Research

A comparison of pre-hospital emergency medical services' response and duration times in urban versus rural areas of Saudi Arabia

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Abstract

Background

Response impacts on treatment outcomes, particularly for time-sensitive illnesses, including trauma. This study compares key outcome measures for emergency medical services (EMS) operating in urban versus rural areas in the Riyadh region of Saudi Arabia.

Methods

A cross-sectional study of EMS users was conducted using a random sampling method. Primary outcome measures were response time, on-scene time, transport time interval and survival rates. Secondary outcomes were the length of stay in the intensive care unit and hospital. Data were compared between the urban and rural groups using the t-test and chi-square test.

Results

Eight-hundred patients (n=400 urban, n=400 rural) were included in the final analysis. Cases in rural areas had significantly higher response times and duration times (median response 15 vs. 22 minutes, median duration 43 vs. 62 minutes). Response times were significantly longer for rural areas for MVC, industrial accidents, medical incidents and trauma, but there was no significant difference in duration time for industrial accidents. While urban areas had significantly shorter response times for all incident types, there was no difference with rural areas in duration time for chest injury, gastrointestinal, neurological or respiratory problems.

Conclusion

The findings indicate that response time and duration differs between urban and rural locations in a number of key areas. The factors underlying these differences need to be the subject of specific follow-up research in order to make recommendations as to the best way to improve EMS in Saudi Arabia and to close the gap in rural and urban service delivery.

Keywords:

emergency medical service; response; time; duration; rural; urban; Saudi Arabia

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Introduction

Certain health conditions, such as stroke, cardiac arrest and sepsis, as well as traumatic injuries, require timely medical treatment to limit poor health outcomes. Such conditions contribute to premature mortality, as well as having significant ongoing impacts on quality-of-life for survivors (1,2). The magnitude of this issue is demonstrated by the fact that annually the deaths arising from traumatic injuries alone is estimated to be equal to the combined mortality of tuberculosis, malaria and acquired immunodeficiency syndrome (3,4).

The primary factor that determines access to timely treatment, and therefore mortality or subsequent disability outcomes, is the appropriateness of pre-hospital care before and during transport to the nearest appropriate healthcare service (5). Improving this can result in a more than 25% reduction in mortality or disability arising from trauma and health emergencies (6). As another example, it is estimated that 74% of deaths due to ischaemic heart disease occur before the patient's arrival at hospital (7). Therefore, suitable pre-hospital care strategies and rapid transportation are critical to reducing mortality or significant ongoing disability outcomes.

Emergency medical services (EMS) have a critical role in organising all aspects of preventive care (pre- and out-of-hospital environments) and improving outcomes for patients with acute diseases or emergencies associated with chronic diseases (8,9). Identified factors that may limit the capacity of EMS include the geography of the transportation area, the quality and frequency of training in life-saving protocols, and the availability of equipment (10,11). In some locations, EMS resources are primarily focussed on providing transport for patients with mild injuries and non-emergency diseases, and they are therefore perceived to be inefficient and/or inadequately equipped to deal with acute diseases and life-threatening medical conditions (12). However, while it is known in the United States, Europe and Australia that living in a rural area will potentially have an impact on the effectiveness and efficiency of EMS, there is limited comparative research between urban and rural areas, and particularly in developing countries (13). The purpose of the current study is to examine the key performance factors of response time and scene duration time for EMS in the Kingdom of Saudi Arabia, and to specifically to compare outcomes for rural versus urban patients.

Methods

The STROBE checklist for cohort, case-control and cross-sectional studies (combined) was used when developing this manuscript (14).

Setting and study design

A cross-sectional study was conducted on patient data from the

Saudi Red Crescent Authority EMS in the Kingdom of Saudi Arabia over a period of 1 year from 1 January to 31 December 2017. The Saudi Red Crescent Authority is the primary provider of EMS for Saudi citizens, and has a history of service provision dating back to 1934 (15).

The geographic location of the study was the Riyadh region, which is one of 13 administrative regions in the Kingdom. While the Makkah administrative region has the largest population base, it was not considered to be representative of Saudi Arabia as it has 1.8 million annual visitors for religious events (pilgrimage) every year (16). The Riyadh region has the second largest population, and was therefore chosen in place of Makkah. Riyadh region is located in the centre of Saudi Arabia, and has a population of approximately 8 million people dispersed over 400,000 km² which includes the capital city of Saudi Arabia, also called Riyadh. For the purposes of this project, all areas outside of Riyadh city were considered 'rural', which is in accordance with the definition provided by the Saudi Red Crescent.

Ethics

Ethical approval was obtained from the University of New England's Human Research Ethics Committee (Approval No. HE18-246), the Saudi Arabia Ministry of Health Ethical Committee, the King Abdelaziz Medical Cities Ethical Committee and the Saudi Red Crescent Authority.

Participants

No participants were directly contacted as this study involved a retrospective de-identified audit of emergency patients' records. All data were located at the Saudi Red Crescent central office situated in Riyadh city. These data were sourced from hard-copy paper records submitted from all 78 ambulance (EMS) stations (30 rural and 48 urban sites) in Riyadh region of Saudi Arabia.

Procedures

Data were collected using a random sample of emergency patient records from Saudi Red Crescent. The Red Crescent Emergency Services centrally store hard copy records of every transport dispatch in the Riyadh regional central office located in Riyadh city. Emergency patient records between January and December 2017 were selected from the files using a computer-generated random number list. A supervisor from Red Crescent de-identified all records that were randomly selected, and provided the lead author with de-identified copies. The data were then electronically transcribed into SPSS (v25).

Sample size calculation

A random sampling method was employed to select the patient records included in this study. To ensure a suitable sample, the sample size was calculated before the commencement of the

project using the below formula (17):

$$n = \frac{2(Z_{\alpha} + Z_{1-\beta})^2 \sigma^2}{\Delta^2}$$

(n: sample size that will be taken from the second group (urban area); Z_{α} : significant level; $Z_{1-\beta}$: power of the test; σ : standard deviation; Δ : anticipated effect size).

For this project, the significant level (α) is 1.96, 80% power of the test ($Z_{1-\beta}$) is 0.8416, the anticipated effect size (Δ) is taken as 0.10, and the standard deviation (σ) is 0.5. Therefore, the required sample size for the urban and rural areas using the above formula is 392. It was agreed before data collection commencing that 400 patient records would be selected from urban areas and 400 patient records would be selected from rural areas, resulting in a total sample of 800.

Outcome measures

The two primary outcome measures for this study were:

- response time – the time from initial emergency call until EMS arrival at scene; and
- duration time – the time from EMS arrival at scene until patient is either released or transported to a health facility.

Statistical analysis

Demographic data were collected on the patients in addition to the primary outcome measures. Three additional measures were recorded from the patient records:

- the time of call was coded as either morning (4:00am to 12:00noon); afternoon (12:01pm to 8:00pm); or night (8:01pm to 3:59am)
- the reason for callout was recorded as either motor vehicle collision (MVC); industrial incident; medical emergency; or traumatic injury
- the incident type was noted as one of the following: fracture-laceration; head-neck injury; chest injury; dizziness; wound-burn; cardiac; gastrointestinal; neurological; respiratory; or other.

Simple descriptive statistics were used to describe the cohort profile, while chi-square tests were used for comparison purposes. Data were compared between the urban and rural groups in relation to the response time and duration time on scene, with a p-value of less than .05 considered significant.

Results

General demographic data

The mean age in urban and rural areas was 42.75 and 39.72 years respectively. There was a gender imbalance in the dataset across both areas, with 66% (264) of urban area patients being male and 73.8% (295) of rural patients being male. Overall, the sample was composed of 559 males and 241 females. This sample therefore does not appear representative of the Saudi citizen population which is approximately 51%

male and 49% female (18), but an accurate gender breakdown via each region is difficult to ascertain from national data. It is also worth noting that while there is a significant gender imbalance in non-Saudi nationals (18), largely composed of male workers from other countries, this cohort may instead access an alternative EMS to Red Crescent (13,15). As this was a cross-sectional study, it was not possible to ascertain the precise reasons for this skew, however it is consistent with a previous study in Turkey that showed males use EMS at a higher rate than females (19). A preliminary analysis of the data was undertaken and this indicated no statistical difference for gender in regard to the key variables of response time ($p=0.204$) and duration time ($p=.903$).

Effect of the geographic location on response time and duration time

The first analysis undertaken was to see whether there was an overall difference between urban and rural areas for mean response time and mean duration time. It indicated that there was a significant difference ($p<.001$) between the urban and rural in terms of response time, with the response time in the rural area significantly longer than it was in the urban area. Overall, there was a response time differential of 7 minutes, with a mean response time of 15 minutes in the urban areas versus 22 minutes in rural areas (Table 1). Similarly, there was a significant difference ($p<.001$) between the urban and rural in terms of a duration time, with duration time in rural areas longer (62 minutes) than in the urban area (43 minutes).

Table 1. Differences in response time and duration time for urban and rural areas

Variable	Urban	Rural	Significance p-value
Response time	15 mins	22 mins	<.001*
Duration time	43 mins	62 mins	<.001*

Further analyses were then undertaken to explore why these differences may be evident between urban and rural locations. The main factors analysed were the effect of the time of the call, the reason for the callout, and the incident type.

Effect of time of call on response time and duration time

The data were initially examined to see whether any patterns for response time and duration time could be determined with respect to the time of call (Table 2). In urban areas, the longest mean response time was recorded during the night (13.93 minutes), then afternoon (13.60 minutes), and morning (11.05 minutes). Similarly, the duration time in urban areas was longest at night (47.25 minutes), then afternoon (45.81 minutes) and again smallest in the morning (40.9 minutes).

However, rural areas had a different call response profile to urban areas, with afternoons having a lower response time than mornings and night-time. The response time was longest in the night (24.18 minutes) when compared to morning

(23.70 minutes) and then afternoon (20.93 minutes). A similar pattern was observed for duration time; it was longest for night (63.70 minutes), then mornings (59.43 minutes), and afternoons were shortest (56.25 minutes).

Table 2. Response and duration time comparison for morning, afternoon and night

	Time of call	Mean (minutes)	
		Urban	Rural
Response time	Morning	11.05	23.70
	Afternoon	13.60	20.93
	Night	13.93	24.18
Duration time	Morning	40.90	59.43
	Afternoon	45.81	56.25
	Night	47.25	63.70

Effect of reason for callout on response time and duration time

The next analysis compared whether the reason for the callout would see any differences with respect to response time and duration time between urban and rural areas. In all cases, there was a significant difference in response time between urban and rural areas for MVC, industrial incidents, medical cases and traumatic injury. A similar pattern was observed for duration on scene, with rural patients having significantly longer duration for MVC, medical and trauma (Table 3). However, there was no significant difference in duration time for industrial accidents.

Table 3. Effect of reason for callout on response time and duration time

	Reason for callout	Mean (mins)		Significance p-value
		Urban	Rural	
Response time	MVC	41.77	100.79	.000*
	Industrial	8.50	19.11	.040*
	Medical	160.70	303.66	.000*
	Trauma	60.81	108.62	.000*
Duration time	MVC	39.64	75.68	.000*
	Industrial	44.00	60.63	.293
	Medical	105.48	154.14	.000*
	Trauma	40.63	59.56	.000*

Effect of incident type of response time and duration time

The final analysis compared whether the incident type would result in any differences with respect to response time and duration time between urban and rural areas. Again, as for type of call, in all cases there was a significant difference in response time between urban and rural areas for each incident type, with urban responses being faster in every case. However, the duration on scene data were different; while fracture-laceration, head-neck injury, dizziness, cardiac and other were all significant, the incident types of chest injury,

wound/burn, gastrointestinal, neurological and respiratory did not show a significant difference between urban and rural areas. While the difference for gastrointestinal incidents was not significant, it is worth noting that the rural duration time was actually lower than for urban; this was the only incident-type that saw this outcome (Table 4).

Table 4. Effect of incident type on response and duration time

	Incident type	Mean (minutes)		Significance p-value
		Urban	Rural	
Response time	Fracture-laceration	39.99	66.92	.000*
	Head-neck injury	33.81	63.09	.000*
	Chest injury	9.71	23.10	.001*
	Dizziness	31.13	71.49	.000*
	Wound-burn	13.0	22.21	.001*
	Cardiac	13.94	20.80	.004*
	Gastrointestinal	11.65	24.89	.000*
	Neurological	10.54	22.58	.000*
	Respiratory	18.83	34.17	.000*
	Other	82.77	155.02	.000*
Duration time	Fracture-laceration	43.44	59.04	.001*
	Head-neck injury	25.22	47.32	.000*
	Chest injury	37.27	55.38	.060
	Dizziness	44.40	61.23	.001*
	Wound-burn	13.11	19.58	.087
	Cardiac	38.18	63.25	.009*
	Gastrointestinal	62.00	57.09	.661
	Neurological	45.50	56.71	.121
	Respiratory	47.86	59.17	.128
	Other	49.34	61.31	.001*

Discussion

The focus of the current project was to examine EMS performance within the Riyadh region in the Kingdom of Saudi Arabia, with specific comparison between rural and urban area EMS in terms of response time and duration time, and the effect of scene location, reason for callout and incident type. At the time of this study, there has been no other research in Saudi Arabia that has comparatively examined these issues.

We found that rural areas had significantly longer response times and duration times (mean response time 15 vs. 22 minutes, mean duration time 43 vs. 62 minutes) when compared to the urban areas ($p < .001$). This finding is supported by previous research in other countries where it was reported that urban patients received an EMS response more

quickly than rural patients (20-23). The primary reason identified in previous research to explain this differential was that the geographical distance between patients and EMS centers is larger in rural areas than in urban areas. However, it has also been recognised that differences in response time in rural areas are not only a consequence of the longer distances that an ambulance must cover in order to arrive at the scene of the incident, but also because of the problems arising from the absence of suitable building identification or labelling and the dispersal of worksites across large areas (21). Moreover, environmental factors such as unsealed roads can also contribute to this observed discrepancy in response time, while weather conditions and poor infrastructure may limit the signals of radio or telephone connections (24) and therefore further inhibit the ability of EMS to accurately identify the correct location in a remote rural area. Staffing levels could be an additional factor, but the number of EMS staff per hundred head of population for urban and rural areas is unfortunately difficult to accurately determine from national statistics. Figures are often provided by region (eg. all of Riyadh), and there are sometimes different interpretations of EMS staff definitions, such as a paramedic versus a technician. Differences in staffing levels across rural and urban locations is an area worthy of additional consideration in future research.

We found that the time of call affected the response time in both urban and rural groups. The shortest time of response in urban areas in the morning, but in the rural areas it was in the afternoon. In contrast to this, Schwartz et al (25) reported the response time at night was actually faster than the morning or afternoon. The reasons for these outcomes are not clear, and further research is required to better understand what aspects of time of day impact on response time for EMS. Factors such as variation in daily staffing levels, available technology, regional demographic differences and age profiles could all contribute to the observed differences.

There were significant differences in response time for all reasons for call out (ie. MVC, industrial accident, medical incident or traumatic injury) between rural and urban areas. This result is not surprising and is indicative of the geographic distance issues, but also could reflect difficulties, as noted earlier, in buildings not being appropriately labelled or precise farm locations being difficult to find. This area requires further research directly with paramedics to better understand these findings and to see if any changes to equipment or process could mitigate some of the response time discrepancy. One suggested focus for future research is to examine the reasons for non-transportation following call-out, to examine whether there can be a better allocation of resources which may in turn reduce response time.

The duration time for different types of callout did show some areas of similarity between urban and rural areas. While there were significant differences in length of time at scene

for MVC, medical incident and traumatic injury, there was no difference for industrial accidents. The duration time at scene is affected by a range of factors, including selection of the original stabilisation technique, the number of respondents and the time required to prepare the patient for transportation. Other on-scene issues include increasing severity of the disease, requirement for the use of advanced intravenous devices, transport options and traumatic complexity (26,27). It was not initially perceived that geographic location would have increased the impact of any of these factors, but the data indicated that rural patients were supported for longer periods of time on-scene. Additional research to examine any potential discrepancies with respect to the availability of essential equipment and the training of paramedics in rural and urban areas would assist to clarify the possible reasons for the observed duration time differences.

As expected from the previous analyses, the specific incident type, in all cases, saw a significant difference in response time between urban and rural areas. However, again there was an interesting difference when considering the duration time data. In particular, the incident types of chest injury, wound-burn, gastrointestinal, neurological and respiratory did not show a significant difference in duration time between urban and rural areas. In fact, while rural patients generally had longer on-scene duration times, this was not always the case, and urban patients actually had a longer mean on-scene time for gastrointestinal incidents.

The nature of cross-sectional studies makes it impossible to determine reasons for these differences in on-scene duration, however it is hypothesised that the time in rural areas is related to a potentially greater need to stabilise the patient before a longer transportation period to the nearest suitable healthcare facility. This argument would seem feasible for the cases of fracture-lacerations, head-neck injuries and cardiac problems, where on-scene support will be vital if there is a longer transportation time. The lack of any significant difference for gastrointestinal, neurological and respiratory cases may indicate that generally either less time is required to stabilise on scene, or simply that the number of available interventions at the scene are more limited. Specific qualitative interviews with paramedics are required to further unpack and explain these findings.

Limitations

The main limitation of this study is its sample size, with 800 cases included in the final dataset. While this was sufficient with respect to the initial power calculation, it is acknowledged that a larger sample with a greater number of cases in the Riyadh region may allow for a more finely nuanced examination of the data. It is also worth noting that these results are from one region of Saudi Arabia, and that the findings may not be generalisable to other locations elsewhere in the world.

Readers are advised to consider the specifics of their own geographic setting when evaluating these results and recommendations. Nonetheless, it is still believed that the data is of general interest, as it is one of the few studies that has comparatively examined rural and urban EMS patients outside of the US, Europe or Australia.

Conclusion

The findings indicate that the urban and rural areas of Riyadh region differ in several critical areas regarding the response time and duration time, and that the factors potentially affecting the response time and duration time also varied. The significance of the observed differences in response time is apparent in time-critical life-saving situations, such as cardiac arrest. Efforts have been made to decrease response time elsewhere in the world; the National Ambulance Service in South Korea has begun dispatching non-frontline police and mild care ambulances to incidents which may not require the same level of support as more complex scenarios, such as multiple vehicle accidents (27). There is a clear disparity in response time between rural and urban regions in Riyadh region, and health outcomes for non-metropolitan residents will likely remain poorer until this discrepancy can be reduced.

Mechanisms to improve the response time of the EMS should be considered for rural areas in order to better address the identified gap between the urban and rural areas in Saudi Arabia. It is recommended that additional research is required specifically with paramedics in order to gain a more complete understanding of why these differences are evident. It is also suggested that future research specifically examines the reasons for non-transportation following call-out, as this may facilitate the more effective allocation of resources and consequently reduce response time.

Competing interests

The authors report no competing interests. Each author of this paper have completed the ICMJE conflict of interest statement.

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