Assessing the pre-hospital care preparedness to face mass casualty incident in Saudi Arabia in 2017-2018

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ABSTRACT

الأهداف: تقييم الاستعداد في الرعاية (MCI) قبل المستشفيات في المملكة العربية السعودية وتحديد وإبراز نقاط الضعف والقوة في التأهب لمواجهه الكوارث .

المنهجية: تعتبر هذه دراسة تحليلية كمية وصفية ، وتشمل جميع فروع هيئة الهلال الأحمر السعودي في 13 منطقة في جميع أنحاء المملكة .و تم استخدام النسخة المعدلة من (SRCA) لتقييم الاستجابة لحالات الطوارئ واستعداد الجاهزية في هذه الدراسة .

النتائج: تم العثور على أكبر عدد من سيارات الإسعاف والسيارات الطبية في منطقة مكة المكرمة تليها الرياض . وقد حصلت مكة المكرمة والمدينة على أربع نقاط وذلك يعني استعدادهم الكبير. ومع ذلك، كان المدينة أفضل من مكة في المقارنة وتم العثور على فرق كبير (0.019=p). حيث كان التأهب محدود في الرياض والمنطقة الشرقية. أيضا، ووجد ايضاً علاقة الإيجابية المعتدلة بين درجات المتوسط العام وعدد الأطباء وجدت مع قيمة 0.656=r و 0.015=p.

الخلاصة: إن استعداد هيئه الهلال الاحمر السعودي جوهري على نطاق أداة التقييم المستخدمة في هذه الدراسة. في منطقتي مكة والمدينة، يعتبر استعداد هيئة الهلال الأحمر السعودي جيد جدا بشكل عام لمواجهة حادثة الإصابات الجماعية.

Objectives: To assess the mass casualty incident (MCI) preparedness of pre-hospital care providers in Saudi Arabia and to identify and highlight their strengths and weaknesses when responding to MCIs.

Methods: This cross-sectional descriptive quantitative analysis was conducted between January 2017 and 2018 and included all Saudi Red Crescent Authority (SRCA) general administration branches in 13 regions in Saudi Arabia. The modified version of the emergency medical specialists (EMS) incident response and readiness assessment (EIRRA) tool was used in this study.

Results: The Makkah region has the largest number of ambulances and medics vehicles, followed by Riyadh.

Makkah and Al Madinah Al Munawarah obtained a median score of 4 and showed substantial preparedness for MCIs. However, Al Madinah Al Munawarah showed higher level of MCI preparedness than Makkah, and a significant difference was found (*p*=0.019). By contrast, Riyadh and the Eastern region showed limited MCI preparedness. In addition, a moderate positive correlation was observed between the overall median scores and the number of physicians (r=0.656 and *p*=0.015).

Conclusion: The SRCA showed substantial preparedness in Makkah and Al Madinah Al Munawarah. The SRCA were highly prepared to face MCIs.

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Disaster can occur anytime and anywhere. The multiple causalities impact quality of life of several individuals and also burden the healthcare system.[1] It primarily affects people's health and financial well-being.[2] In 2015, several major incidents occurred in Kingdom of Saudi Arabia (KSA). Approximately 2,000 people were left injured due to a natural disaster, while 1,200 were affected due to a manmade disaster.[3] Health status gradually declines during a disaster, and the community requires outside assistance for smooth functioning.[4]

Mass casualty incident (MCI) has been described as any incident that affects a significant number of people.[5] During MCI, the primary consideration is not the number of casualties but the surging capacity of the medical system to meet the healthcare needs of victims in this situation.[6] Emergency medical service (EMS) personnel plays a crucial role in managing disasters for over 35 years.[7] For this reason, their roles have been strengthened by the national association of EMS physicians in all the disaster cycle phases: mitigation, preparedness, response, and recovery.[8]

Mass casualty incident planning should include the proper distribution of resources by a push or pull model; push involves the distribution of all resources to the community, while pull involves the centralization of resources in the foremost place, and the patient is pulled to the central infrastructure.[8] The level of preparedness varies in every community; some of the communities have response capabilities, while some lack response capabilities.[9] Moreover, planning is essential for achieving a good outcome through successful management of disasters. Therefore, leaders must address the questions to ensure readiness and proper planning.[10]

In 2007, 56 passengers on board a motor coach to Telluride, Colorado, passed through the Phoenix Arizona route. When the driver took the right side of the road, the motor coach suddenly swerved and rolled over resulting mass casualties: 9 passengers died, and 43 sustained minor to serious injuries.[11] In January 2004, 13 cargo tankers crashed into 4 small cars, resulting mass casualties. In 2008, an MCI occurred in Mexican Hat, resulting 53 casualties.[12] After that, the National Transportation Safety Board recommended that "the preparedness, readiness, and response system of the Federal Interagency Committee of Emergency Medical Services (FICEMS) should be evaluated and then a new guideline for EMS response to disaster conditions should be set and implemented to all states".[11]

In 2003, a study conducted to assess the public schools' preparedness to face MCI, and 307 schools in Arkansas were surveyed to evaluate their level of preparedness. Approximately 51.3% of school districts reported that they had not established a plan for managing MCI. On the contrary, 72.2% of school districts planned to conduct an emergency lockdown, while 91.2% planned to do an emergency evacuation.[13]

A previous study was conducted in 13 private hospitals in KSA to evaluate their level of preparedness. A total of 12 (92.3%) hospitals showed preparedness for external and internal disasters. Of them, 9 (69.2%) made an agreement with other hospitals to accept more patients, whereas 4 (30.8%) had no interhospital agreements. Moreover, disaster preparedness exercises and training have not been conducted in hospitals in the last 12 months.[14] A recent study was conducted in KSA to evaluate the level of MCI preparedness in airports. This study showed that the airports have a sufficient number of EMS personnel who can respond to MCIs. However, within a relatively short period of time, they might n. level of preparedness to face MCI. Moreover, for pairwise comparisons across regions, the Mann-Whitney-Wilcoxon test was used. The Statistical Package for Social Sciences, version 21 (IBM Corp., Armonk, NY, USA) software was used to run these statistical tests

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Only a few studies have examined the status of EMS in pre-hospital settings to determine their level of preparedness during MCI or disaster situations. To the best of our knowledge, we did not nd previous publications studying prehospital preparedness in Saudi Arabia. is study aimed to determine the level of readiness and preparedness of hospitals in KSA to provide pre-hospital medical care for MCI between 2017 and 2018.

Methods. This study was a cross-sectional descriptive quantitative analysis. e EMS Incident Response and Readiness Assessment (EIRRA) tool was used in this study. is tool was designed by the United States National Association of State Emergency Medical Services O cials (NASEMSO) to determine the level of preparedness for MCI. e latest edition was used during the study period. e executive director of NASEMSO, was contacted to request permission for the modi cation of EIRRA so it can be applicable in KSA. e modi ed copy was reviewed and approved by 5 experts before the implementation. e EIRRA tool includes 7 benchmarks: personnel, infrastructure, emergency care system, public awareness

and noti cation, evaluation, mass casualty planning, and governance. ere are 31 indicators under all benchmarks. Each indicator has sub-indicators. Each sub-indicator is assessed using the following rating scale: 0=unknown, one=none, 2=minimal, 3=limited, 4=substantial, and 5=comprehensive. Moreover, this tool was distributed to all Saudi Red Crescent Authority (SRCA) general administration branches in 13 regions in KSA.

The permission to conduct this study from SRCA had been obtained. Moreover, this study was approved by the King Saud Research Ethics Committee. Before the study was conducted, each participant was contacted by phone, and the purpose of the study was brie y described. Consent was obtained after explaining the importance of their contribution.

Statistical analysis. A descriptive analysis of the mean and median values was conducted. Non-parametric tests were the only statistic methods used to identify if there was a signi cant di erence between SRCA 13 branches in terms of level of preparedness to face MCI around KSA. In this study, the Kruskal-Wallis test was used to determine if all 13 regions had signi cant di erences in terms of level of preparedness to face MCI. Moreover, for pairwise comparisons across regions, the Mann-Whitney-Wilcoxon test was used. Statistical Package for Social Sciences, version 21 (IBM Corp., Armonk, NY, USA) software was used to run these statistical tests.

Results. The demographic data were as follows: the total number of centers, operation centers, dispatchers, ambulance drivers, EMT, EMS, field supervisors, physician, ambulance, and non-ambulance response vehicles in each region. These data varied per region. Riyadh, Makkah, Eastern region, and Al Madinah Al

Munawarah have the highest numbers, while the North borders have the lowest numbers as summarized in **Table 1** and **Figure 1**.

The average number of centers is 33.5 centers. **Figure 2** shows the number of centers in each region. Riyadh has the largest number of centers (89 centers, 21%). Makkah and Eastern regions have 3 operation centers, while the remaining regions only have one operation center.

The average number of dispatchers is 30.7. Riyadh has the largest number of dispatchers (n=87), while Aljof and Albaha regions have the smallest number of dispatchers (n=15). The average number of ambulance drivers is 34. Riyadh and Makkah have the most significant number of ambulance drivers, whereas Najran has the lowest number of ambulance drivers.

The average number of EMTs is 354.3. Riyadh and Makkah have the largest number of EMTs, while the North borders have the lowest number of EMTs.

The average number of EMSs is 13.5. Riyadh and Makkah have the largest number of EMS, while Aljof, Tabuk, Albaha, and Najran have the lowest number of EMS. Moreover, there are no EMS in the North borders and Jazan regions.

The average number of physicians is 12.9. Riyadh has the largest number of physicians (n=54) followed by Makkah (n=46), while Najran, Albaha, Aljof, Jazan, and North borders have the smallest number of physicians (n=1).

The average number of ambulance cars is 67.7. Makkah has the largest number of ambulance cars (n=168, 19%) followed by Riyadh (145, 16%) and Eastern region (n=120, 14%). By contrast, Hail (n=30,

Table 1 - The demographic data of 13 regions.

Name of region	Center	Operations center	Dispatchers	Driver	EMTs	EMS	Field supervisors	Physicians	Ambulance cars	Non-ambulatory response cars
Riyadh	89	1	87	93	1206	53	10	54	145	12
Makkah	84	3	38	90	950	40	13	46	168	13
Eastern Region	61	3	52	56	257	20	13	30	120	8
Asir	35	1	22	30	328	10	5	2	69	3
Al Madinah	31	1	43	36	400	14	5	20	62	5
Tabuk	24	1	24	27	245	4	5	5	52	1
Alqasim	23	1	23	30	250	15	5	4	54	3
Jazan	19	1	20	12	200	0	4	1	40	0
Najran	15	1	27	5	198	5	5	1	50	7
Aljof	14	1	15	17	160	1	7	1	28	0
Albaha	14	1	15	17	140	5	5	1	30	0
Hail	14	1	17	15	141	8	5	2	30	1
North border	12	1	17	14	131	0	5	1	32	0
Grand total	435	17	400	442	4606	175	87	168	880	53

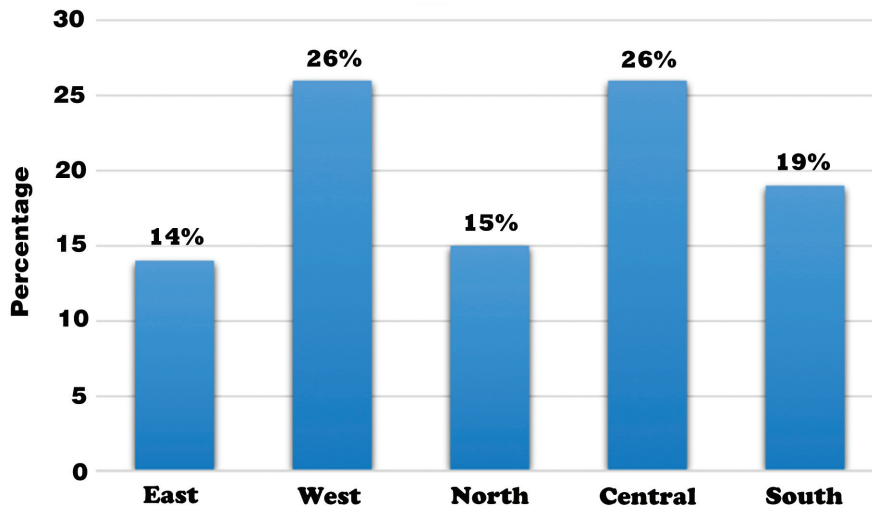EMTs - emergency medical technician, EMS - emergency medical specialists

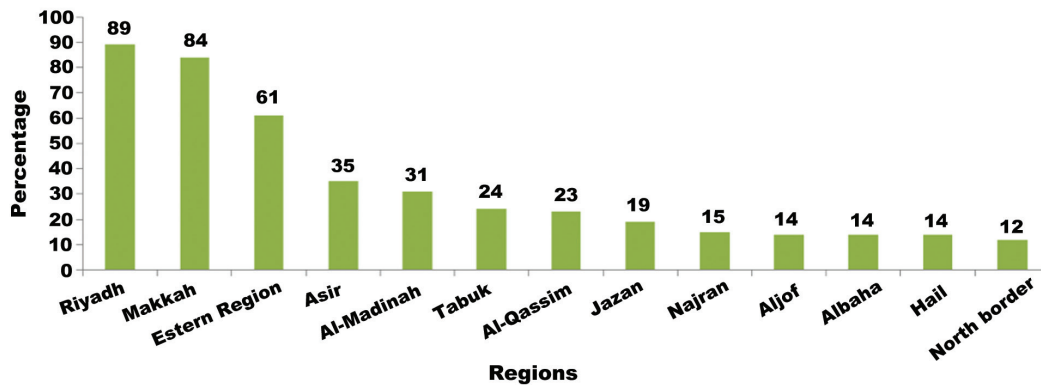**Figure 1 -** The distribution of centers in Saudi Arabia (5 areas).

Figure 2 - Number of centers per region.

3%) and Albaha (n=30, 3%) have the lowest number of ambulance vehicles followed by Aljof (n=28, 3%).

Illustrated in **Table 2**, the median scores for each benchmark as well as the overall median scores across all regions in KSA. Makkah and Madinah obtained a median score of 4, which indicated that their emergency medical system is substantially equipped to manage MCIs. Riyadh, North borders, Eastern region, Tabuk, Jazan, Hail, and Qasim obtained a median score of 3, which indicated that their emergency medical system has limited capabilities to manage MCIs. The remaining regions obtained a median score of 2, which indicated that their emergency medical system has minimal capabilities to manage MCIs.

Moreover, for the entire country, the results showed that the median for all benchmarks is the same (3) except for the evaluation benchmark, which is 2. This

finding indicates that there were no differences between the benchmarks across all regions in KSA.

Furthermore, the result of 5 areas (North, South, Central, East, and West) were analyzed. The West region has a median score of 4, which indicated that their emergency medical system is substantially prepared for managing MCIs. The East, Central, and North regions have a median score of 3, which indicated that their emergency medical system has limited capabilities to manage MCIs. While the South region had a median score of 2, which indicated that their emergency medical system has minimal capabilities to manage MCIs.

The correlation between the overall median scores of each indicator for all regions and the demographic variables are presented in **Table 3**. Results exhibited that a significant correlation was observed between the

Table 2 - The emergency medical specialists incident response and readiness assessment results in 13 regions.

Region	Personnel 100	Infrastructure 200	Emergency care system 300	Public awareness and notification 400	Evaluation of 500	Mass causality planning 600	Governance 700	Overall median score
Makkah	3	4	4	4	3	4	4	4
Riyadh	3	3	3	3	2	3	3	3
Al Madinah	4	4	4	4	4	4	3	4
Aljof	3	2	2	2	3	2	4	2
Asir	4	3	2	2	2	2	2	2
Eastern Region	3	3	3	3	2	4	4	3
Tabuk	3	3	2	3	3	3	3	3
Albaha	3	3	2	4	2	1	1	2
Najran	3	1	2	1	2	2	2	2
Jazan	3	2	3	2	3	3	1	3
Hail	3	3	3	4	3	4	4	3
Alqasim	3	3	3	3	2	3	2	3
North border	3	3	3	4	2	3	3	3
Grand median	3	3	3	3	2	3	3	3

Table 3 - Correlations between the overall median score for each benchmark and demographic variables (N=13).

Variables	Center	Operation center	Dispatcher	Driver	EMT	EMS	Supervisor	Physicians	Ambulance cars	Medics cars
Spearman's rho										
Correlation coefficient	0.428	0.410	0.528	0.471	0.481	0.393	0.182	0.656*	0.504	0.410
Significance (2-tailed)	0.144	0.164	0.064	0.104	0.096	0.184	0.551	0.015	0.079	0.164
*The correlation was significant at the 0.05 level (2-tailed). EMT - emergency medical technician, EMS - emergency medical specialists,										

overall median scores and the number of physicians in the center (r=0.656 and *p*=0.015).

There was a statistical difference in the level of MCI preparedness of the emergency medical system between Makkah and Riyadh regions (*p*=0.038). Moreover, to determine which region has higher levels of MCI preparedness, a one-tailed test was performed and showed a *p*=0.019. This finding indicates that Makkah has higher levels of MCI preparedness than Riyadh.

There is significant difference in the level of MCI preparedness between Makkah and the Eastern region (**Table 4**, *p*=0.038). Moreover, to determine which region has higher level of MCI preparedness, a one-tailed test was performed and showed a *p*=0.019. This finding suggests that Makkah has higher levels of MCI preparedness than the Eastern region.

There was a statistical difference in the levels of MCI preparedness of the emergency medical system between Makkah and Al Madinah Al Munawarah regions (*p*=0.038). Moreover, to determine the level of MCI preparedness of the emergency medical system in each region, a one-tailed test was performed and showed a *p*=0.019. This finding suggests that the emergency medical system in Al Madinah Al Munawarah has higher level of preparedness for MCI than that in Makkah.

Furthermore, there was a statistical difference in the level of MCI preparedness of the emergency medical system between Riyadh and Al Madinah Al Munawarah (*p*=0.038). There was a statistical difference in the level of MCI preparedness of the emergency medical system between West and East regions (*p*=0.026). Additionally, there was a statistical difference in the level of MCI preparedness of the emergency medical system between West and South and West and Central regions (*p*=0.001).

There were no statistical differences in the level of MCI preparedness of the emergency medical system between the East and Central regions (*p*=0.259). However, there was a statistical difference in the level of MCI preparedness of the emergency medical system between the East and South regions (*p*=0.011).

There were no statistical differences in the level of MCI preparedness of the emergency medical system between the East and North regions (*p*=0.259) and between the Central and South regions (*p*=0.073). There were no statistical differences in the level of MCI preparedness of the emergency medical system between the Central and North regions (*p*=1) and between the South and North regions (*p*=0.073).

Table 4 - Ranks and statistical tests [†,‡] (Makkah-Eastern region) N=14.

Region	Number	Mean rank	Sum of ranks	Mann-Whitney U	15.500
Makkah	7	8.79	61.50	Wilcoxon W	43.500
Eastern region	7	6.21	43.50	Z	−1.217
Total	14			asymptotic significance (2-tailed)	0.223
				Exact significance [2*(one-tailed sig.)]	0.038[‡]

† Grouping variable: region, ‡ Not corrected for ties, sig - significance, *multiplication

Discussion. Saudi EMS students reported low perception of and attitudes toward their preparedness for disaster management. To assess the level of MCI preparedness of EMS in KSA, quantitative research is carried out. The findings in this study can be used as a reference to identify the causes of variations in the level of MCI preparedness among the 13 SRCA branches in KSA. Therefore, it will help in improving the preparedness level. The results of this study were divided into 2 parts: demographic results and assessment results.

The distribution of ambulance center and ambulance deployment is affected by the population and size of each region.[16] The 2 regions with the largest number of centers, as shown in **Figure 1**, were Riyadh and Makkah. According to the 2016 Saudi statistical report, Riyadh and Makkah had the highest population among other regions.[17] In Makkah and the Eastern regions, both had the highest number of operation centers. The SRCA organizational chart showed that both regions were divided into 3 units. Makkah region divided into 3 units; Holy Capital unit, Taif unit; and, Jeddah unit when Estern Region divided into AL Ahsa unit, Hafr Albateen Unit and Eastern region unit Each of these units had an operation center connected to the main operation center in both regions with the highest population. To operate an ambulance center, sufficient human resources are needed. Riyadh had the highest number of ambulance centers, which can be affected by the population size. The SRCA used the following 3 criteria to locate a new ambulance station: population size, medical records, which may support the demographic results suggesting that Riyadh had more ambulance stations and personnel than other regions.[18] On the contrary, deployment of ambulance should minimize the population's transportation cost.[16] Makkah had higher number of ambulance vehicles than Riyadh as shown in **Table 1**. This can be due to the preparedness programs offered during Hajj and Umrah seasons, which are the largest annual religious mass gatherings in the world, and the KSA government has provided great attention to these programs.[19]

In the first benchmark, the entire KSA garnered a score of 3, which indicates lack of personnel. The limited number of EMS personnel might be due to the small number of paramedic graduates, as reported in Alaniz's study.[20] In 2012, diploma programs were no longer offered in KSA. In order to become an EMS personnel, one should finish a bachelor's degree in paramedical science as a minimum requirement.[21] Moreover, EMS personnel are trained on how to respond to MCIs. Alshamrani,[22] reported that the SRCA only offered limited trainings to all EMS personnel, and they were asked to perform daily routine work such as basic life support, advanced cardiac life support, pre-hospital trauma life support, and international trauma life support. This finding supports the results of previous studies, which reported that the EMS personnel in KSA lacked training in disaster management.[22] The medical directors are among the important key players in MCI management, should develop guidelines, and must participate in disaster preparedness planning.[23] Saudi Red Crescent Authority lacked EMS consultants who can supervise the day-to-day work of all EMS personnel and assess disaster conditions. In this study, there was a moderate positive correlation between the overall median scores and the number of physicians in the center, which indicates a lower personnel benchmark score. Infrastructure was the second benchmark and one of the important factors in incident management. Infrastructure was determined in overall with limited score. Makkah and Al Madinah Al Munawarah were found to have substantial level of MCI preparedness due to the programs conducted during Hajj and Umrah seasons in these regions. In 2014 (1435 AH), a joint operation room was established during the Hajj season. All emergency agencies participated by sending one dispatcher to work there, and 911 was the universal number used for emergency calls.[3,19,24] The emergency care system benchmark had a lower overall median score. The results of Alsadhan's study,[25] were similar to those reported in this study and suggested that the Saudi

pre hospital care system need to improved. Moreover, Makkah and Al Madinah Al Munawarah were superior than other regions in terms of public awareness and notification and had a higher score in the public awareness benchmark than the remaining regions, which can be attributed to the programs conducted during Hajj season. Saudi Red Crescent Authority had a lower score in the evaluation benchmark, which examines whether the area has an effective evaluation system that can be used to provide a thorough review of the performance of emergency responders during MCIs. Myers,[26] reported a few evidence and measures to review in the EMS performance system. Moreover, a study conducted by Alsadhan,[25] showed that the evaluation system in KSA has limited capabilities to assess the status of pre hospital medical care. Riyadh obtained an overall median score of 3, which indicates that this region had limited preparedness to handle MCIs. Riyadh is the most populous region in the KSA, with an estimated population of 8,002,100.[17] A study conducted in 2011 in the United States of America showed that New York City has limited MCI preparedness. It has a total population of 8,244,910 and has the same status with Riyadh.[17,27,28]

Additionally, the Eastern region obtained a low score in the overall assessment. It is an important energy industrial region in KSA, where the biggest oil company (Saudi Aramco) in the world is located. The Eastern region is the largest province of KSA by area, with a total population of 4,780,619.[17,29] The state of Alabama has the same industrial status, and the total population is very close to that of KSA's Eastern region (4,780,135). It obtained a low score in the same evaluation method in the study conducted by Dia et al.[27,30,31]

The West region had a higher overall score, which may be due to the preparedness programs conducted during Hajj and Umrah seasons. The Saudi Arabian government pays attention to the safety of people attending the pilgrimage. Saudi Red Crescent Authority is a member of Hajj supreme committee. It includes all Saudi emergency agencies, and each of this organization had to prepare a Hajj emergency plan.[3,32] In this study, Riyadh, Makkah, Al Madinah Al Munawarah, and the Eastern region were compared, and results showed that Al Madinah Al Munawarah was the most superior among the regions. A significant difference was observed between Makkah and Al Madinah Al Munawarah in terms of level of preparedness to face MCI. Despite that, both regions conducted the same Hajj preparedness program. The SRCA organization chart showed that Makkah was divided into 3 units based on its population

size. Al Madinah Al Munawarah population that might the cause made Al Madinah Al Munawarah better than Makkah in the preparedness to face MCI.[17,18]

Study limitations. Pre-hospital medical care preparedness has not been tested before, and no baseline data were obtained for this study.

In conclusion, the SRCA prepared well to manage MICs in Makkah and Al Madinah Al Munawarah regions. Riyadh, North borders, Eastern region, Tabuk, Jazan, Hail, and Qasim had a median score of 3. The remaining regions had a median score of 2. Some important aspects were not discussed in this study.

Furthermore, the SRCA should encourage EMS consultants to act as medical directors and supervise all EMS personnel. Moreover, more physicians should be deployed in all regions. Emergency medical specialists personnel preparedness should be improved by establishing a training program related to MCI. All EMS personnel should take the incident command system courses. Additionally, performing regular exercises and drills for MCI at least twice a year is important, and SRCA should take the leadership role. Saudi Red Crescent Authority should take into consideration the importance of implementing a unified management and restructure of the organizational chart in Makkah and Eastern regions. Privatization may be one of the solutions to increase the region's level of MCI preparedness.

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