



JEMTAC

Journal of Emergency Medicine
Trauma & Acute Care

A PEER REVIEWED JOURNAL

OPEN ACCESS

Research article

Current State of Trauma Services in Saudi Arabia

Abdullah Alshamrani^{1,*}, Talal Alshammari², Simon Sawyer³, Brett Williams³

ABSTRACT

Trauma is a major public health problem in Saudi Arabia and a leading cause of mortality and morbidity in young age groups. In 2018, traumatic injuries caused by road traffic accidents were the leading cause of death after ischemic heart diseases. Therefore, a new road safety system is important to reduce the incidence of road accident trauma. First aid care by bystanders to road accidents must be improved to become an effective part of pre-hospital care and avoid aggravation. Moreover, trauma centers need further training and education to provide a high level of trauma care. However, literature about trauma care in Saudi Arabia is lacking. Thus, this paper aims to provide an overview of the Saudi trauma system, emergency medical services, and healthcare providers' training and education efforts.

Keywords: Trauma, trauma system, trauma mortality

¹Department of Community Emergency Health and Paramedic Practice, Monash University, Victoria, Australia, and Department of Emergency Medical Care, Prince Sultan Military College of Health Sciences, Al-Dhahran, Saudi Arabia

²Department of Emergency Medical Care, College of Applied Medical Sciences, Imam Abdulrahman bin Faisal University, Saudi Arabia

³Department of Community Emergency Health and Paramedic Practice, Monash University, Victoria, Australia

*Email:

abdullah.alshamrani@monash.edu

<http://dx.doi.org/10.5339/jemtac.2020.6>

Submitted: 12 December 2019

Accepted: 4 April 2020

© 2020 Alshamrani, Alshammari, Sawyer, Williams, licensee HBKU Press. This is an open access article distributed under the terms of the Creative Commons Attribution license CC BY 4.0, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

كيوساينس
QSCIENCE

دار جامعة حمد بن خليفة للنشر
HAMAD BIN KHALIFA UNIVERSITY PRESS

Cite this article as: Alshamrani A, Alshammari T, Sawyer S, Williams B. Current State of Trauma Services in Saudi Arabia, *Journal of Emergency Medicine, Trauma & Acute Care* 2020;6
<http://dx.doi.org/10.5339/jemtac.2020.6>

TRAUMA OVERVIEW

Trauma is a major problem in Saudi Arabia and a leading cause of mortality and morbidity in young age groups. In 2018, injuries caused by road traffic accidents were the leading cause of death after ischemic heart diseases.¹ Globally, around 1.2 million people are killed in road accidents each year and 90% of the deaths occur in developing countries.² In 2015, the World Health Organization (WHO) estimated road traffic fatalities in Saudi Arabia at 27.4 per 100,000 population, whereas countries such as the US, UK, and Australia had fatality rates between 2.9 and 10.6 per 100,000 people.³ In 2013, road accidents killed one person and injured four others every hour in Saudi Arabia. The Saudi Ministry of the Interior reported 7661 road fatalities (88% male), which is considerably higher than that of other causes of trauma death, such as falling, asphyxia, and burns.^{4,5}

The increasing global population and the rise in vehicle ownership worldwide are expected to increase road traffic deaths by up to 1.9 per 100,000 by 2020.⁶ The number of registered vehicles in Saudi Arabia in 2013 was eight million, nearly double the number 30 years ago. In 2018, Saudi women gained the right to drive a car, which may further boost the number of registered vehicles.⁷ The increase in car registrations is associated with increasing road traffic casualties.⁸ In the past 25 years, 29 studies in Saudi Arabia were about road traffic accidents.⁹ However, studies about the status of trauma and trauma care in Saudi Arabia remain lacking despite the development of the country's Vision 2030. The vision, a development plan to reduce the country's dependence on oil, aims to develop public services, such as health and education, and increase the employment rate, particularly for females. Information in the literature about trauma care in Saudi Arabia is incorrect or misleading.¹⁰ Therefore, the present paper provides an informed overview of the Saudi trauma system, emergency medical services (EMS), and the impact of training and education on healthcare providers.

TRAUMA SYSTEM

Trauma is defined generally as any violence or external force that causes physiological or psychological injury.¹¹ Trauma systems provide a comprehensive care approach for injured patients by building cooperative links between the local healthcare system and the emergency medical system or services. The trauma system aims to ensure that injured people are appropriately cared for, triaged, and transferred to the correct facility with necessary urgency. Therefore, competent professionals are required to perform these steps to ensure that care management is delivered smoothly. The fundamental trauma system components.^{12–14} are shown in Figure 1.



Figure 1. Components of a trauma system.

The trauma system requires eight fundamental elements to provide the correct care for injured people at the appropriate facility in the shortest possible time:

- leadership
- professional resources
- education and advocacy
- information management
- finances
- research
- technology
- disaster preparedness and response: conventional and unconventional.¹²

Correct implementation of a trauma system and its elements reduces the risk of death among injured patients by 15%–20%.^{15,16}

Trauma systems were first recognized and established in the US and subsequently in the UK, Australia, Canada, Hong Kong, and other developed countries. These countries differ in implementation because of local policy, population, and geographical variations. The US first recognized the need for a trauma care system in 1966, when two trauma centers were established in San Francisco and Chicago.¹⁷ Trauma center facilities continued to increase over the decades; by 2002, 1154 centers at

different trauma levels (I, II, III, IV, and V) were built across the US.¹⁸ In 2005, trauma centers at levels I and II were accessible to 69.2% of the US population within 45 minutes by air or road emergency services.¹⁹ The US trauma system reduced trauma mortality and confirmed the relationship between reduced road traffic death rates and the presence of a trauma system.²⁰ The reduction of trauma mortality after serious injury was between 15% and 25%.^{21–23}

In the UK, the trauma care system had some deficiencies that were highlighted in a report by the Royal College of Surgeons (RCS) in 1988.²⁴ One-third of the fatalities were preventable, and two-thirds of noncentral nervous system injuries resulting in death were possibly preventable, with the main causes of death being hypoxia, inadequate hemorrhage control, delayed surgery, and missed injuries. Improvements in trauma care were proposed by the development of pre-hospital care, training doctors in Advanced Trauma Life Support (ATLS), improvement of audit programs to monitor progress, and increasing research into major trauma outcomes. From 1989 to 1997, trauma care improved and trauma mortality reduced by almost 40%.²⁵ In 2003, in accordance with RCS criteria, “perfect” trauma care was only provided in 21% of hospitals in England, Wales, and Northern Ireland.²⁶ In 2010, London launched a reformed trauma system, which was rolled out in regional areas in 2012.^{27,28} In 2017, England had 27 trauma centers (11 for adults and children, 10 for adults, 5 for children, and 1 collaborative center). For injured patients who reached one of these centers alive, their chance of survival improved by 19% over the previous trauma system.²⁹

INJURY PREVENTION

Injury prevention is the first component of a trauma care system, and it plays a substantial role in reducing mortality and disability.³⁰ The Saudi Government’s prevention component was to implement improved road traffic regulations to increase driver and passenger safety in conjunction with a high standard of trauma care, with the goal of reducing road traffic accidents. The factors influencing road accidents are identified in Haddon’s Matrix, which aims to understand the injuries caused and the epidemiological approach to their control. Haddon’s Matrix illustrates the interaction between three factors: humans, vehicles and equipment, and environment.³¹ Based on these factors, road accidents in Saudi Arabia should be lower than other countries. Among the human factors, alcohol is banned; hence, driving under the influence of alcohol is considerably less common. The literature shows a high risk of injury related to drinking alcohol and driving.^{32–35} In the environmental factors, Saudi Arabian conditions are predominantly dry and clear, with snow and black ice being a rarity. Driving in snow or on black ice increases the risk of accidents.³⁶

The Saudi Government introduced regulations, such as mandatory use of seatbelts by drivers and passengers. High-speed driving coupled with low seatbelt use has been associated with many deaths and severe injuries for Saudi car users. In 2010, the Government introduced regulations to implement road safety and speed cameras, with fines imposed on drivers caught speeding. The introduction of speed cameras significantly reduced mortality and the severity of injuries among road traffic casualties.⁹ In 2017, a study investigated the differences in trauma mortality and injury severity between 2005 and 2014 at a Saudi trauma center and after the implementation of the speed camera system.³⁷

Injury severity ($n = 6196$) was measured by the Injury Severity Score (ISS) (scale of 1–75, with 75 indicating most severe injury) and the Glasgow Coma Scale score (GCS score) (scale of 3–15, with 3 indicating deep coma). Results showed the mean for both measurements in order (mean pre-implementation: mean post implementation p value) ISS (16.0: 13.5 $p < 0.001$) and GCS (11.8: 12.2 $p < 0.001$). The mortality rate significantly reduced (pre-implementation: post implementation p value) (184: 50 $p < 0.01$). Despite the improvement, road accident fatalities and trauma remained a concern for the Government and researchers. Areas for further improvement were sought. The pre-hospital care system plays a major role in reducing trauma mortality by triaging and managing injured patients and then transferring them to the appropriate level of trauma center.³⁸ The implementation of trauma care systems shows improved outcomes for injured people, with some differences between countries¹⁰ However, the other main components of a trauma system need to be added to the current state of Saudi trauma care.

PRE-HOSPITAL CARE

Pre-hospital care is the second component of an effective trauma system. High-income countries have few pre-hospital trauma deaths because of improved treatment at the pre-hospital stage.³⁹

Pre-hospital care provides urgent intervention for injured patients, such as bleeding control, airway security, and safe transportation to an appropriate facility.⁴⁰ The US pre-hospital system of care is delivered through emergency services, such as police, firefighters, and ambulance crews, which attend each instance of road trauma. Most US states follow national categories for rescue services by using four levels of emergency medical technician (EMT). The four levels are based on education and qualifications: EMT first responder or trainer, EMT-B basic, EMT-I intermediate, and paramedic⁴¹

Pre-hospital treatment in the UK is provided by the National Health Service ambulance service and emergency paramedics. The UK Government instituted specialist training for paramedics in the early 1990s.⁴² By 1996, all pre-hospital trauma care was being provided by paramedics. Globally, pre-hospital care is primarily provided by trained emergency personnel of different levels, demonstrating the effectiveness of pre-hospital care in reducing trauma mortality.^{43,44}

EMS in Saudi Arabia

EMS are an organized pre-hospital system that aims to care for injured and sick patients and transport them to a hospital if required. Pre-hospital care in Saudi Arabia is provided for the civilian population by the Saudi Red Crescent Authority (the history of the SRCA is described elsewhere⁴⁵). The SRCA's services are distributed throughout the 13 regions of Saudi Arabia. In 2015, the SRCA had 384 centers and more than 1965 vehicles, covering all cities.

Separate pre-hospital care services are provided in military areas and industrial locations, which have their own facilities, vehicles, and staff. Personnel assigned to the Medical Service in the Armed Forces (MSD) provide pre-hospital and in-hospital care for all military areas. The MSD has 24 hospitals and 147 clinics responsible for all medical care for military personnel, civilian defense workers, and their families. The MSD also has mobile hospitals to provide medical care during combat and military training.

Injured patients receive pre-hospital care from one of Saudi's EMS, but it is also common for injured patients to receive initial care from bystanders.

Effective early treatment given by bystanders in nontraumatic cardiac arrest improves outcomes for out-of-hospital cardiac arrest patients.⁴⁶ The frequency of the first aid given by bystanders and the outcomes have been studied in a systematic review.⁴⁷ A 5.8% reduction in mortality was observed after first aid given by a bystander.⁴⁸ The importance of bystander intervention to control bleeding and clear the airway was underlined.^{49,50}

In Saudi, bystanders can hamper the efficiency of EMS workers by crowding the scene and trying inappropriate interventions. Saudi bystanders often do not have a high level of trust in paramedics and sometimes try to transfer the injured person to the nearest hospital themselves, regardless of the patient's condition.⁵¹ However, the SRCA has developed its EMS dispatch protocol to consider public behavior. Bystanders can call 997 to communicate with emergency dispatch. The SRCA has also developed an app for smartphones to speed up lodging an accurate request for EMS. Educating and training bystanders could help minimize the obstacles they present and help improve the quality of pre-hospital care for trauma victims. Training and education for EMS personnel have been improved recently, and EMS core competencies have been developed for an EMS degree.⁵²

EMS personnel are eligible to practice their skills after registering and receiving a healthcare practitioner license from the Saudi Commission for Health Specialties. The minimum degree for an EMT is a diploma equivalent to three-and-a-half years of education. The EMT also requires a qualification in Basic Life Support, Pre-Hospital Trauma Life Support (PHTLS), or International Trauma Life Support (ITLS). A PHTLS or ITLS is mandatory for EMS personnel, including doctors. EMS personnel who have a bachelor's degree or higher are required to provide Advanced Cardiac Life Support and Pediatric Life Support. The SRCA also has doctors who attend trauma scenes and a medical director to ensure the highest quality of service is provided. The role of EMS personnel is to provide life-saving treatment at the scene and to transfer patients to the correct medical facility for the severity of their injuries.

ACUTE CARE FACILITIES

An acute care facility is the third component of a trauma system, which is provided by trauma centers depending on their capability. Trauma centers should provide leadership for the overall trauma system and be committed to injury prevention initiatives, training, and research.⁴⁰ Their responsibility is to provide multiple specialist medical interventions to manage trauma patients with multiple injuries from arrival until the completion of their recovery and rehabilitation.

The Ministry of Health (MOH), along with other governmental and private sector providers, is the main provider of healthcare in Saudi Arabia. The country has 494 hospitals and 75,225 beds, equivalent to one bed for every 445 people. In 2018, the MOH managed 284 hospitals with a budget of approximately \$24 billion (9.20% of government spending). In addition, 163 hospitals were run by other governmental sectors and 47 private hospitals. Trauma centers showed a lower trauma mortality than nontrauma centers.²¹ King Abdulaziz Medical City (KAMC) is one of the largest hospitals in the capital, with a total capacity of more than 700 beds, 132 of which belong to its emergency department. KAMC is equivalent to a level-1 trauma center.³⁷ However, studies on the effectiveness of trauma centers for injured patients in Saudi Arabia are lacking.

POSTHOSPITAL CARE

Trauma is the main cause of disability and, according to WHO, is associated with moderate to severe disability for more than 45 million people annually.^{53,54} Posthospital care is the last component of trauma system care, which aims to provide care for patients with sustained and potentially disabling injuries. This type of care is often the longest and the most difficult phase of care for patients and families. Moreover, the rehabilitation care tends to provide care in different and complex patterns of injuries, and the quality of this care can be challenging.⁵⁵ However, some lines of evidence show an improvement in quality of life after injuries, and others shows functional outcome even a year after injury in trauma centers.^{56,57} However, in Saudi Arabia, despite having posthospital rehabilitation units, evidence that these units are effective in postinjury care for traumatic patients is lacking. One potential solution in improving care for trauma systems and posthospital care is the establishment of a data registry or trauma registry; such registries are key in evaluating the effectiveness of any intervention for patients care and outcome.

Information management is one of the eight fundamental elements of an effective trauma system, which encompasses the idea of a trauma registry. Trauma registries have existed for more than three decades and are designed to provide information about injured patients to trauma facilities to help improve the quality of trauma care.⁵⁸ In a recent global review of trauma registries, the National Trauma Data Bank in the US published 288 studies, the Victorian State Trauma Registry in Australia published 45 studies, and the Trauma Audit and Research Network in the UK published 13 studies.⁵⁹ A trauma registry was established in Saudi Arabia at KAMC in 2001, and it has dramatically increased studies in trauma.^{60–64} By contrast, studies on trauma and trauma training effectiveness for EMS practitioners in Saudi Arabia are absent.

Training and education

Trauma education and training for healthcare providers are crucial in building an effective trauma system. Trauma education aims to improve the quality of trauma care delivered by increasing knowledge, skills, attitudes, and relationship objectives.⁶⁵ Multiple methods, such as lectures, workshops, discussion, skill stations, and scenarios, are available to teach skills and knowledge.⁶⁵ Credentialed trauma courses have been established for many years and dramatically increased skills in ATLS, PHTLS, and ITLS.

In 1978, the first ATLS course was conducted in Nebraska, US, by the American College of Surgeons, which then distributed it widely.⁶⁶ In 2019, the ATLS course was made available in more than 80 countries worldwide.⁶⁷ It is a three-day course for doctors using lectures and practical exams. At the end of the course, participants are required to pass multiple-choice and practical exams.

In the late 1980s, a PHTLS course was developed in the US to meet the needs of EMS professionals. Today, it is a two-day course providing trauma skills and knowledge for paramedics and EMTs, conducted by the National Association of Emergency Medical Technicians. ITLS is another critical course for EMS professionals, first run in 1985 when it was known as Basic Trauma Life Support International. The new name "ITLS," approved in 2005, better reflects its global nature. It is a two-day course that includes lectures and practical exams.^{68–70} Evaluating performance outcomes and practitioner confidence gained from the international course is challenging because of its various training and education components.^{71,72}

Healthcare providers in Saudi Arabia practice according to their practitioners' license, which must be renewed every 5 years. Continuing education and training courses is required to renew a practitioner's license. Education and training are crucial in building a trauma system, but the impact of trauma training courses on trauma mortality outcome is unclear. Evidence in support of ATLS training reducing

trauma mortality is still lacking.⁷³ Furthermore, the management of injured patients by ATLS-certified doctors is worse than that by noncertified doctors in nontrauma centers.⁷⁴ The impact of trauma training and education on healthcare providers in the Saudi trauma system needs to be determined. Whether or not trauma training in Saudi Arabia improves the confidence of healthcare providers in dealing with trauma patients is unknown. Healthcare providers are expected to be confident when dealing with trauma cases. However, a previous study on participants involved in Early Management of Severe Trauma training reported low practitioner confidence in rural hospitals. This low confidence even after attending the course is correlated with the frequency of managing trauma cases.⁷⁵ Improved training enables paramedics to provide advanced levels of care and is expected to improve outcomes, but some studies do not support this finding.^{76–78} The current status of trauma training and education in Saudi Arabia is unknown, and further research is warranted to evaluate the impact of training courses.

CONCLUSION

Trauma is a major public health problem in Saudi Arabia, and the implementation of a new road safety system is important to reduce road traffic accidents. First aid care by bystanders to road accidents must be improved to become an effective part of pre-hospital care and avoid aggravation. The quality of trauma care at trauma centers needs further assessment, and the effectiveness of trauma training and education of healthcare providers requires evaluation.

REFERENCES

- [1] Alghnam S, Alkelya M, Al-Bedah K, Al-Enazi S. Burden of traumatic injuries in Saudi Arabia: lessons from a major trauma registry in Riyadh. *Saudi Arabia. Ann Saudi Med.* 2014;34(4):291–296.
- [2] Peden M, Scurfield R, Sleet D, Mohan D, Hyder AA, Jarawan E, et al. World report on road traffic injury prevention. World Health Organization Geneva; 2004.
- [3] Organization WH. Global status report on road safety 2015; World Health Organization; 2015.
- [4] Ansari S, Akhdar F, Mandoorah M, Moutaery K. Causes and effects of road traffic accidents in Saudi Arabia. *Public health.* 2000;114(1):37–39.
- [5] Al Turki YA. How can Saudi Arabia use the Decade of Action for Road Safety to catalyse road traffic injury prevention policy and interventions? *Int J Inj Contr Saf Promot.* 2014;21(4):397–402.
- [6] Evans JA, van Wessem KJ, McDougall D, Lee KA, Lyons T, Balogh ZJ. Epidemiology of traumatic deaths: comprehensive population-based assessment. *World journal of surgery.* 2010;34(1):158.
- [7] DeNicola E, Aburizaize OS, Siddique A, Khwaja H, Carpenter DO. Road Traffic Injury as a Major Public Health Issue in the Kingdom of Saudi Arabia: A Review. *Frontiers in Public Health.* 2016;4(215).
- [8] Hakim S, Shefer D, Hakkert A-S, Hocherman I. A critical review of macro models for road accidents. *Accident Analysis & Prevention.* 1991;23(5):379–400.
- [9] Mansuri FA, Al-Zalabani AH, Zalat MM, Qabshawi RI. Road safety and road traffic accidents in Saudi Arabia. A systematic review of existing evidence. *Saudi Med J.* 2015;36(4):418–424.
- [10] Dijkink S, Nederpelt CJ, Krijnen P, Velmahos GC, Schipper IB. Trauma systems around the world: a systematic overview. *Journal of trauma and acute care surgery.* 2017;83(5):917–925.
- [11] Kurdin A, Caines A, Boone D, Furey A. TEAM: A Low-Cost Alternative to ATLS for Providing Trauma Care Teaching in Haiti. *J Surg Educ.* 2018;75(2):377–382.
- [12] US National Highway Traffic Safety Administration. Trauma system agenda for the future 2019. Available from: <https://one.nhtsa.gov/people/injury/ems/emstraumasystem03/comprehensivevlll.htm>.
- [13] Borgohain B, Khonglah T. Developing and organizing a trauma system and mass casualty management: some useful observations from the Israeli trauma model. *Ann Med Health Sci Res.* 2013;3(1):85–89.
- [14] World Health Organization. Who global alliance for care of the injured (gaci) 2019. Available from: <https://www.who.int/emergencycare/gaci/en/>.
- [15] Mullins RJ, Mann NC. Population-Based Research Assessing the Effectiveness of Trauma Systems. *The Journal of Trauma: Injury, Infection, and Critical Care*; 1999.
- [16] Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma.* 2006;60(2)(371-8):discussion 8.
- [17] Starr P. The social transformation of American medicine: The rise of a sovereign profession and the making of a vast industry. Basic books; 2008.
- [18] MacKenzie EJ, Hoyt DB, Sacra JC, Jurkovich GJ, Carlini AR, Teitelbaum SD, et al. National Inventory of Hospital Trauma Centers. *JAMA.* 2003;289(12):1515–1522.
- [19] Branas CC, MacKenzie EJ, Williams JC, Schwab CW, Teter HM, Flanagan MC, et al. Access to Trauma Centers in the United States. *JAMA.* 2005;293(21):2626–2633.
- [20] Shafi S, Nathens AB, Elliott AC, Gentilello L. Effect of trauma systems on motor vehicle occupant mortality: A comparison between states with and without a formal system. *J Trauma.* 2006;61(6)(1374-8):8–9.
- [21] MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, et al. A national evaluation of the effect of trauma-center care on mortality. *New England Journal of Medicine.* 2006;354(4):366–378.

- [22] Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *Journal of Trauma and Acute Care Surgery*. 2006;60(2):371–378.
- [23] Durham R, Pracht E, Orban B, Lottenburg L, Tepas J, Flint L. Evaluation of a mature trauma system. *Annals of surgery*. 2006;243(6):775.
- [24] Anderson I, Woodford M, De Dombal F, Irving M. Retrospective study of 1000 deaths from injury in England and Wales. *Br Med J (Clin Res Ed)*. 1988;296(6632):1305–8.
- [25] Lecky F, Woodford M, Bouamra O, Yates D. Lack of change in trauma care in England and Wales since 1994. *Emergency Medicine Journal*. 2002;19(6):520–523.
- [26] Browne J, Coats T, Lloyd D, Oakley P, Pigott T, Willett K, et al. High quality acute care for the severely injured is not consistently available in England, Wales and Northern Ireland: report of a survey by the Trauma Committee, The Royal College of Surgeons of England. *The Annals of The Royal College of Surgeons of England*. 2006;88(2):103–107.
- [27] Vondy A, Willett K. Trauma care in England: London's trauma system goes live. *Emergency medicine journal: EMJ*. 2011;28(3):250.
- [28] Lendrum R, Lockey D. Trauma system development. *Anaesthesia*. 2013;68:30–39.
- [29] Moran CG, Lecky F, Bouamra O, Lawrence T, Edwards A, Woodford M, et al. Changing the system-major trauma patients and their outcomes in the NHS (England) 2008–17. *EClinicalMedicine*. 2018;2:13–21.
- [30] Harris T, Davenport R, Hurst T, Jones J. Improving outcome in severe trauma: trauma systems and initial management; 2012.
- [31] Haddon Jr W. Advances in the epidemiology of injuries as a basis for public policy. *Public health reports*. 1980;95(5):411.
- [32] Gruenewald PJ, Nephew T. Drinking in California: Theoretical and empirical analyses of alcohol consumption patterns. *Addiction*. 1994;89(6):707–723.
- [33] Treno AJ, Gruenewald PJ, Ponicki WR. The contribution of drinking patterns to the relative risk of injury in six communities: a self-report based probability approach. *Journal of Studies on Alcohol*. 1997;58(4):372–381.
- [34] Freedland ES, McMicken DB, D'Onofrio G. Alcohol and trauma. *Emerg Med Clin North Am*. 1993;11(1):225–239.
- [35] Rehm J, Gmel G, Sempos CT, Trevisan M. Alcohol-related morbidity and mortality. *Alcohol Res Health*. 2003;27(1):39–51.
- [36] Pawłowski W, Goniewicz K, Naylor K, Goniewicz M, Lasota D. Risk indicators for road accident in Poland for the period 2004–2017. *Central European journal of public health*. 2018;26(3):195.
- [37] Alghnam S, Alkelya M, Alfraidy M, Al-Bedah K, Albabtain IT, Alshenqeety O. Outcomes of road traffic injuries before and after the implementation of a camera ticketing system: a retrospective study from a large trauma center in Saudi Arabia. *Ann Saudi Med*. 2017;37(1):1–9.
- [38] Cameron PA, Gabbe BJ, Cooper DJ, Walker T, Judson R, McNeil J. A statewide system of trauma care in Victoria: effect on patient survival. *Medical Journal of Australia*. 2008;189(10):546–550.
- [39] Mock CN, Jurkovich GJ, Arreola-Risa C, Maier RV. Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. *Journal of Trauma and Acute Care Surgery*. 1998;44(5):804–814.
- [40] Trauma ACoSo. Resources for optimal care of the injured patient: *Amer College of Surgeons*; 1990.
- [41] Smith RM, Conn AK. Prehospital care - Scoop and run or stay and play? *Injury*. 2009;40(4):S23–S26.
- [42] Carney CJ. Prehospital care—a UK perspective. *Br Med Bull*. 1999;55(4):757–766.
- [43] McNicholl B. The golden hour and prehospital trauma care. *Injury*. 1994;25(4):251–254.
- [44] Honigman B, Rehweder K, Moore EE, Lowenstein SR, Pons PT. Prehospital advanced trauma life support for penetrating cardiac wounds. *Annals of emergency medicine*. 1990;19(2):145–150.
- [45] AlShammari T, Jennings P, Williams B. Evolution of emergency medical services in Saudi Arabia. *Journal of Emergency Medicine, Trauma and Acute Care*. 2017;2017(1):4.
- [46] Nolan JP, Soar J, Zideman DA, Biarent D, Bossaert LL, Deakin C, et al. European resuscitation council guidelines for resuscitation 2010 section 1. Executive summary. *Resuscitation*. 2010;81(10):1219–76.
- [47] Tannvik T, Bakke H, Wisborg T. A systematic literature review on first aid provided by laypeople to trauma victims. *Acta Anaesthesiologica Scandinavica*. 2012;56(10):1222–1227.
- [48] Murad MK, Husum H. Trained lay first responders reduce trauma mortality: a controlled study of rural trauma in Iraq. *Prehosp Disaster Med*. 2010;25(6):533–539.
- [49] Ashour A, Cameron P, Bernard S, Fitzgerald M, Smith K, Walker T. Could bystander first-aid prevent trauma deaths at the scene of injury? *Emergency Medicine Australasia*. 2007;19(2):163–168.
- [50] Henriksson E, Öström M, Eriksson A. Preventability of vehicle-related fatalities. *Accident Analysis & Prevention*. 2001;33(4):467–475.
- [51] Alanazi AF. Emergency medical services in Saudi Arabia: A study on the significance of paramedics and their experiences on barriers as inhibitors of their efficiency. *International Journal of Applied and Basic Medical Research*. 2012;2(1):34.
- [52] AlShammari T, Jennings PA, Williams B. Emergency medical services core competencies: a scoping review. *Health Professions Education*. 2018;4(4):245–258.
- [53] Organization WH. World Health Organization global burden of disease. Geneva: World Health Organization. 2007.
- [54] Robinson LR. Trauma rehabilitation: Lippincott Williams & Wilkins; 2006.
- [55] Huyse Frits J, Stiefel F. Integrated care for the complex medically ill: Saunders; 2006.
- [56] Gabbe BJ, Biostat GD, Simpson PM, Sutherland AM, Dip G, Wolfe R, et al. Improved functional outcomes for major trauma patients in a regionalized, inclusive trauma system. *Annals of surgery*. 2012;255(6):1009-15.
- [57] Gabbe BJ, Sutherland AM, Hart MJ, Cameron PA. Population-based capture of long-term functional and quality of life outcomes after major trauma: the experiences of the Victorian State Trauma Registry. *Journal of Trauma and Acute Care Surgery*. 2010;69(3):532-6.
- [58] Moore L, Clark DE. The value of trauma registries. *Injury*. 2008;39(6):686-95.

- [59] O'Reilly GM, Cameron PA, Joshipura M. Global trauma registry mapping: a scoping review. *Injury*. 2012;43(7):1148-53.
- [60] Aljerian N, Alhaidar S, Alothman A, AlJohi W, Albaqami FA, Alghnam SA. Association between the mode of transport and in-hospital medical complications in trauma patients: findings from a level-I trauma center in Saudi Arabia. *Ann Saudi Med*. 2018;38(1):8-14.
- [61] Alhusain FAM, Alhassan NFA, Aljohi WAA, Alrumaih FI, Al Jerian NA, Alharthy NA. Paediatric emergency department during the holidays: Findings from a 10-year analysis of visit rates and trauma patterns. *Journal of Health Specialties*. 2017;5(3):142.
- [62] Alselaime N, Malaekah H, Saade M, Hussein M, AlTokhais T, Albedah K, et al. Does obesity impact the pattern and outcome of trauma in children? *Journal of pediatric surgery*. 2012;47(7):1404-9.
- [63] Alghnam S, Palta M, Hamedani A, Alkelya M, Remington PL, Durkin MS. Predicting in-hospital death among patients injured in traffic crashes in Saudi Arabia. *Injury*. 2014;45(11):1693-9.
- [64] Alghnam S, Towhari JA, Al Babbain I, Al Nahdi M, Aldebasi MH, Alyami M, et al. The associations between injury mechanism and extended hospital stay among pediatric patients: findings from a trauma Center in Saudi Arabia. *BMC pediatrics*. 2019;19(1):177.
- [65] Carley S, Driscoll P. Trauma education. *Resuscitation*. 2001;48(1):47-56.
- [66] Driscoll P, Wardrope J. ATLS: past, present, and future. *British Association for Accident and Emergency Medicine*. 2005.
- [67] Surgeons ACo. ATLS International Promulgation; 2019. Available from: <https://www.facs.org/quality-programs/trauma/atls/promulgation>
- [68] Gwinnutt C, Driscoll P. Advanced trauma life support. *European journal of anaesthesiology*. 1996;13(2):95-101.
- [69] Ali J, Adam RU, Gana TJ, Bedaysie H, Williams JI. Effect of the prehospital trauma life support program (PHTLS) on prehospital trauma care. *Journal of Trauma and Acute Care Surgery*. 1997;42(5):786-790.
- [70] Ali J, Cohen RJ, Gana TJ, Al-Bedah KF. Effect of the Advanced Trauma Life Support program on medical students' performance in simulated trauma patient management. *Journal of Trauma and Acute Care Surgery*. 1998;44(4):588-591.
- [71] Holcomb JB, Dumire RD, Crommett JW, Stamateris CE, Fagert MA, Cleveland JA, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. *Journal of Trauma and Acute Care Surgery*. 2002;52(6):1078-1086.
- [72] Forsetlund L, Bjørndal A, Rashidian A, Jamtvedt G, O'Brien MA, Wolf FM, et al. Continuing education meetings and workshops: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews*. 2009(2).
- [73] Mohammad A, Branicki F, Abu-Zidan FM. Educational and clinical impact of Advanced Trauma Life Support (ATLS) courses: a systematic review. *World journal of surgery*. 2014;38(2):322-329.
- [74] Drimousis PG, Theodorou D, Toutouzias K, Stergiopoulos S, Delicha EM, Giannopoulos P, et al. Advanced Trauma Life Support certified physicians in a non trauma system setting: is it enough? *Resuscitation*. 2011;82(2):180-184.
- [75] Lopez DG, Hamdorf JM, Ward AM, Emery J. EARLY TRAUMA MANAGEMENT SKILLS IN AUSTRALIAN GENERAL PRACTITIONERS. *ANZ Journal of Surgery*. 2006;76(10):894-897.
- [76] Sookram S, Tse A. Paramedical and Nonmedical Personnel. Trauma Team Dynamics. Springer. 2016. p. 35-38.
- [77] Smith RM, Conn AK. Prehospital care- Scoop and run or stay and play? *Injury*. 2009;40:S23-S26.
- [78] Conn AK. BCLS Versus ACLS. Penetrating Trauma: Springer. 2012. p. 29-33.