Outbreak, Surveillance, Investigation & Response (OSIR) Journal

Field Epidemiology Training Program, Division of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625903894, Fax: +6625903845, Email: osireditor@osirjournal.net, http://www.osirjournal.net

An Injury Investigation of a Bus-Train Collision, Chachoengsao, Thailand, October 2020

Saran Sujinpram[1]*, Thanawadee Chantian[1], Prangsiri Nalam[1], Rutchayapat Samphao[1], Natkritta Pumpech[2], Nittayaporn Chaiyasan[2], Kesarin Kornnoungklang[3], Preeya Suripon[3], Rattiya Yomma[3], Sasithorn Pongprapan[3], Pantila Taweewigyakarn[1], Witaya Swaddiwudhipong[1]

1 Division of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand

2 Division of Injury Prevention, Department of Disease Control, Ministry of Public Health, Thailand

3 Office of Disease Prevention and Control 6 Chonburi, Department of Disease Control, Ministry of Public Health, Thailand

*Corresponding author email: tooyoour@gmail.com

Abstract

On October 2020, there was a bus-train collision at Chachoengsao Province with 18 fatalities. The Division of Epidemiology conducted a joint investigation during October 2020 to describe characteristics of the event and deaths, and identify factors associated with fatalities. A descriptive study was conducted by interviewing officers, witnesses, policemen, rescuers and survivors. We also reviewed medical records and closed-circuit television and performed environmental survey of the roads and bus wreckage. A retrospective cohort study was performed with multiple logistic regression and Haddon matrix analyses. The bus collided with a cargo train at an illegal road-railway crossing intersection. Eighteen people died (25.4%). Most deaths were caused by lethal injuries to the head and neck (17/18, 94.4%). The bus was overloaded and turning on loud music. The intersection did not have crossing gates and the warning signal was broken. This bus-train collision resulted in high fatality. Standing on the overloaded bus was the significant risk of death. Regulations of noise limits, number of passengers, limit standing on the buses, and improvement of safety controls for all road-railway intersections should be strictly implemented for injury prevention.

Keywords: bus-train, collision, risk, death

Introduction

Road traffic injury (RTI) is one of the leading causes of death worldwide.[1] The global status on road safety 2018 by the World Health Organization reports about 1.35 million RTI deaths annually and the RTI rates are highest in Africa and South-East Asia.[1] In 2018, Thailand was ranked first in Asia and was among the top ten countries in the world for RTI, with 32 deaths per 100,000 population per year.

Collisions between a bus and a train are rare events,[2,3] but can result in a significant loss. Reports of collisions from many parts of the world describe the number of deaths ranging from one to 20 per event.[2-5] In Thailand, during 2002–2018, there were five events of bus-train collisions reported to the State Railway of Thailand. The most recent event occurred in 2018, which resulted in three deaths.[3]

According to the Thailand Ministry of Transport, in 2019 there were 2,684 road-railway intersections in the country, most of which (2,278, 84.9%) were at ground level (i.e. not tunnels or bridges).[4] Among the ground-level intersections, about 27% were illegal, defined as an intersection created by local administrators, but not officially registered under the State Railway of Thailand. Illegal intersections are not regulated and so often lack adequate safety control measures, like traffic signals, road signs, sufficient visibility, and safe design.[4] Almost half (39/86, 45.3%) of road-railway intersection injuries in 2019 occurred at illegal intersections in Thailand.[4] Injury investigation including host, agent, and environmental factors in pre-crash, crash, and post-crash by Haddon's matrix is needed for systematic primary, secondary, and tertiary prevention.

The Division of Epidemiology, Ministry of Public Health was notified of a bus-train collision, resulting in 18 fatalities in Chachoengsao, in October 2020. The Division of Epidemiology and local health authorities conducted a joint investigation to describe characteristics of the event, injured cases, and deaths, identify factors associated with fatalities, and provide recommendations for injury prevention and mitigation of similar events in the future.

Methods

Descriptive Study

We reviewed medical records of patients involved in the collision from six hospitals to determine demographic data, injury characteristics, outpatient or admitted patients, and treatment outcomes using a case report form. We interviewed 53 survivors of the collision using a semi-structured questionnaire to collect data about seat position, activity before and during crash, and use of seat belts. We also reviewed interview-video-clips from news reports to gather information from the train driver about the collision.

For this investigation, 'survived' was defined as any person who was traveling on the bus, and was alive within 30 days after the collision. Any person traveling on the same bus who died at the scene or died within 30 days as a result of the road injury accident was defined as 'died'.

The Injury Severity Score (ISS) was calculated based on injury characteristics.[6] The ISS is an anatomically based, consensus-derived, global severity scoring system that classifies an individual injury, and is calculated as the sum of the squares in each of the three most severely injured body regions. The median and interquartile range were calculated for continuous variables, and ratio and proportion were calculated for categorical variables.

Analytic Study

We performed a retrospective cohort study to identify risk factors related to fatalities. The cohort included all who traveled on this bus on 11 Oct 2020. The dependent variable categories were 'died' and 'survived', as defined above. Independent variables were gender, age, race, standing on the bus (yes/no), and drinking alcohol before the collision (yes/no). Bivariate analysis was conducted using the chi-square test or Fisher's exact test. To adjust for confounders, we performed multivariable analysis using multiple logistic regression.[7] The variables with *p*-value less than 0.1 in univariable analysis were included in the model and reported adjusted odds ratio with 95% confidence interval (CI) as a result. STATA-14 was used for data management and analyses.

Environmental Study

We surveyed the environment at the collision site and reviewed recorded video from a nearby closed-circuit television. We measured the distance between the crash site and the bus wreckage, yaw mark, warning signals, and assessed the drivers' visibility. We interviewed disaster prevention and mitigation officers and witnesses to collect data about the environment at the time of the collision.

The bus wreckage was inspected to assess its general appearance, external and internal damage, impact sites, seatbelts, and driver's visibility. We also reviewed reports from the Department of Land Transport to gather additional information about the bus including the number of seats, license plate expiration date, and information about the train such as type, size, and emergency braking distance. In addition, we interviewed the policemen and rescuers who were at the collision site to describe the timeline of the event, identification of fatalities, and triage and rescue procedures. Haddon's matrix, a field model of injury prevention to reduce the morbidity and mortality,[8] was used for the analysis to identify human, vehicle, and environmental risks before, during, and after the collision.

Results

Event Description

On 11 Oct 2020, a single deck inter-provincial bus carrying 70 passengers and one driver departed from Factory P at 6.30 a.m. heading to Bang Pla Nak Temple in Bang Toey Subdistrict in Chachoengsao Province (63 kelometers from Factory P). On this group tour bus, they opened loud music, sang songs, danced, and drunk alcohol. When the bus crossed a ground-level road-railway intersection near Klong Kwaeng Klan Train Station (60 kelometers from the Factory P), a cargo train heading to Bangkok collided into the bus at 8.05 a.m. (Figure 1). The bus was moving at a speed of 40 kilometers per hour (km/h), according to GPS tracking, as it crossed the railroad tracks and was struck by the train from its right side. Close-Circuit Television revealed the speed of the bus remained consistent while crossing the railroad track. The bus overturned onto its right side, the back of the bus scraped against the moving train and its roof was ripped off. The bus was pushed by the train for 13 meters and stopped in a one-meter-wide groove between the two railroad tracks.

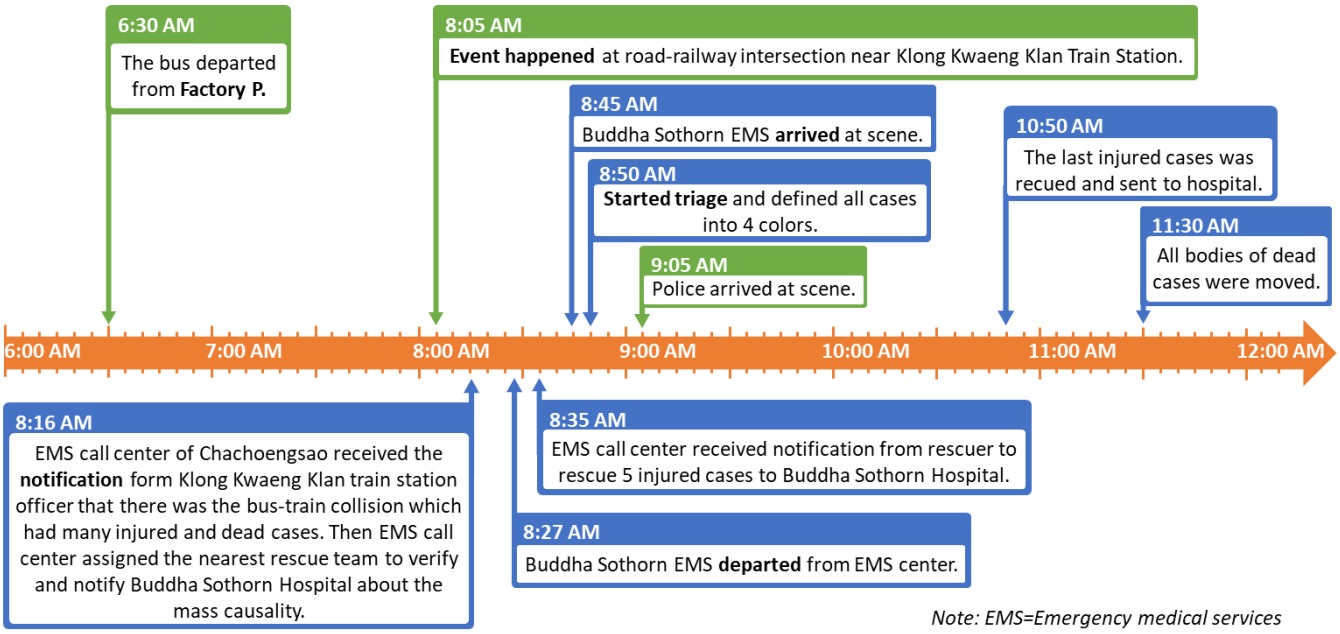

Figure 1. Timeline of the bus-train collision in Chachoengsao Province, 11 Oct 2020

Characteristics of Individuals Who were Injured and Died

All 71 people in the bus, consisting of 70 passengers and one driver, were injured and 18 died, including the driver, giving the case-fatality rate (CFR) of 25.4%. Seventeen people died at the collision scene, and one died during transfer to Buddha Sothorn Hospital, which is a tertiary hospital. Out of 53 survivors, 33 (62.3%) were treated as out-patients, 14 (26.4%) were admitted, and 6 (11.3%) did not go to the hospital. There were no pedestrians injured, neither was the train driver. Most of the 71 people on the bus were female (69.0%) and Thai (71.8%), and the median age was 32 years (Q1=27, Q3=40). Characteristics of individuals who died in the collision were shown in Table 1. A significantly higher rate of fatality was observed in males (45.5%) than females (16.3%). Individuals who stood on the bus had a significantly higher rate of fatality (61.1%) than those sitting on the bus (13.2%). Drinking alcohol on the bus was also significantly associated with fatality. Of 71 individuals on the bus, only the bus driver fastened his seat belt. There were no significant associations between fatality and age or race.

Table 1. Characteristics and outcome of individuals in the bus-train collision, Chachoengsao Province, October 2020 (n=71)

Characteristics	Total	No. died (%)	Odds ratio (95% CI)	*p*-value
Gender				
Male	22	10 (45.5)	4.27	0.009
Female	49	8 (16.3)	(1.38,13.23)	
Age (years)				
≤30	34	8 (23.5)	1.20	0.737
>30	37	10 (27.0)	(0.41,3.52)	
Race				
Non-Thai	20	6 (30.0)	1.39	0.570
Thai	51	12 (23.5)	(0.44,4.42)	
Standing on the bus when crashed				
Yes	18	11 (61.1)	10.33	<0.001
No	53	7 (13.2)	(3.00,35.58)	
Drinking alcohol on the bus before the crash				
Yes	22	11 (50.0)	6.00	0.002
No	49	7 (14.3)	(1.89,19.08)	

Most of the injured body regions were extremities, followed by head and neck, face, thorax, and abdomen, respectively. Autopsy reports indicated that most deaths were caused by lethal injuries to the head and neck (17/18, 94.4%) and the remaining one had a severe abdominal injury (1/18, 5.6%). Higher

proportions of head, neck, and face injuries were observed among the deaths than the survivors. The median of ISS among the deaths was 61, compared to 8 among the survivors (Table 2).

Table 2. Body region of injury and Injury Severity Score of the victims who survived and died in the bus-train collision, Chachoengsao Province, October 2020 (n=71)

Injury characteristics	No. died (%)	No. survived (%)
Body region of injury[+]		
Head & neck	17 (94.4)	27 (50.9)
Face	15 (83.3)	15 (28.3)
Thorax	5 (27.8)	19 (35.8)
Abdomen	6 (33.3)	11 (20.8)
Extremities	14 (77.8)	42 (79.2)
Total	**18 (100.0)**	**53 (100.0)**
Injury severity score		
Median (Q1, Q3)	61 (61, 75)	8 (4, 17)

[+]*Some had more than one body region injuries*

The passenger seat map and crash site are shown in Figure 2. The collision occurred at the right site of the bus. Those who were on the right side of the bus were more likely to die than those on the left side. During the crash, 18 passengers were standing on the bus and 11 died (61.1%) whereas 7 of 53 (13.2%) who were sitting died in this collision.

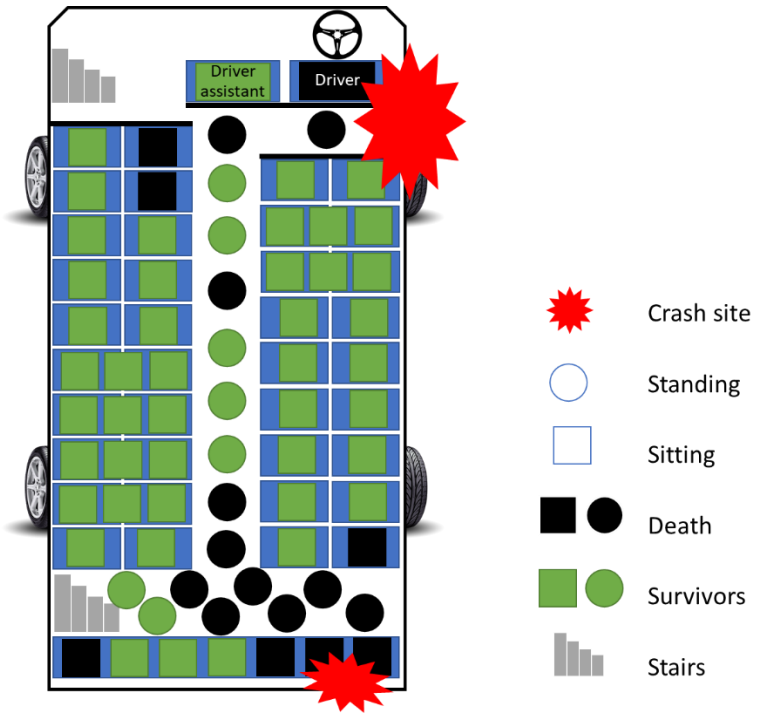

Figure 2. Seat map of all passengers and driver on the bus of the bus-train collision in Chachoengsao Province, 11 Oct 2020 (n=71)

Analytic Study

Table 3 shows multivariable analysis of the determinants of fatality in the bus-train collision. Only standing on the bus was significantly associated with fatality (Adjusted odds ratio=6.46; 95% CI 1.65-25.20), after adjusting for gender and drinking alcohol on the bus.

Table 3 Multivariate analysis of the determinants of fatality in the bus-train collision, Chachoengsao Province, October 2020

Factors	Adjusted Odds Ratio	95% CI
Gender (male/female)	2.68	0.71-10.03
Standing in the bus (yes/no)	6.46	1.65-25.20
Drinking alcohol in the bus (yes/no)	2.37	0.60-9.39

Environmental Study

Site of collision

The collision occurred at an illegal crossing intersection where a two-lane road with opposing traffic crossed three parallel railroad tracks that ran perpendicular to the road. The collision occurred on the third track (Figure 3). The road leading up to the tracks had a 30-degree incline, was made of smooth asphalt, and was approximately 4-6 meters wide. The road-railway intersection did not have a road-railway barrier (a crossing gate). There were two train warning signs approximately 300 meters and 10 meters in front of the railroad tracks. However, the warning light signal was broken. The bus driver's visibility was obstructed by trees and shrubs, which were removed after the event. (Figure 3). At the time of the collision, it was drizzling, and yaw marks were not observed. The distance from the crash site to the bus wreck was approximately 90 meters and to the train-engine was approximately 600 meters. This event occurred 20 kilometers from the Buddha Sothorn Hospital. It took 30 minutes for the first emergency medical services (EMS) to get to the scene after receiving notification. However, there was a long iron fence blocking the rescue team from getting access to the collision site. Rescue cars were obstructed by a nearby traffic jam. Some survivors were trapped under the wreckage or bodies of the deceased.

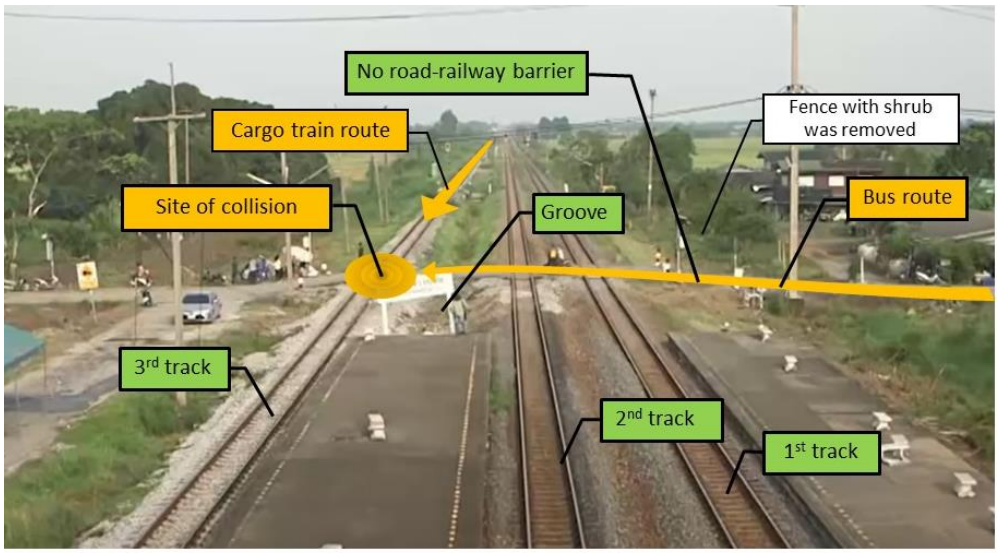

Figure 3. Site of the bus-train collision in Chachoengsao Province, 13 Oct 2020[9]

Vehicles

The bus was registered as a bus with 42 seats, one floor, two doors, six wheels, and no toilet. The license had already expired on 30 Sep 2020, and the last documented maintenance was on 30 Sep 2019 which should be annual maintenance. We found the leaf spring (load resisting part of the bus) was adapted to transport more passengers. Every seat had its own belt. The driver's window had limited visibility due to stickers and black film used for sunscreen. After the collision, six of 19 bottom seat cushions had been separated from their seat base. Large significant damage in front of the bus was observed. The back roof was torn off and seats in the back were destroyed by a 1-meter-deep groove between the 2nd and 3rd railway that kept the back of the bus crashing on the railway from reviewing the closed-circuit television. Nearby witnesses heard the train whistle and loud music from the bus. The survivors reported the bus turning on loud music while crossing the intersection. A passenger sitting next to the driver did not hear the train whistle.

Cargo train number 5102 was 493 meters long and weighed 2,000 tons. Its speed before the crash was 70 km/h. The train had an emergency brake distance of 600-1,000 meters.

Drivers

The bus driver was a 50-year-old Thai man, with 30 years of driving experience, and no history of underlying disease nor history of drinking alcohol. A tour manager reported that the route was not the driver's regular route.

From reviewing the interview-video-clips from the news, the train driver saw the bus driving slowly across the intersection at 300 meters distance before the crash, then he turned on a warning light and blew the train whistle as well as started the emergency brake.

Haddon's matrix applied to this bus-train collision is shown in Table 4.

Table 4. Haddon's matrix applied to the bus-train collision, Chachoengsao Province, October 2020

	Human	Vehicle	Environment
Pre-crash	**Driver** • Unusual route for the driver • Driver may not hear the train whistle • Loud music on the bus	**Bus** • Limited visibility from the driver's window • Stickers and black film	• Broken warning signal • No railway barrier • Obstructed visibility (trees & shrubs) • 30° slope of uphill road
Crash	**Passenger** • Used alcohol • Standing and dancing • No seat belt	**Bus** • Passengers overloaded • Back roof ripped off **Train** • Heavyweight with speed of about 70 km/h	• 1-meter-deep groove between the 2nd & 3rd railway (making the back of the bus crashed on the railway)
Post-crash		**Bus** • Bus flipped right side down • Collapsed bus structure	• Drizzling • Appropriate life support (ALS) arrived on the scene 30 minutes after crash • Long iron fence obstructed rescue team • Rescue cars stuck in heavy traffic

Discussion

Almost half of road-railway intersection accidents in Thailand have occurred at illegal crossings.[2] Our findings were concordant with previous reports showing factors related to road-railway intersection accidents included less awareness while crossing the intersection, limited or obstructed visibility, and the crossings had improper safety controls.[4] The rainy weather may have reduced the train drivers' visibility. Once he noticed the bus and switched on the train whistle, the distance to the bus was too short to completely stop the train, even with the emergency brake. Since we observed the bus was traveling at a steady speed crossing the railroad tracks and a passenger nearby the bus driver reportedly did not hear the train's whistle, together with limited visibility from the bus window, we believe the bus driver may not have been aware of the train.

The case fatality rate in this event (25.4%) was higher than the 5-year median case fatality rate of total road traffic injuries in Thailand (14.8%)[2] and was the most fatal bus-train collision event in Thailand since 2002.[2,3] The bus from this event was carrying almost double the number of passengers allowed for the bus registration. Hence, the passengers sitting on the bus were not seated properly and 18 passengers had to stand while traveling. We found passengers who were standing on the bus during the crash were over six times more at risk of death than those who were sitting. None of the passengers fastened seat belts, despite their availability. Not wearing a seat belt has been found to be associated with severe head injury and death,[10] similar to previous studies of bus collisions[11,12] in which the head and neck were the most commonly injured area of the body. One study showed wearing a seat belt could reduce the probability of being killed by 25% for passengers.[13]

The site of the collision was 20 kilometers from the provincial hospital. The time between the crash and the first EMS arrival was 30 minutes. It was late compared to the standard response time in Thailand, which is eight minutes for EMS to reach an emergency patient after being notified.[14] The delayed EMS arrival might have contributed to the high fatality rate. However, given the severity of the injuries and causes of death, rapid resuscitation still might not have increased their chances of survival.

There were some limitations in our investigation. First, information about passengers who died was mainly provided by the survivors. This might lead to information bias including misclassification of exposure, nonetheless we validated the information with several passengers. In addition, the autopsy did not explore internal organs, which might result in lower ISS among the deaths. Lastly, information gathered from the train driver was limited to what was available from interview by the news reporters, and it was not possible to validate the responses.

Conclusion and Recommendations

This bus-train collision resulted in 18 deaths and 53 injured cases. Multiple factors, including the unusual route for the bus driver, loud music, low visibility and lack of safety measures at an illegal intersection, probably contributed to this event. The Chachoengsao event demonstrates that bus-train collisions can be substantially more fatal than other types of road traffic injury,[15] and as such, adequate safety measures should be implemented for all road-railway intersections in Thailand.

We recommend additional safety regulations for noise limits on public transportation to ensure drivers and passengers can maintain optimal levels of awareness of the surroundings. In addition, regulations regarding public bus licensing, number of passengers, seatbelt use, and driver's visibility should be strictly implemented. Office of Land Transport should promote fastening a seat belt on public transportation (especially long-distance routes) and limit standing on the buses (especially inter-city buses). Local administrations and State Railway of Thailand should jointly improve safety control for all illegal road-railway intersections including warning signs, adequate visibility, and intersection barriers. The local emergency response protocol should be reviewed to address the delayed response.

Acknowledgements

We thank the staff of Buddha Sothorn Hospital, Kasemrad Hospital, Banpho Hospital, Klongkhuen Hospital, Samrong General Hospital, Samut Prakan Hospital, Chachoengsao Provincial Health Office, Samut Prakan Provincial Health Office, Office of Disease Prevention and Control 6 Chonburi, Chachoengsao Disaster Prevention and Mitigation Office, Division of Injury Prevention and Division of Epidemiology.

Suggested Citation

Sujinpram S, Chantian T, Nalam P, Samphao R, Pumpech N, Chaiyasan N, et al. An injury investigation of a bus-train collision, Chachoengsao, Thailand, October 2020. OSIR. 2022 Mar;15(1):20–7.

References

1. World Health Organization. Global status report on road safety 2018. Geneva: World Health Organization; 2018. 403 p.
2. Office of Transport and Traffic policy and Planning, Thailand Ministry of Transport. Report of road accident situation analysis 2019. Bangkok: Thailand Ministry of Transport; 2020.
3. Thai PBS News. [Bus-train collision with 3 deaths in Nakhon Pathom province]. Thai PBS News [Internet]. 2016 Apr 3 [cited 2021 Mar 24]; Crime:[about 4 p.]. <https://news.thaipbs.or.th/content/251451>. Thai.
4. Office of Transport and Traffic policy and Planning, Thailand Ministry of Transport. Results of action to resolve the intersections between road and rail, fiscal year 2019. Bangkok: Thailand Ministry of Transport; 2020.
5. Organization for Economic Co-operation and Development. OECD factbook 2015-2016: economic, environmental and social statistics. Paris: OECD Publishing; 2016. 228 p.
6. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma. 1974; 14(3): 187-96.
7. Lindquist K. How can I estimate relative risk using glm for common outcomes in cohort studies? Stata FAQ [Internet]. Los Angeles (CA): UCLA Statistical Consulting Group; [cited 2021 Jan 31]. <https://stats.idre.ucla.edu/stata/faq/how-can-i-estimate-relative-risk-using-glm-for-common-outcomes-in-cohort-studies/>
8. Barnett DJ, Balicer RD, Blodgett D, Fews AL, Parker CL, Links JM. The application of the Haddon matrix to public health readiness and response planning. Environ Health Perspect 2005;113(5): 561–6.
9. Landscape after adjusted [photograph on the internet]. Bangkok: Amarin Television; 2020 Oct 13 [cited 2022 Jan 27]; Exclusive news: [about 10 p.]. <https://www.amarintv.com/news/detail/49711>. Thai.
10. Jedwanna K, Howimanporn S. Crash types of and factors affecting severity of inter-city bus accident. Bangkok: Rajamangala University of Technology Phra Nakhon; 2012. 157 p. Thai.
11. Tammaros T. The injury investigation of a bus that plunges into the ravine, Uttaradit province, 24 – 25 November 2016. Nonthaburi: Division of Epidemiology, Thailand Ministry of Public Health; 2018.
12. Sirirungreung A, Tithichai P, Saikumthorn P, Sopakul W, Waiyanate N. Injury investigation of a bus that plunged into ravine in Lampang province, Thailand, 25 – 27 October 2013. Wkly Epidemiol Surveill Rep. 2014; 45(29): 449–56.

13. Ogundele O, Ogunlade S, Adeyanju S, Ifesanya A. The impact of seat-belts in limiting the severity of injuries in patients presenting to a university hospital in the developing world. Niger Med J. 2013; 54(1): 17-21.

14. National Institute for Emergency Medicine, Thailand Ministry of Public Health. Emergency medical triage protocol and criteria-based dispatch. Nonthaburi: National Institute for Emergency Medicine; 2013.

15. Suriyawongpisal P, editor. Thailand road traffic injury report 2012-2013 [Internet]. Bangkok: Road Safe Fund, Department of Land Transport; 2015 [cited 2021 Jan 27]. p. 70. <http://www.roadsafetythai.org/edoc/doc_20181208173717.pdf>. Thai.