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An Overview of the Ambulance Safety: Towards the Improvement in ASEAN Countries

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Abstract – *Ambulances have been utilized as one of the important vehicles in operating the Emergency Medical Services (EMS) system. As safety is the utmost priority for an EMS crashes involving ambulances would not only delay patient transfers but would also endanger its occupants and other road users. Although the numbers of accidents involving ambulances are considered to be low as compared to other types of vehicles, preventive measures need to be taken in order to eliminate the high risk of accidents occurring as ambulances should be able to provide reliable and safe emergency transport services for the benefit of the public. An overview of ambulance accidents is highlighted in this paper. Based on the literature reviews, four main factors have been identified as the contributor to the causes of the accidents involving ambulances – driver-related factor, vehicle-related factor, task-related factor, and environment-related factor. From the findings, future research should be focused on creating mitigation plans on a structured preventive measure that could be implemented particularly in reducing fatal accidents involving the ambulance in ASEAN countries.*

Keywords: Ambulance accidents, safety, driver-related factor, vehicle-related factor, task-related factor, environment-related factor

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1.0 INTRODUCTION

An ambulance is one of the most important health services in providing a fast response on prehospital care whilst transporting a patient to the hospital for extensive care. Moreover, an ambulance is a specialized vehicle meant to transport the sick or injured person, safely to a medical treatment facility (Vijaindren & Jay, 2019; Becker et al., 2003).

Although we know that an ambulance is one of the most important forms of transport being used by the EMS, there is no exception for the ambulance from being involved in a road accident. Crashes involving ambulances would not only delay patient transfer but could also endanger its occupants and other road users. (Sanddal et al., 2008; Macdonald-Ames, 2020; Pattanarattanamolee et al., 2017).

Why do ambulance crashes happen? – since we know that the ambulance has always been associated with the transportation of patients to hospitals for medical treatment. This is probably due to the high traveling speeds of the ambulance since patients needed to be ferried to the hospital within the shortest time possible. Although sharing similar features with some vehicle types, a higher risk is attached towards ambulances as having a higher potential being involved in an accident. (Ersoy et al., 2012).

The statistic has shown that ambulances on a per mile basis, poses a threat of being thirteen times higher in terms of risk involvement in traffic accidents as compared to other vehicles. (Ersoy et al., 2012).

Ambulance accidents not only happen in middle and low-income countries but also involves high-income countries such as the United States. It is a substantial problem in the United States for the accidents involving their emergency vehicles (Arnold, 2018). Between 1993-2010, there were approximately 97 fatalities involving EMS staff in ambulance crashes (Maguire et al., 2002).

The National Highway Traffic Safety Administration (NHTSA) has released a report in April 2014 whereby the agency had carried out a study on ambulance accidents over a 20-year period in which data was collected from 1992-2011. They have revealed that an estimated 6,500 accidents involving ambulances occurred each year, with 35% of crashes resulted in injury or fatality to at least one occupant (Arnold, 2018). Another study that was done with statistical data collected, states that on average, 2,600 people are injured in 1,500 ambulance accidents each year and nearly 60% of ambulance accidents occur during an emergency use (Sutliff & Stout, Injury & Accident Law Firm, n.d.).

Besides the USA, ambulance accidents happened in ASEAN Countries with low-income and middle-income countries. Data has shown that the rate of ambulance accidents in Thailand for 2014 was 0.05, with a mortality rate of 0.02 per 1,000 operations, or there were 130 injured victims with 19 deaths per year (Pattanarattanamolee et al., 2017). In Malaysia, the statistics show that 646 cases happened between the years 2006-2014 with an average of 129 cases per year. In addition to that, referring to the available report, most ambulance accidents occurred during the daytime at around 70.4 percent, 55.7 percent on weekdays, 49.7 percent of accidents on straight roads, and 35.4 percent happened on federal roads (Vijaindren & Jay, 2019).

Besides Malaysia and Thailand, the number of accidents in Indonesia shown an incremental figure every year. Although the accidents cases involving ambulances are still considered low as compared to other types of vehicles, preventive measures are needed to be taken in order to eliminate the risk of accidents from occurring, as ambulances should provide reliable and safe emergency transport services for the benefit of the public. Thus, in this paper, the contributing factors towards the occurrence of ambulance accidents in ASEAN countries will be deliberated and shared as the findings.

2.0 CONTRIBUTING FACTORS TOWARDS THE AMBULANCE ACCIDENTS

Road accidents can be caused by many factors from different scenarios. According to the Malaysian Institute of Road Safety Research (MIROS), there are four elements of risk in road crashes which are vehicles, humans, roads, and systems.

Ambulance accidents do happen because of the challenges that ambulance drivers face when they are on duty. According to Dewar et al. (2007), ambulance crash is attributable to losing control of set procedures during interactions with the system of road users, vehicles, and the environment. The study shows that these interactions could include a) road users' personality traits and their belief systems; their education level and acquired training; and their states of physical, mental, and emotional; (b) vehicle design, maintenance, and operation, including safety features and systems; (c) the built and natural environment, including infrastructure, roads, and traffic control devices; and (d) climate conditions (Dewar et al., 2007).

Other than that, proper action must be taken in order to reduce and avoid ambulance accidents from happening that can increase the likelihood of fatality. Many studies had researched the risk factors that can lead to ambulance accidents such as shown in Table 1.

Table 1: Example of studies related to risk factors of ambulance accidents

No	Risk Factors	Sources
1	Driver workload and fatigue from having long driving hours and irregular shifts	Abdelwanis, 2013
2	Vehicle weight and mechanical malfunctions	USFA, 2002
3	Lack of recognition of emergency vehicles by other drivers	Saunders & Heye, 1994
4	Lack of training and qualifications for operating heavy vehicles	USFA, 2014
5	Complicated urban intersections	Retting et al., 1995
6	Risky driving	Savolainen et al., 2009
7	High traffic volumes in urban areas	Ray & Kupas, 2007

In general, the contributing factors towards ambulance accidents were categorized under four main areas as shown in Figure 1. The driver-related factor is focusing more on driver behavior and experience and also individual differences. Factors related to vehicle include its warning signal, in-vehicle equipment and its characteristics.

The task-related factors are more focused on the task that ambulance drivers must face as challenges whilst being on duty; it includes task challenges such as time pressure, secondary task demands, prognostic failure, long shift hours, and driving under emotional distress. While environment-related factors do include intersections and configurations of roads and the driver's interactions with natural or environmental conditions such as light, weather and pedestrian.

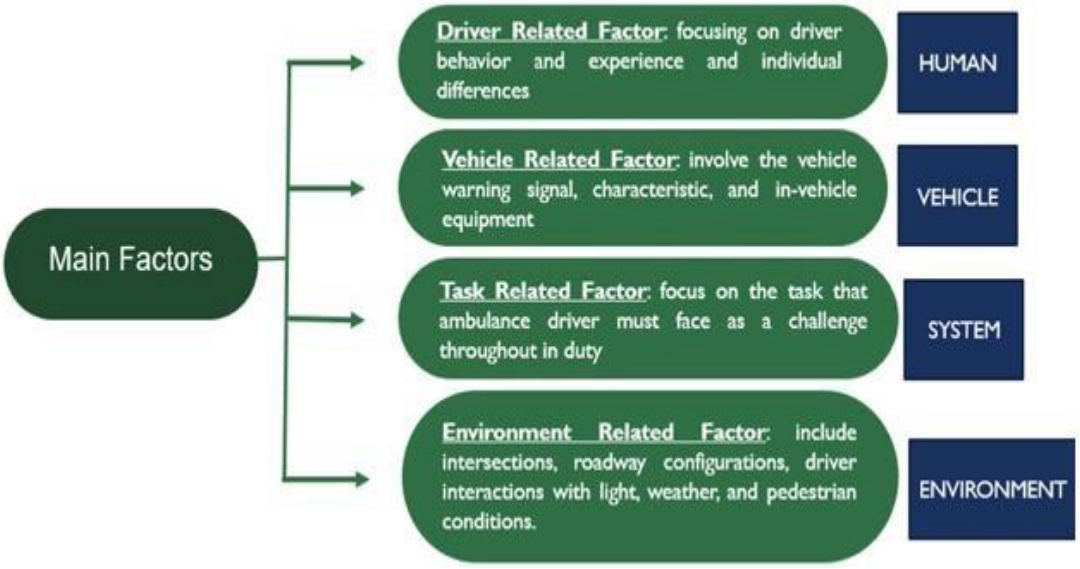

Figure 1: Main factors of ambulance accidents

2.1 Driver-related Factor

Operating any emergency vehicle could be affected by various personal factors that tend to decrease individual performance levels during periods of intense activity. All the factors can be synthesized into individual differences, driver's experience, and driver's behavior.

2.1.1 Individual Differences

Every individual is different from one another and one of the individual differences that can affect performance in driving the emergency vehicle are age and gender. This is because many studies have shown that age and gender are likely to affect driving performance and behavior. Young driver and old driver performance and behavior are not the same as each other. Young drivers usually are more eager when it comes to driving. They tend to drive faster and more aggressively compared to an older driver. According to Boyce & Geller (2002) and Horswill et al. (2020), young drivers (< 25 years) usually drive significantly faster. Moreover, Eluru et al. (2010), define that, younger drivers will be highly prone towards making bad judgements and being involved with severe crashes.

Based on those studies, it clearly shows that young emergency vehicle drivers do increase the chances of an ambulance accident happening because of their behavior. On the contrary, there is also no exception towards older drivers because they would also tend to be involved in a crash due to their differences. Older drivers may not possess the behavior of driving fast and aggressively any longer, but they could have declined in performance and slacks in making better judgment calls.

2.1.2 Driver Experience and Training

While there are factors that affect ambulance drivers as they age, but these problems can all be countered by providing sufficient, scheduled, and continuous training to the drivers. In order to gain enough experience to face various situations efficiently. This is because that aging is not a contributing factor on emergency vehicle driving as all emergency vehicle drivers are

required to undergo specific training and qualifying tests to be certified professionals. (Abdelwanis, 2013; Savolainen et al., 2009; USFA, 2014).

Lack of experience and training can be very dangerous both to the driver and public road users. This is because training must be repeated until the ambulance driver is qualified and ready to take on the task of driving the emergency vehicle on duty. Moreover, the then MIROS Chairman, Tan Sri Lee Lam Thye (Bahaudin, 2018) asserted that ambulance drivers need special training. It clearly expresses that adequate training is crucial for ambulance drivers. This is because due to lack of training and experience makes crashes involving emergency medical vehicles to occur in higher frequency and would involve drivers with less than 3 years of driving experience. (Custalow & Gravitz, 2004; Prohn & Herbig, 2020). The studies show that an experienced driver is more likely to avoid crashes compared to an inexperienced driver. This is because Cavallo & Laurent (1988) defined that drivers with experience mostly possess improved driving competency and having higher adaptive in controlling stress and time pressure, better skills to narrow the focus of attention appropriately, clever use of visual information, having precautionary sense for predictable contingencies, and a more calculated decision-making process.

The experienced driver also will adapt in operating the emergency medical vehicle because of repeated training. This is because the emergency medical vehicle is different in size and weight. With sufficient training and experience, ambulance drivers will be more familiar with operating a particular vehicle. However, the (USFA, 2002) strongly opposes the idea of being over-confident in ones driving ability among experienced emergency vehicle drivers, as it could lead to riskier driving maneuvers during ED and eventually leads to a crash.

2.1.3 Driver Behavior

There are much bad behavior and risky attitudes that emergency vehicle driver does that can lead to a crash. Crashes can happen due to speeding, riskier and aggressive driving styles. These behaviors are intolerable for an ambulance driver because it poses danger to other drivers and for the safety of patients riding inside the ambulance.

These drivers are being subjected to constant time pressure and due to the urgency nature of emergency duty. Additionally, the effects of the siren syndrome tend to cause a delusion among emergency vehicle drivers having the false sense of invincibility with their warning lights and sirens turned on. (USFA, 2014).

Based on the studies, ambulance drivers cannot use the warning lights and sirens as an advantage for speeding and risky driving. Even though the warning lights and sirens are in use, the driver must always follow the rules and regulations on the road for the safety of the driver and the patient. This behavior should not be taken lightly as an ambulance driver because there are many lives on their hands.

Overconfident behavior due to long experience in driving also cannot be taken lightly due to miss judgment on the road that can cause crashes to happen. Due to overconfident, a particular emergency vehicle driver with a previous crash record is more likely and has the indicator of being involved in another crash. Custalow and Gravitz (2004) noted that ambulance drivers who've experienced multiple collisions totaling 49%, were also then responsible for 71% of all ambulance collisions in Denver from 1989 to 1997.

2.2 Task-related Factor

When accidents happened, emergency medical services such as ambulances will respond immediately in helping the people that are involved in the accident. So, when responding to these emergency calls, an ambulance driver will have to drive as fast as possible to reach the destination on time to save lives. Usually, an ambulance driver will turn on the warning light or siren so that public drivers are aware that an ambulance is on their way to respond to an emergency.

In task-related factors, few sub-factors have been identified as part of the contributing factors of ambulance accidents such as time pressure, secondary task demand, prognostic failure, long shift hours, and driving under emotions.

2.2.1 Time Pressure

Time pressure can be considered as one of the most dangerous task-related factors. Time pressure can increase the potential of a crash due to the urgency that forces the driver to drive exceeding the speed limit. This happens because, during high-speed driving, it is difficult for the driver to make proper decision making at the same time, and dealing with the size and weight of the ambulance, the time needed for the ambulance to stop or maneuver towards avoiding crashes also increases. Time pressure does not just lead to premature decision-making, it would impair cognitive performance and health.

2.2.2 Secondary Task Demand

During emergency vehicle driving, the task is not only to transport the patient to the hospital for extensive care. Ambulance drivers always tend to have additional tasks while driving such as having a conversation or dialing from the hospital or to an accident victim. This additional task can decrease the performance of an emergency vehicle driver and distract their focus off from the road. The distraction from these conversations can be worst in traffic due to the higher number of public vehicles. This is attributable towards a higher mental burden (e.g., information processing) and could disrupt driving attention, particularly in high traffic density areas (Recarte & Nunes, 2002; Recarte & Nunes, 2003; Narad et al. 2020).

The secondary task also demands the driver to look away from focusing only on the road. When this happens during an emergency driving situation, their response time to outmaneuver a crash will be slower. Taken into perspective, a five-second visual distraction caused by phone texting, at 90 km/hour (the general speed limit of a federal road in Malaysia), a car would have been able to travel the length of a football field on its own.

Other multitasking such as communicating or looking at other occupants and operating equipment while driving would also lead to bad effects on the driver's performance which indirectly increases the likelihood of a crash happening. As it is discovered that inattention being the most frequent cause of crashes at 46% of emergency driving situations and being the second most frequent at 23% during non-emergency driving (Saunders & Heye, 1994).

2.2.3 Prognostic Failure

Prognostic failure is also a part of the contributing factors in ambulance accidents. Prognostic failure happens when the ambulance driver assumes that other public drivers will comply to stop or slow down their vehicle immediately during the upcoming red light. Having this flawed

assumption induces unpredictable traffic conflicts at signalized intersections. Ambulance drivers under stress during emergency driving could experience severe prognostic failures at signalized intersections. Possessing the believe that they had the right-of-way, as the "code 3 running" with lights and sirens entitles them so (USFA, 2014). This assumption is a fallacy as drivers believe they had given enough visual marker and indicators of an emergency situation, and one that warrants other road users to comply. This could cause drivers from differing sides to outmaneuver and being forced into unavoidable situations that leads to crashes.

2.2.4 Long Shift Hours

Working for long hours can lead to mental and physical stress that would cause the ambulance driver to be drowsy along the way. When driving for a long time, naturally it will lead a person to become fatigued or exhausted that can negatively affect their performance and reaction-time while driving.

Healthcare workers in the Ministry of Health (MOH) Malaysia have been reported to be subjected unbalanced shift hours and on-call duty rosters that ranges from 24 hours to 36 hours, often being non-stop working. USFA (2014) stated that fatigued and drowsy drivers may experience delayed reaction time and takes longer to recognize road hazards. Fatigue reduces visual efficiency and obstructs sound decision-making, such as overestimating the distance towards a traffic-signs and seeing larger variations in lane position (Liu & Wu, 2009). The serious danger posed to drivers is that these symptoms of body fatigue and drowsiness whilst driving are unrecognizable until the crash has taken place.

2.2.5 Driving Under Emotions

It is unavoidable for a person not to be exposed to bad emotions whilst having to respond to every emergency call and being fully prepared to drive at any time once summoned (Requardt et al., 2020). This situation will lead to drivers driving under various emotional states. Ambulance drivers also have to face any unfamiliar areas with probable bad driving behaviors such as improper lane changes and sudden stops, dangerous rural driving conditions, and having a potentially high risk of contracting an illness from the patient. This leads to other heavy emotional burdens on the driver. These stressful conditions will probably give a negative side effect on the ambulance driver's performance.

2.3 Vehicle-related Factor

Ideally, ambulances should be specifically designed to support specific operations and functions. Although, some emergency vehicles were initially designed based on a regular or commercially available vehicle, but it is then enhanced with specialized equipment to increase the performance when driving these vehicles. The emergency vehicle also performs differently compared to the regular and commercial vehicle due to these modifications that make emergency vehicle design more unique. Furthermore, because of the unique design and functions, sharing the road with other road users often presents an upgraded challenge for the emergency vehicle driver to handle and the public driver to accommodate.

2.3.1 Vehicle Characteristic

The ambulance is different from other regular passenger vehicles because of its specialized characteristics and design but the main difference is its weight and size. The size of an ambulance is usually heavier than other commercial vehicles such as a van. This is due to the

equipment that they had installed such as the portable power and climate-controlled storage. The ambulance also has a large space to transport patients to the hospital. So, it must have adequate space for them to treat the patients effectively before moving or during the ride. With the large size of space needed and equipment installed, the weight of the ambulance also increases, hence it poses a threat to other public drivers during a crash but it is also meant to protect the patients and other occupants inside the ambulance.

The disadvantages from the large size and weight as it also affects the style of driving. Compared to a general motor vehicle, an emergency vehicle such as an ambulance is much harder to steer and maneuver due to its characteristics. The duration to stop the vehicles during potential crash incidents is also longer compared to other general motor vehicles. According to Horberry et al. (2004), Heavier and often larger emergency vehicles (e.g., fire trucks and ambulances) are usually harder to control and would require special maneuvering skills to be operated on roads. Moreover, heavy and large emergency vehicles has a higher center of gravity compared to smaller vehicles, and this demand drivers having the necessary training and experience to optimize its operational capacity (Custalow & Gravitz, 2004).

Based on studies, because of the higher center of gravity, an emergency vehicle such as an ambulance produces great momentum during turning at intersections. So, this will affect the driver in maneuvering and controlling the vehicle. Muir et al. (2020) has proposed a solution so that emergency vehicle operate and turn the vehicle slowly. But the downside is that when making turns at the intersections with low speed can increase the chance of collision with other vehicles.

In addition, the larger size of an ambulance could affect other road users. This is because due to its large size, it would obstruct the view of vehicle drivers nearby. It can affect other driver's visual information for decision-making during an overtake or during traffic signal changes. This can increase the likelihood of crashing onto other road users. During an overtake, the other vehicle's driver must make the proper calculation due to the length of the ambulance. Pure assessment and judgment can increase the chance of a crash happening. Based on studies from Muir et al. (2020), while larger vehicles are highly noticeable and can be detected earlier, but it takes considerably longer for adjacent drivers to assess the speed and length of a large vehicle. As their assessment accuracy is typically lower, this would adversely delay their decision making. It is known that road sharing between emergency vehicles with other road users can be difficult and often very challenging.

2.3.2 In-vehicle Equipment

In-vehicle equipment also contributes to accidents involving ambulances. Ambulances usually are equipped with a radio transmitter, warning devices, laptop computer, and map navigator) interaction using this equipment while driving can increase the likelihood of fatal crashes. According to USFA (2014) Most often the case, these ambulance drivers needs to interact with their in-vehicle equipment (e.g., radio transmitter, warning devices, laptop computer, and map navigator) whilst driving. Dabbling with multiple equipment clusters and trying to operate them during driving periods has a negative impact unto drivers. These multitasking activity forces the driver to be distracted of the road and indirectly makes slower decisions upon any crash avoidance. Thus the multitasking gives a negative impact on the ambulance driver.

2.4 Environment-related Factor

The performance of an emergency vehicle driver could also be affected by environmental factors including road design, traffic signal, weather, and various other road conditions. Although having varying degrees of impact to the driver, it could still lead to poor driver's performance. Other public drivers are also affected by environmental factors, this indirectly induces a challenge to both emergency vehicle drivers and other road users when converging on the same stretch of road.

2.4.1 Intersection

The intersection is one of the most hazardous places where an ambulance and other road users crash could crash into each other. Intersections with more lanes can give a minimal turning radius for an ambulance due to its large size and weight. Crash at intersections would also happen because road users are not aware of the presence of an ambulance until it is too late. This situation makes it more difficult for the ambulance driver to stop immediately due to the weight of the vehicle that requires a longer stopping time. Thus, it increases the chance of having a rear-end collision which is the more common type of collision for two-vehicle accidents.

2.4.2 Road Speed Limit

Ambulance crashes always correlate with the road speed limit. According to Abdelwanis (2013), higher severity of crashes involving ambulances would occur at street intersections and roads allowed to have higher speed limits.

It is unavoidable for ambulance drivers to not exceed the road speed limit during emergency driving due to having the desire in reaching the destination as fast as possible. Thus, it is likely with the increased traveling speeds also increases the chance of crashing with other road users, because the time needed to stop and maneuver effectively has been reduced due to the speeds applied.

Furthermore, with large momentum produce by an ambulance while speeding can be very dangerous and fatal both to the ambulance driver and other road users. The situation usually happens when both the ambulance driver and other road users are chasing the green light before the light turns red again. This situation is very dangerous due to potential miss judgments and bad decision-making by both drivers that would lead to a fatal crash.

2.4.3 Other Environment-related Factor

According to Pirrallo and Swor (1994), an ambulance driver would be exposed to differing light conditions, weather changes and unpredictable pedestrian behaviors. All of these are other uncontrollable environmental factors.

Light conditions especially during the night can reduce the vision or sight distance during driving. It is hard to detect any objects or vehicles from a distance during night conditions. The glare produced from the headlight of other vehicles also could impair the eyesight of emergency drivers during nighttime drives. According to the National Safety Council, 2019 that perception of depth, recognition of color and our peripheral vision could be compromised within a darken state. Glaring headlights from oncoming vehicles does temporarily blinds a driver.

Inclement weather may influence emergency vehicle driving (USFA, 2014). Driving inside bad weather, e.g. heavy rain, could also impair the driver's vision. In addition, during heavy rain, the ability to steer the vehicle becomes more difficult due to slippery roads. It affects both emergency vehicles and other road users, but emergency vehicles will be more affected because of their size and weight. Moreover, during heavy rain road users must mind their distance gap because of the increase in stopping duration due to less grip being available on roads. However, according to NHTSA (2011), the majority of emergency vehicle crashes occur on dry roads in clear weather. This is mainly because road users usually decrease their vehicle's operating speed and be more cautious during bad weather.

Pedestrian engagement can also affect the crash rate of the ambulance to increase. This is because of the area that has a high density of pedestrians such as schools, gaming centers, and amusement places. These high pedestrian density areas can increase the chance of crashes happening between emergency vehicles and pedestrians especially during emergency driving. Pirrallo and Swor (1994), reported that approximately 59% of pedestrians were involved in fatal non-motor-vehicle ambulance crashes in the United States.

3.0 WAY FORWARD AND CONCLUSION

An overview of ambulance safety was deliberated in this paper. As one of the most important vehicle in emergency medical services, safety aspects during operations needs to be given a stricter focus by all ambulance drivers. Crashes involving ambulances could be categorized as major disasters in a country, as these accidents would not only involve the driver and other EMS staff but would also include the patients being transported that needs treatment as well. Though the volume of reported accidents involving ambulances is relatively low as compared to other vehicle types, its numbers are steadily rising on a year-to-year basis, especially in ASEAN countries. In addition, there have been limited numbers of studies being conducted about ambulance safety and accidents in major ASEAN countries. The effectiveness of preventive action towards reducing the ambulance accidents rate has also not been assessed properly. In that sense, within this study, the data and information about the contributing factors towards ambulance accidents were identified and has been highlighted. In summary, the four main factors as to the causes of ambulance accidents were driver-related factor, vehicle-related factor, task-related factor, and environment-related factor. Thus, a further study on the effectiveness of preventive measures on the reduction of ambulance accidents in ASEAN Countries needs to be conducted by assessing the potential risks associated with these identified factors.

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REFERENCES

Abdelwanis, N. (2013). Characteristics and contributing factors of emergency vehicle crashes. PhD dissertation. Clemson, SC: Clemson University.

Arnold, I. (2018). Statistics on emergency vehicle accidents in the United States.

Bahaudin, N. H. (2018). Beri latihan khusus kepada pemandu ambulans – MIROS. Retreived from https://www.bharian.com.my/berita/nasional/2018/08/458133/beri-latihan-khusus-kepada-pemandu-ambulans-miros

Becker, L. R., Zaloshnja, E., Levick, N., Li, G., & Miller, T. R. (2003). Relative risk of injury and death in ambulances and other emergency vehicles. Accident Analysis & Prevention, 35(6), 941-948.

Boyce, T. E., & Geller, E. S. (2002). An instrumented vehicle assessment of problem behavior and driving style: Do younger males really take more risks? Accident Analysis & Prevention, 34(1), 51-64.

Cavallo, V., & Laurent, M. (1988). Visual information and skill level in time-to-collision estimation. Perception, 17(5), 623-632.

Custalow, C. B., & Gravitz, C. S. (2004). Emergency medical vehicle collisions and potential for preventive intervention. Prehospital Emergency Care, 8(2), 175-184.

Dewar, R. E., Olson, P. L., & Gerson, J. A. (2007). Human factors in traffic safety.

Eluru, N., Paleti, R., Pendyala, R. M., & Bhat, C. R. (2010). Modeling multiple vehicle occupant injury severity: A copula-based multivariate approach. Transportation Research Record, 2165, 1-11.

Ersoy, G., Ersoy, O., Yuksekbas, O., Kurnaz, G., Akyildiz, E. U., & Ekemen, S. (2012). Why did the patient die? The relationship between ambulance accidents and death of patients: Forensic medical issues. Journal of Forensic and Legal Medicine, 19(8), 474-479.

Horberry, T., Castro, C., Martos, F., & Mertova, P. (2004). An introduction to transport signs and an overview of this book. In: The Human Factors of Transport Signs. Publication of: CRC Press LLC.

Horswill, M. S., Hill, A., & Silapurem, L. (2020). The development and validation of video-based measures of drivers' following distance and gap acceptance behaviours. Accident Analysis & Prevention, 146, 105626.

Macdonald-Ames, S. (2020). How do emergency vehicle markings and warning systems influence the interaction between emergency and civilian drivers? (Unpublished Thesis) Loughborough University.

Maguire, B. J., Hunting, K. L., Smith, G. S., & Levick, N. R. (2002). Occupational fatalities in Emergency Medical Services: A hidden crisis. Annals of Emergency Medicine, 40, 625–632.

Muir, C., Newnam, S., Newstead, S., & Boustras, G. (2020). Challenges for safety intervention in emergency vehicle fleets: A case study. Safety Science, 123, 104543.

Narad, M. E., Nalepka, P., Miley, A. E., Beebe, D. W., Kurowski, B. G., & Wade, S. L. (2020). Driving after pediatric traumatic brain injury: Impact of distraction and executive functioning. Rehabilitation Psychology, 65(3), 268-278.

NHTSA (2011). When ambulance crash – EMS provider & patient safety. Retrieved from http://www.ohiohealthems.com/wp-content/uploads/2015/09/NHTSA-OEMS-Ambulance-Crash-Infographic-2015-09.pdf

Pattanarattanamolee, R., Lertsinudom, S., Nakahara, S., & Sakamoto, T. (2017). Ambulance crash in a rural area of Thailand. The Journal of Emergency Medicine, 53(5), 730-734.

Pirrallo, R. G., & Swor, R. A. (1994). Characteristics of fatal ambulance crashes during emergency and non-emergency operation. Prehospital and Disaster Medicine, 9(2), 125-132.

Prohn, M. J., & Herbig, B. (2020). Evaluating the effects of a simulator-based training on knowledge, attitudes and driving profiles of German ambulance drivers. Accident Analysis & Prevention, 138, 105466.

Ray, A. M. & Kupas, D. F. (2007). Comparison of rural and urban ambulance crashes in Pennsylvania. Prehospital Emergency Care, 11(4), 416-420.

Recarte, M. A., & Nunes, L. (2002). Mental load and loss of control over speed in real driving: Towards a theory of attentional speed control. Transportation Research Part F: Traffic Psychology and Behaviour, 5(2), 111-122.

Recarte, M. A., & Nunes, L. M. (2003). Mental workload while driving: effects on visual search, discrimination, and decision making. Journal of Experimental Psychology: Applied, 9(2), 119-137.

Requardt, A. F., Ihme, K., Wilbrink, M., & Wendemuth, A. (2020). Towards affect-aware vehicles for increasing safety and comfort: recognising driver emotions from audio recordings in a realistic driving study. IET Intelligent Transport Systems, 14(10), 1265-1277.

Retting, R. A., Williams, A. F., Preusser, D. F. & Weinstein, H. B. (1995). Classifying urban crashes for countermeasure development. Accident Analysis and Prevention. 27, 283–294.

Sanddal, N. D., Albert, S., Hansen, J. D., & Kupas, D. F. (2008). Contributing factors and issues associated with rural ambulance crashes: Literature review and annotated bibliography. Prehospital Emergency Care, 12(2), 257-267.

Saunders, C. E. & Heye, C. J. (1994). Ambulance collisions in an urban environment. Prehospital and Disaster Medicine, 9, 118–124.

Savolainen, P., Dey, K. C., Ghosh, I., Karra, T. L. N. & Lamb, A. (2009). Investigation of emergency vehicle crashes in the state of Michigan. West Lafayette, IN: Purdue University, NEXTRANS Centre.

Sutliff & Stout, Injury & Accident Law Firm (n.d.). Emergency Vehicle Accidents - “What were they thinking?”. Retrieved from https://www.sutliffstout.com

USFA (2002). Safe operation of fire tankers. U.S. Fire Administration.

USFA (2014). Emergency vehicle safety initiative. U.S. Fire Administration.

Vijaindren, A. & Jay, B. N. (2019). Ambulance crash not an isolated tragedy. The New Straits Times.