call\ received$	Time call received (minutes): _____

difference between time call received and time response team is deployed)		Time of dispatch (minutes): _____ EMS team deployed after (minutes): _____
9. Time to arrival of EMS response team (mean time interval between time EMS response team is deployed to time of arrival at patient scene in minutes)	$Time\ at\ scene - Time\ EMS\ team\ deployed$	Time EMS team deployed (minutes): _____ Time at scene (minutes): _____ EMS team arrived after (minutes): _____
10. On scene time (mean time interval between time call received to time of arrival at patient scene in minutes)	$Time\ at\ scene - Time\ call\ received$	Time call received (minutes): _____ Time of at scene (minutes): _____ On scene time (minutes): _____
11. Time to preferred destination (mean time interval between time call received to time patient is delivered to preferred destination in minutes)	$Time\ at\ hospital - Time\ call\ received$	Time call received (minutes): _____ Time at hospital (minutes): _____ Patient delivered after (minutes): _____
12. Adverse events	From the PCR records on examination of the airways, breathing, and circulations, records on the details of "Com. and "Exam." and "History and Treatment" and health status at the scene	Adverse events: _____ _____ _____
13. Complete documentation (percentage of complete EMS records): Variables	Examine each PCR to identify missing records under required variables.	Is the PCR complete? (Yes/No): _____

not measured and documented in the prehospital care reports		
14. Provision of advanced treatments: Treatments provided by the EMS team to patients during the EMS response	Examine the PCR under history and treatment to identify the provided treatments	Were advanced treatments provided? (Yes/No): _____ Provided treatments: 1. _____ 2. _____ 3. _____
15. Arrival of the patient to the hospital	Examine the PCR records under "Details of Com. and Exam" and hospital receiving the patient	Tick appropriate box □ Alive □ Not alive □ Unknown/missing

Appendix 5. Questionnaire for senior SRCA staff survey

Date: _____ Investigator Name: _____

Designation: _____EMS centre: _____

1. During the Hajj season, do you send your Riyadh EMS providers and ambulances to Makkah? If yes, do you do this each year?

   - ☐ Yes; Please explain if you always send the providers every year _____
   - ☐ No

2. If your answer to question 1 above is Yes:

   a. What challenges do you face while providing EMS services in Riyadh during this time that you send your EMS providers and ambulances to Makkah?

   _____

   _____

   _____

   _____

   _____

   _____

   b. Do you legally partner with other government agencies to provide EMS services in Riyadh during such seasons?

      - ☐ Yes
      - ☐ No

   c. If your answer to question 2b above is Yes, what are some of the agencies you have partnered with in 2018 and what were their duties and responsibilities as outlined in the partnership agreement if any.

Agency	Duties and responsibilities
i)	
ii)	
iii)	
iv)	
v)	

3. What are some of the EMS guidelines that you use while responding to emergencies in Riyadh? Among these, which ones are for managing CVD cases? *Please allow the interviewer to physically observe each guideline and indicate whether they are evidence-based and consistent with similar guidelines internationally*.

Guideline	Assessment	
	Does it have a reference to a systematic literature review? (Evidence-based?) (Yes or no)	Consistency with similar guidelines (yes or no, name of compared guidelines)
General guidelines		
CVD guidelines		

4. Is the dispatch centre staffed 24/7 by a specially trained pre-hospital physician?

    □ Yes

    □ No

5. Have you recruited any of your patients to a research study in 2018? If yes, what was the objective of the study and the number of patients enrolled?

    □ Yes; Objective: _____

    _____

    _____; Number of patients enrolled:

    _____

    □ No

Appendix 6. Questionnaire for frontline EMS provider surveys

Designation: _____

EMS centre: _____

Date_____

Number of years with SRCA _____

Gender _____

Education _____

1. Were you deployed to respond to medical emergencies in 2018?

    Yes

    No

Please continue and complete this questionnaire only if your answer to question 1 above is yes (*Since this will be an electronic questionnaire, we will restrict access to the other questions based on the response to question 1 above*)

2. In the deployment, was a physician from EMS involved dispatching your response team be dispatched?

    All the time

    Most of the time

    Sometimes

    Never

    Don't know

3. When providing EMS response to medical emergencies, which of the following activities did you carry out.

    Communicate with the patient and their relatives

    Ensure own safety and that of the patient, bystanders, and fellow EMS providers

- Ensure the safety of the environment and minimise potential damage by, for example, using fire extinguishers, containing chemical spillage, and removing objects
- Stabilise the patient by providing basic and/or advanced life support including cardiopulmonary resuscitation and mechanical ventilation
- Safely move the patient to the ambulance and transport him/her to an appropriate health facility
- Provide basic and/or advanced life support and treatment when transporting the patient
- Address the needs of the patient relatives directly or through collaborating services such as using the police to take a report

4. When verbally communicating with patients and/or their relatives during an EMS response:
   a. Which of the following activities do you carry out?
      - I use the local language such as Arabic that is well understood by the patient and/or their relatives
      - I use a translator from the Saudi Red Crescent Authority or from collaborating government agencies
      - I engage in a private one-on-one conversation with the patients and/or their relatives
      - I communicate with the patient and/or their relatives publicly in a manner that other EMS providers and bystanders can also hear
   b. What do you consider to be the top three major challenges?

      _____

   c. How do you think the challenges you mentioned in question above can be addressed?

5. In providing EMS services to patients during a medical emergency
   a. How do you maintain the privacy of your patients?
      - Only collecting the information indicated in the prehospital care report
      - Engaging in a private one-on-one conversation with the patients and/or their relatives
      - Privately filling the patient's prehospital care report before submitting it for safe storage at the EMS centre
      - Maintaining confidentiality in handling and storing the patient data

   b. What do you consider to be the top three major challenges?

   c. How do you think the challenges you mentioned in question above can be addressed?

6. While providing EMS services to patients
   a. Did you address the needs of the patient's relatives, directly or by collaborating services?
      - Yes
      - No
   b. If your answer to question 6a above is yes, please indicate whether you used own SRCA staff or collaborating services such as the police, army, etc. to address such needs

- Own SRCA staff
- Collaborating services such as police, army etc.

c. What do you consider to be the top three major challenges?

_____

d. How do you think the challenges you mentioned in question above can be addressed?

_____

7. After responding to an EMS case, were you debriefed?
   - All the time
   - Most of the time
   - Sometimes
   - Never
   - Don't know
8. If you were debriefed, who carried out the debriefing? How was it conducted? Please describe.

_____

_____

_____.

Appendix 7. Study information sheet for Senior Saudi Red Crescent Authority Staff

Study Title: A Mixed Method Investigation into the Response of the Saudi Emergency Medical Service System to Medical Emergencies in Riyadh City, Saudi Arabia

PARTICIPANT INFORMATION SHEET

Research Ethics Reference: 18-652E
Version 1.0 Date: 12/12/2018

We would like to invite you to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. One of our team will go through the information sheet with you and answer any questions you have. Please take time to read this carefully and discuss it with others if you wish. Ask us anything that is not clear.

What is the purpose of the research?

In this study, we will investigate the response of the Saudi EMS system to medical emergencies in Riyadh city. In particular, this study will be carried out to meet the following three objectives:

1. To determine the timeliness of the Saudi EMS system response to medical emergencies in Riyadh city.
2. To evaluate the safety, efficiency, effectiveness, patient-centeredness, and equity aspects of the Saudi EMS system relevant to medical emergencies in Riyadh city.
3. To determine how EMS providers use the Saudi EMS system for prehospital management of medical emergencies in Riyadh city.

Why have I been invited to take part?

You have been invited to take part in this research because you are a director or assistant director of the Saudi Red Crescent Authority EMS centre in Riyadh or a frontline EMS provider (EMS physicians, doctors, paramedics, nurses, EMS technicians, and other providers) working with the Saudi Red Crescent Authority in Riyadh, aged 18 years and above.

The inclusion criteria are: having worked as a director or assistant director for Saudi Red Crescent Authority in Riyadh for two years (for directors and assistant directors) or you are a Saudi Red Crescent Authority frontline EMS provider who responded to at least one medical emergency in 2018 9for frontline EMS providers).

In this study, we will be recruiting up to 26 directors or assistant directors for the Saudi Red Crescent Authority in Riyadh and all frontline EMS providers who responded to at least one medical emergency in 2018.

1. Do I have to take part?

No. It is up to you to decide if you want to take part in this research. We will describe the study and go through this information sheet with you to answer any questions you may have. If you agree to participate, we will ask you to sign a consent form and will give you a copy to keep. However, you would still be free to withdraw from the study at any time, without giving a reason and without any negative consequences, by advising the researchers of this decision. This would not affect your legal rights.

2. What will happen to me if I take part?

A researcher will contact you to go over the information sheet, explain the procedures, and go through a pre-screening with you to check if it is safe for you to participate. If you agree to take part in the study, you will be asked to attend a face-to-face interview (for directors and assistant directors) or complete a short questionnaire online (for frontline EMS providers).

Before the interviews, we will talk you through the study procedures and give you chance to ask any questions through verbal communication (for face-to-face interviews for directors and assistant directors) or sending us an email (for frontline EMS providers)

The study will involve the collection of your responses to specific questions about the Saudi Emergency Medical Service system

This should take approximately 30 minutes (for face-to-face interviews for directors and assistant directors) or 10 minutes (for the electronic questionnaire for frontline EMS providers).

If you are still happy to take part, then you will then be asked to sign a consent form.

3. Are there any risks in taking part?

Your participation in the study by completing the questionnaire does not put you in any direct or indirect risks

4. Are there any benefits in taking part?

The study will help identify the strengths and weaknesses of the Saudi EMS system and develop ways of improving the system to effectively respond to medical emergencies. There are no short-term or long-term, direct or indirect befits that will accrue to you if you participate or not participate in the study.

5. Will my time/travel costs be reimbursed?

Participants will not receive an inconvenience allowance to participate in the study.

6. What happens to the data provided?

The research data will be stored confidentially using the hard copy of the completed questionnaire (for directors and assistant directors) or text form (for frontline EMS providers). To help ensure your privacy, you will be assigned a volunteer study identification number (for example P01 for participant number 1), and it will be used instead of your name. We will save all your responses using that volunteer study identification number so that none of the data will have your real name or other individual identifiers associated with them. Your name and any information about you will not be disclosed outside this study. Your data will be stored and managed according to the European Union General Data Protection Regulations (GDPR). The GDPR is a legislation of the European Union adopted by the UK in May 25, 2018 to regulate and protect the use of manual and electronic personal data.[1]

The researcher will have access to the research data.
We would like your permission to use fully anonymised direct quotes in research publications.

[1] University of Nottingham, Records and information management, available at https://www.nottingham.ac.uk/governance/records-and-information-management/gdpr-overview.aspx

All research data and records will be stored for a minimum of 7 years after publication or public release of the work of the research.

We would like your permission to use anonymised data in future studies and to share our research data (e.g. in online databases) with other researchers in other Universities and organisations both inside and outside the European Union. This would be used for research in health and social care. Sharing research data is important to allow peer scrutiny, re-use (and therefore avoiding duplication of research) and to understand the bigger picture in particular areas of research. All personal information that could identify you will be removed or changed before the information is shared with other researchers or results are made public. Data sharing in this way is usually anonymised (so that you could not be identified)

7. What will happen if I don't want to carry on with the study?

Even after you have signed the consent form, you are free to withdraw from the study at any time without giving any reason and without your legal rights being affected. Any personal data will be destroyed.

If you withdraw, we will no longer collect any information about you or from you but we will keep the anonymous research data that has already been collected and stored as we are not allowed to tamper with study records. This information may have already been used in some analyses and may still be used in the final study analyses. To safeguard your rights, we will not use any personally-identifiable information.

8. Who will know that I am taking part in this research?

All information collected about you during this research would be kept strictly confidential. Any collected data will be anonymised with a code as detailed above. All such data are kept on password-protected databases sitting on a restricted access computer system and any paper information (such as your consent form, contact details, and any research questionnaires) would be stored safely in lockable cabinets in a swipe-card secured building and would only be accessed by the research team.

Under UK Data Protection laws the University is the Data Controller (legally responsible for the data security) and the Chief Investigator of this study (named above) is the Data

Custodian (manages access to the data). This means we are responsible for looking after your information and using it properly. Your rights to access, change or move your information are limited as we need to manage your information in specific ways to comply with certain laws and for the research to be reliable and accurate. To safeguard your rights we will use the minimum personally – identifiable information possible.
You can find out more about how we use your information and to read our privacy notice at: https://www.nottingham.ac.uk/utilities/privacy.aspx/

Designated individuals of the University of Nottingham may be given access to data for monitoring and/or audit of the study to ensure we are complying with guidelines.

Anything you say during an interview will be kept confidential, unless you reveal something of concern that may put yourself or anyone else at risk. It will then be necessary to report to the appropriate persons.

9. What will happen to the results of the research?

The research will be written up as a thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The thesis will be published in open access.

The research will be written up as a dissertation for the degree of PhD.in Emergency Medicine

10. Who has reviewed this study?

All research involving people is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given a favourable opinion by the Faculty of Medicine and Health Sciences Research Ethics Committee (Reference number: FMHS _____)

11. Who is organising and funding the research?

This study is organized by Mr. Moharmis Alolyani (the chief investigator) and funded by the Saudi National government.

12. What if something goes wrong?

If you have a concern about any aspect of this project, please speak to the Principal Investigator, Mr. Moharmis Alolyani, who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how he/she intends to deal with it. If you remain unhappy and wish to complain formally, you can do this by contacting the FMHS Research Ethics Committee Administrator, c/o The University of Nottingham, Faculty PVC Office, B Floor, Medical School, Queen's Medical Centre Campus, Nottingham University Hospitals, Nottingham, NG7 2UH. E-mail: FMHS-ResearchEthics@nottingham.ac.uk

13. Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Mr. Moharmis Alolyani
The Division of Epidemiology and Public Health, The University of Nottingham
Tel: +966 551555992
Email: moharmis.alolyani@nottingham.ac.uk

Appendix 8. Participant consent form

Title of Study: A Mixed Method Investigation into the Response of the Saudi Emergency Medical Service System to Medical Emergencies in Riyadh City, Saudi Arabia

REC ref:

Name of Researchers: Name, position, Lead investigator, Supervisor etc.

Name of Participant:

1. I confirm that I have read and understand the information sheet for the above study which is attached and has had the opportunity to ask questions. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐
3. I understand that should I withdraw, more than 7 days after the interview has taken place then the information collected so far cannot be erased and that this information may still be used in the study analysis. ☐
4. I understand that relevant sections of my data collected in the study may be looked at by the research group and by other responsible individuals for monitoring and audit purposes. I give permission for these individuals to have access to these records and to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential. ☐
5. I understand that the *interview/Focus Group/seminar session etc.* (*delete/revise as appropriate) will be audio recorded using a digital device and that anonymous direct quotes from the interview may be used in the study reports. ☐
6. I understand that what I say during the*interview/Focus Group/seminar session etc.* (*delete/revise as appropriate) will be kept confidential unless I reveal something of concern that may put myself or someone else at any risk. It will then be necessary to report this to the appropriate persons. ☐
7. I understand that information about me recorded during the study will be made anonymous before it is stored. It will be uploaded into a secure database on a computer kept in a secure place. Data will be kept for 7 years after the study has ended and then destroyed. ☐

8. **Optional:** I agree that my research data may be stored and used in possible future research during and after 7 years, and shared with other researchers including those working outside the University. ☐

9. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Name of Person taking consent	Date	Signature

Appendix 9. Top 40 EMS centres in Riyadh based on their total EMS cases in 2017

Rank based on EMS cases in 2017	EMS centre	Location	Total EMS cases in 2017
1.	Naseem	Riyadh city	12, 865
2.	Hamra	Riyadh city	12, 132
3.	Towaiq	Riyadh city	8, 005
4.	Rawdha	Riyadh city	7, 970
5.	Rabwa	Riyadh city	7, 859
6.	Oraijaa	Riyadh city	7, 752
7.	Orouba	Riyadh city	7, 451
8.	Dhabab	Riyadh city	6, 915
9.	Swaidi	Riyadh city	6, 778
10.	Nadheem	Riyadh city	6, 674
11.	Sahafa	Riyadh city	6, 488
12.	Shifa	Riyadh city	6, 107
13.	Kharj road	Riyadh city	6, 086
14.	Rora University	Riyadh city	5, 220
15.	Maseef	Riyadh city	4, 121
16.	Al-Esnad	Riyadh city	4, 091
17.	Laban	Riyadh city	3, 725
18.	Al-Dar Albaidha	Riyadh city	3, 370
19.	Kharj	Riyadh city	3, 326
20.	Khalideyya	Riyadh city	3, 325
21.	Manfouha	Riyadh city	3, 311
22.	Sultana	Riyadh city	3, 123
23.	Kasr Alhokm	Riyadh city	3, 112
24.	Malaz	Riyadh city	3, 074
25.	Sili	Riyadh city	3, 053
26.	Dereyyah	Riyadh city	3, 031
27.	Olaisha	Riyadh city	2, 964
28.	Al-Safarat	Riyadh city	2, 835

29.	Amanah	Riyadh city	2, 344
30.	Giddeyya	Riyadh city	2, 253
31.	Al-Remal	Riyadh city	1, 924
32.	Al-Salam	Riyadh city	1, 829
33.	Derab	Riyadh city	1, 485
34.	Eshbailya	Riyadh city	1, 289
35.	Dawadmi	Riyadh city	1, 277
36.	Dagham	Riyadh city	1, 228
37.	Okaz	Riyadh city	1, 228
38.	Majmaa	Rural regions of Riyadh	1, 127
39.	Zulfi	Rural regions of Riyadh	1, 081
40.	Ha’yir	Riyadh city	1, 083

Appendix 10. Randomisation of the 38 EMS centres in Riyadh city

The names of the 38 EMS centres in Riyadh city were entered into the randomisation box of an online randomiser (www.random.org/lists; Randomness and Integrity Services Ltd, Dublin, Ireland) and the "randomize" button clicked.



The online randomizer generated the following randomised list. The first 12 centres were selected.

