MED EMERGENCY / URGENCE

MJEM

Mediterranean Journal of Emergency Medicine

Endorsed by Lebanese Resuscitation Council

Indexed by Index Medicus

2018 - N°26

INFLUENTIAL FACTORS ON URBAN AND RURAL RESPONSE TIMES FOR EMERGENCY AMBULANCES IN QATAR

WILSON P, ALINIER G, REIMANN T, MORRIS B. Influential factors on urban and rural response times for emergency ambulances in Qatar. Med Emergency, MJEM 2018; 26:8-13.

Key words: ambulance response times, communication technology, rural, urban

ABSTRACT

Introduction: Ambulance response times are affected by several factors and play a critical role in the outcome of patients requiring urgent treatment. This article aims to highlight the response time differences within and outside Doha (Capital city of Qatar), identify causal trends in slower response times observed, and explore related technological advances.

Methods: High-priority response times were collected for a two-day period in three-hour time slots and categorised as urban or rural. The average response time within each time slot was analysed to determine trends and identify the worst peaks so communication logs between dispatchers and ambulance crews could be played back to determine the cause of the "delayed" response.

Results: Over the period analysed, 394 high-priority calls were received with an overall median average response time of five minutes 32 seconds. The average urban and rural setting response times were respectively five minutes 15 seconds (n = 311) and six minutes 22 seconds (n = 83). Radio communications of the highest median response time peaks for urban and rural response calls were analysed (n = 11): three with dispatchers giving directions, one crew reporting a physical obstruction preventing them from approaching the scene, and seven others containing no indication for the delayed response time.

Discussion: Over the period analysed, high-priority response time targets were met 100%. As expected, rural setting response times were usually longer than in the urban setting. The average response times appear longer on the second day (Tuesday) particularly in the afternoon in the urban setting, but there is otherwise no apparent trend between the two days over the different time slots. Ambulance crew familiarity with their environment and clear information by the caller play an important role in an ambulance reaching the scene quickly but new navigation and information sharing technology is expected to alleviate challenges faced at the time of the pilot study.

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Article history / info:

Category: Original article
Received: Apr. 19, 2017
Revised: May 24, 2017
Accepted: June 07, 2017

Conflict of interest statement:

There is no conflict of interest to declare.

INTRODUCTION

Over the last few decades Qatar has become a fast developing country in terms of infrastructure and population despite its hot and dry desert climate. Between 1986 and 2016, the number of residents has increased from 369,079 to around 2,600,000, with over 70% living in the capital, Doha, and its immediate suburb of Al Rayyan [1;2].

The principal public healthcare entity, Hamad Medical Corporation (HMC) provides the vast majority of the healthcare system infrastructure around the country and has steadily developed to respond to the needs of the growing population. Alongside this, a pre-hospital emergency medical service started operating in 1985 [3], now known as HMC Ambulance Service (HMCAS). Over the last five years it has been totally restructured and new service lines have been introduced to better serve the population of Qatar. HMCAS is now recognised for playing a very important role in the outcome of patients requiring emergency assistance in the pre-hospital setting. HMCAS' main stream service (999 ambulance service) employs around 1,300 clinical and support staff, has 200 ambulances, 22 rapid response vehicles, 16 bicycles, and a fleet of three helicopters that respond to over 100,000 "999" emergency calls a year [4]. In order for the service to respond quickly to these emergency calls, it uses a "hub and spoke model" of deployment. The hub is the location of supervisory officers and other administrative and support functions, while the spokes are small standby ambulance stations located in strategic areas throughout Qatar [5]. The HMCAS distribution model currently divides Qatar into six hubs, each with five to seven spoke stations **(Figure 1)**. The distribution model initially defines the necessary hub and spoke stations and ranks them in relation to their importance, based on historical call volume and response time performance. HMCAS regularly revisit agreed deployment models to ensure that they are in line with population growth and the increasing 999 call volume.

Figure 1: Map of Qatar showing the current different ambulance spoke stations.

Coordination of resources responding to emergency calls is managed from a dedicated national dispatch centre, which is co-located with other emergency service agencies (fire service and various police services). Emergency calls are in the first instance triaged by a Ministry of Interior call taker to determine if the call is related to fire, medical, or police, and initial information is captured in the computer assisted dispatch (CAD) system referred to as "Najem", which is an Arabic abbreviation that stands for "unified geographic system".

If the call is deemed to require ambulance service response, the call is transferred onto one of the emergency medical dispatchers (EMD) who will request for the case location and initiate the dispatch of an ambulance as priority one (lights and sirens) by informing a dispatcher responsible for the area were the call originates from via a "call for service" (CFS) code. The dispatcher will dispatch an ambulance unit by radio and or via a mobile data terminal (MDT) with CFS as priority 1 (lights and sirens) including basic information about the case. The engaged EMD will continue speaking with the caller to determine the chief complaint through a telephone triage process (ProQA®) and identify what skill level is required for that specific call. Should additional units or a higher clinical skill level be required, the relevant resources will also be dispatched with the same CFS by the dispatcher. If the chief complaint is not time critical, the call is downgraded to priority 2 (no lights and no sirens). The EMD will continue to stay on the line with the caller, if so required, to give pre-arrival instructions (PAI) which are first aid instructions given over the phone. During that time the Dispatcher communicates by radio with the relevant units to inform them about the case.

All aspects of every emergency call are carefully recorded for retrospective review. Statistics collected show response times of emergency vehicles from dispatch to arrival on scene, arrival at the patient, time on scene, time at hospital, and readiness to take the next emergency call. These times are recorded and analysed to monitor the performance of HMCAS in relation to set targets. Target response times vary depending on the call category and whether it is in an urban or rural environment **(Table 1)**. Although these targets are normally met at an acceptable standard, this is not always the case and reason(s) behind *ad-hoc* delays in a particular context have not benefited from detailed study.

AIMS AND OBJECTIVES OF THE PILOT STUDY

The aim of the pilot study presented in this article is to highlight the differences in response times within Doha (urban setting) compared to the rest of the country (rural setting), and identify any causal trend in the slower response times observed during a set period of time, whilst also discussing how technology can impact on response times.

Priority code	Unit dispatched	Urban	Rural
Priority 1 / Zulu code (Category A)	1 ambulance (Alpha Unit with 2 paramedics), 1 rapid response car (Charlie unit with 1 critical care paramedic and 1 paramedic) if available, and 1 supervisor vehicle (Delta unit with 1 paramedic) if available, moving with lights and siren. For calls outside Doha: 1 helicopter (LifeFlight).	75% < 10 minutes	95% < 15 minutes
Priority 1 / Yankee code(Category A)	1 Alpha Unit & Delta unit moving with lights and siren.		
Priority 2 / X-ray code (Category B or C)	1 Alpha unit & Delta unit if available moving without lights and siren.	75% < 15 minutes	95% < 20 minutes
Transport (Priority 3)	1 patient transport service unit (Tango) or Alpha unit moving without lights and siren.	95% < 15 minutes 20 minutes	

Table 1: Priority response codes and targets used by HMCAS.

LITERATURE REVIEW

In the out-of-hospital context, certain patients have a more positive outcome if emergency care reaches them sooner rather than later [6]. Some have argued that advances in pre-hospital medical technology and care makes that the classic trimodal distribution of death (immediate deaths, early deaths, and late deaths) attributable to traumatic injuries seems to be shifting to a bimodal distribution as the majority of deaths happen within the first hour of injury [7;8]. Most of these deaths occur from airway compromise, respiratory failure, and uncontrolled haemorrhage. All of these injuries can be initially dealt with at a basic first aid level to prevent death. With the intervention of highly trained paramedics responding to the scene in a timely fashion, patient outcome can be significantly improved [9].

In the UK, response times are measured in order to evaluate the quality of service provided, although it is sometimes argued as a "wrong" indicator in comparison to clinical performance indicators [10]. Patients are placed into category A (immediate life threatening – Equivalent to Priority 1 HMCAS calls), category B (serious conditions), and category C (non-specified). Category A patients require an emergency response vehicle on scene within eight minutes. This target time has to be met in at least 75% of all category A calls. Category B and C calls have to be attended to within 14 minutes in an urban environment, and 19 minutes in a rural environment. These target times have to be met by 95% of all calls to these categories [11-13].

A study was conducted in Washington State, United States of America, comparing the response times of the urban ambulance to the rural ambulance. It was discovered that the difference in the response times of the rural ambulance was significantly slower than that of the urban counterpart. The slower response time was associated with a higher mortality rate [14]. Factors affecting the response times can be poor road conditions, unpredictable weather, and suboptimal distribution of ambulance vehicles, which produces issues and problems that have to be overcome somehow. Iceland, the Western Isle of Scotland, and the Vasterbotten area of Sweden face similar issues [15]. In these parts of the world it has been highlighted again that faster response times are linked to better patient outcomes. One way to tackle the response time issue is to have more emergency vehicles distributed over the geographical area based on demand and response time of travel coverage, and potentially to even request from crews to remain in their vehicle whenever they are not engaged in patient care to reduce the activation time [16]. Adding extra emergency vehicles however has significant costs implications and often leads to paramedics having less exposure to patients due to the proportionally lower population density they cover. This reduces the number of calls each ambulance responds to, and hence may result in a reduction in the level of clinical skills of the paramedics and, in turn, adversely impact patient outcome. It seems an unsolvable issue between quality of care and response targets, one having to give way for the other [17].

Response time targets in developed countries may be easier to meet than in other nations thanks to more developed infrastructures such as roads, street names, and building numbers. Attending to emergency calls in developing countries in urban or rural areas can prove challenging. Although there may be an infrastructure in place, it may be struggling to keep pace with the urbanisation process, creating traffic congestions, leading to delays in response times, and adversely affecting patient outcome [18].

METHODS

Data was collected over a two-day period, in the middle of a week (16-17 June 2014) through the quality and improvement department at HMCAS. The anticipated sample over the two days identified was in the order of 500 response calls. The data collected and analysed were Priority 1 CFS calls, location zone, dispatch time, and time of arrival on scene. Qualitative data of the recorded communications between the response unit and the dispatcher was also collected from the radio call logs. All data was collated into a spreadsheet to show the response times of the units in minutes and seconds. This was then used to highlight the national Priority 1 response time average over these two days. The data was then split into two groups, separating calls between Urban and Rural. The two days were divided into three-hour periods (16-time slots over 48 hours). The average response time within each time slot was analysed to see if there were any trends and plotted onto a run chart. The four slowest peaks of response times were identified from each group off the run chart. The qualitative data of the recorded communications between the slowest response units and the dispatcher during these peaks were analysed to determine the cause of the "delayed" response.

ETHICS

This pilot study has been approved by HMC medical research centre as a quality improvement project exempted from full ethical approval and was conducted following the Hamad Medical Corporation, Medical Research Centre's Policies and Guidelines. (Proposal #14361/14)

RESULTS

During the two-day period, a total of 394 Priority 1 CFS met the inclusion criteria of first unit dispatched and first unit on the scene. The median average response time for all Priority 1 calls, urban and rural, was five minutes and 32 seconds. There were 311 (79%) CFS in the urban setting and their average response time was 5 minutes 15 seconds. There were 83 (21%) CFS in the rural setting and the average response time was 6 minutes 22 seconds. Day one and two median average response times in the urban and rural settings are presented in **Table 2**.

A more detailed analysis of the average response times over the 48 hours observed, overall and according to the setting, is presented in **Figure 2** in three-hour blocks. Where there is no trace on the chart for the rural response time, it indicates that no unit were dispatched to a Priority 1 call over that time period. Four long response time peaks have been identified in the urban setting and five in the rural setting. They respectively correspond to Day 1; 15:00-18:00, Day 2; 03:00-06:00, 9:00-12:00, 15:00:18:00, and Day 1; 09:00-12:00, 15:00-18:00, Day 2; 03:00-06:00, 12:00-15:00, 18:00-21:00. Only the 10% slowest response vehicles within the four longest response peak time radio communications in both settings (urban and rural) were analysed for comparison purposes. It corresponded to eleven radio communications between the ambulance crew and the dispatcher. All communications were done in english although it is generally a second or third language for the interlocutors, and hence the various accents may hinder the communication. Of these eleven communication recordings analysed, seven showed no specific indication as to why their response time was slower than the median average. Three were directions given to the scene which would indicate difficulty in finding the scene or unfamiliarity of the staff with the area. One reported that it could see the scene however the response vehicle had difficulty in accessing it due to a physical obstruction (fence) preventing them from reaching the patient. These issues were spread equally between the rural and urban setting.

Median average response time (minutes:seconds)	**Urban (n=311)**	**Rural (n=83)**
Day 1 (Monday) (n=185)	4:57 (n=143)	6:04 (n=42)
Day 2 (Tuesday) (n=209)	5:30 (n=168)	5:54 (n=41)

Table 2: Median average response times in both settings for day one and two.

DISCUSSION

Using the national average response time over the two days as a baseline it is possible to see the time difference between the urban and the rural setting from **Figure 2**. As is generally the case with most emergency services worldwide, response times in the rural setting were usually longer than in the urban setting. There is no immediate identifiable trend over the two days observed. The average response times appear longer on the second day, particularly in the afternoon in the urban setting, which was a Tuesday. This is the middle of the week in Qatar with residents potentially heading out to socialise. Morning rush hour traffic, between the times of 06:00 and 09:00 am can be extremely busy, particularly in Doha. **Figure 2** indicates that morning rush hour traffic had no visible effect on the response times in either setting. There are four peaks that have been identified highlighting the longer response times in the urban setting and five peaks in the rural setting but these do not seem to be linked to a specific time period on both days. Delays are sometimes induced by CFS being received when the crew is not inside their vehicle. For this reason, crews in a busy area might achieve better response times more easily due to them often being "caught on wheels" returning to a spoke station for example, hence reducing their activation time.

The majority of the response times in the urban setting were less than 10 minutes which is the national standard for HMCAS **(Table 1)**. No response times in the rural setting were longer than the maximum nationally set standard of 15 minutes.

Information from the radio communication recordings indicated that on occasions the responders face difficulties in findings the scene whether they are responding to a case in the urban or rural setting. There is anecdotal evidence that facing difficulties in

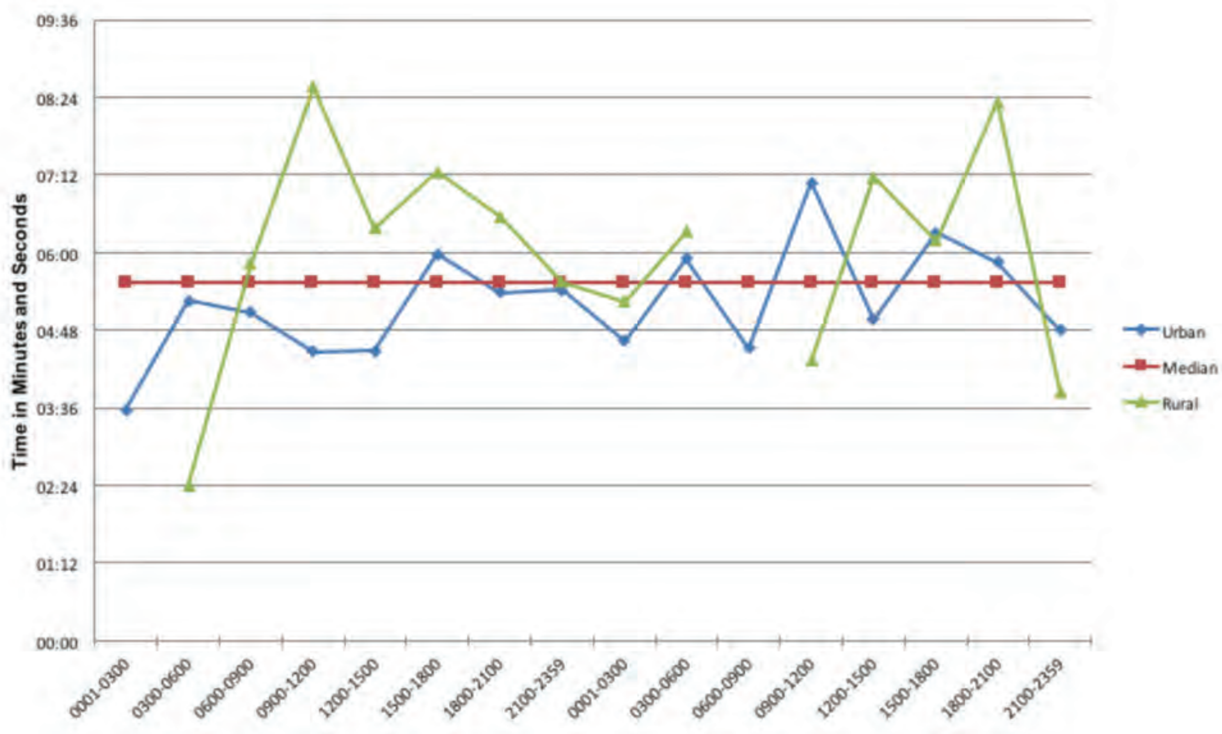

Figure 2: Median response times in three hours blocks in the urban and rural setting on 16-17 June 2014

finding or accessing the scene or the caller is a regular occurrence in Qatar as people are not yet familiar with using the street names and official building numbers which have been allocated over the last five years in most parts of the country. Road closures due to building works are also a common issue as the country is expanding its infrastructures.

It is important to note that the first unit dispatched and the first unit on scene may not necessarily be the same. In effect the second vehicle dispatched may have actually reached the scene before the first unit and hence in absolute terms responded in a shorter period time than recorded.

Ambulances are becoming increasingly sophisticated and adopt technologies used in other industries [19]. Since the time of this pilot study, HMCAS has equipped its ambulance fleet with an automated vehicle location (AVL) system and Mobile Data Terminal (MDT) that support the dispatchers and the crews. Dispatched units immediately receive the CFS and updates about the current call on their MDT as well as an initial radio communication. The MDT details include information obtained by the EMD using the ProQA® system. This provides responding crews an initial feel for the call and can support them in preparing for arrival on scene. The MDT also functions as a navigation tool, which guides responding units to the exact address of the call, based on cellular network triangulation or a "dropped pin" if the caller is using the recently implemented building/street/zone numbering system or is not at the scene of the emergency.

The AVL system gives relatively accurate ambulance speeds on the roads and distances travelled, which allows our models to be more accurate. Operational modelling tools are proven mathematical models which use data to provide answers to performance questions. "These modelling techniques are iterative research tools that rely as much on abstract mathematical models as on data from the real world" [20]. HMCAS now also uses operational modelling to conduct series of "what if's" analysis linked with a geographical information system (GIS). It is relevant for a national provider of ambulance service to clearly understand how major incidents, changes in urban or rural infrastructure will affect response time and utilization percentages of the deployed operational units as HMCAS has limited external ambulance providers to call upon. This is done to reduce the variability in available units as much as possible because this greatly affects response times [21]. Another recent implementation managed by the public works authority in Qatar is the installation of an automated traffic light control system at key intersections in Doha. It facilitates the flow of vehicles by changing the lights to help emergency vehicles equipped with that system to cross intersections more rapidly and safely.

LIMITATIONS

This pilot observational study was only conducted over a period of two days and hence may not help identify all possible issues linked to other days of the week or periods of the year when people may be prone to make emergency calls for varying reasons. Additional data that may have been of value to determine causes for delays could have been to obtain the distance between the scene of the emergency and the dispatched unit(s) but also the communication between the caller and the EMD to determine if there was language barrier issues or if the caller did not know their exact location and the length of service of the crew in the ambulance service and in the hub they were working in at the time. The number of units dispatched nationally within any three-hour block could have been analysed to determine if it had any effect on response times. We could also have determined objectively if during busy periods, our additional peak units deployed consistently ensured adequate response time performance. Using the AVL, it would have been possible to determine the time delay between the crew receiving a CFS and the ambulance moving. A final limitation for consideration relates to the fact that only communications between the ambulance service dispatcher and the responding units was considered in this review. Another area of potential delay has to do with the communications between the person calling for help and the call takers as well as internal communication between call taker and dispatchers within the control room.

CONCLUSIONS

Response times within the urban and rural settings in Qatar are consistently within set target ranges as would be expected of a high quality ambulance service and despite challenges faced daily on the roads due to the many ongoing construction projects. Although it is not uncommon for a crew to have difficulties in finding the location of an emergency call, on this occasion, no outstanding factor could be identified from the data and charts as to the cause of slower response times. Further research is recommended over a longer time period and using new on-board vehicle communication and tracking technology. This would help determine if the response times on particular days are longer in the afternoons and evenings as roads are usually more congested. It is also recommended that more communications from the radio call logs for slower response times be collected and listened to in order to ascertain whether difficulty in finding the scene location is more frequent than already determined in this pilot study or if delays are caused by the crew activation process.

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