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Epidemiology of Multiple Casualty Incidents from Road Accidents in Thailand, 2006-2011

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Abstract

Investigations that focus on multiple casualty incidents (MCIs) can identify factors which can determine a very high burden of injury and death. Five MCI investigations were carried out in Thailand using surveillance data, physical investigation data from the scenes and vehicles, in-depth interviews with survivors and witnesses, and extraction of medical information from hospital records. Haddon's matrix was utilized to structure results in three phases (pre-event, event and post-event) which were stratified into four agents (human, vehicle, physical and socio-economic environment). The five MCIs involved 113 people, nine pickup trucks, four sidecar motorcycles and one each of a car, bus, prime mover truck and prime mover truck with a flatbed semi-trailer. Ten (8.8%) people died and 81 (71.7%) people were injured. Many amenable risk factors were human-related (inexperience, falling sleep, dangerous driving, non-use of seat belts, riding in the cargo area or on the rear platform). Vehicle-related factors were also present (poor tire treads and lack of safety devices), and environmental factors were prominent (wet and slippery roads, poor signage and lighting). Other notable facts included delay in contacting emergency services, lack of cutting equipment and limited first aid support. Many modifiable risk factors were identified, highlighting the need to reform roads and vehicles, and educate passengers and drivers.

Keywords: Multiple casualty incidents, road accident, investigation, Haddon matrix

Introduction

The World Health Organization (WHO) predicted that road traffic accidents would increase from the ninth leading cause of death in 2004 to the fifth leading cause of death by 2030.[1] As road traffic accidents happen in all regions of the world, there have been efforts to find solutions to prevent injuries, disability and mortality. Road traffic accidents can involve pedestrians, cyclists, and drivers and passengers of motor vehicles.

In Thailand, statistics from the Royal Thai Police from 2007 to 2014 showed that the annual number of road traffic accidents as 17,779 to 20,973 motorcycles, 14,790 to 16,923 cars, 6,775 to 9,587 pickup trucks, and 7,124 to 9,332 other types of vehicles.[2] Of all road traffic accidents occurring in 2014, the vehicles contributed most were motorcycles (35.6%), cars (34.3%) and pickup trucks (17.0%).[3]

In order to prevent road traffic accidents in the future, it is important to investigate the cause and severity of past incidents. Multiple casualty incident (MCI) contributes significantly to the burden of disease from injuries and deaths due to road traffic accidents.[4,5] When MCI involves with a large number of victims and severe injuries, it creates curiosity and instill fear in the public. In a setting of economic and transportation development, MCI may occur more frequent, yet limited resources prevent in-depth investigations to identify the causes.

Recently in Thailand, the Bureau of Epidemiology under Department of Disease Control, Ministry of Public Health placed an emphasis on MCI. The criteria for triggering an investigation on MCI is

mainly based on the number of victims involved. However, there had been no public health research studies which focused on identifying the causes, and documenting the number and severity of injuries and death toll resulted from MCIs in Thailand.

This study concentrated on an analysis of five major MCIs in Thailand that occurred between 2006 and 2011, aiming to assess the information which would lead to improve policies and strategies for better prevention and control of such incidents in the future. In addition, this study demonstrated the utility of MCI investigations for revealing potential preventable causes of injury and death, focusing particularly on victim behavior and medical response.

Methods

The public health approach to problem solving consists of four steps: identify the problem (surveillance), identify risk factors, develop interventions and implement interventions.[4,5] The epidemiologic model of injury investigation guides further analysis of the host (pedestrian, passenger, rider or driver), the agent (mechanical force, energy), the vector (vehicles) and the environment (weather, road and traffic conditions).[6,7]

The Haddon matrix helps to organize the data into three crucial stages of MCI (pre-crash, crash and post-crash).[2,3,5,6] This staging system is important when preparing investigation forms, collecting and analyzing data, identifying risk factors, and preventing further MCIs. During an investigation, an epidemiological model was used together with the Haddon matrix to divide the determinants of MCI into three aforementioned stages. These features of investigation on MCI in Thailand consisted of five components: behavioral factors of pedestrians, passengers, riders and drivers; nature of accident; scene and environment; vehicle(s); and crash simulation analysis (Table 1).[8] Adapting the public health approach and the national guideline for MCI investigations, a protocol was developed for MCI investigations in this study (Figure 1).

An epidemiologic approach was used to describe five MCI investigations in Thailand. From this information, conclusions were drawn in terms of

Table 1. Haddon matrix employed for investigations on multiple casualty incidents in Thailand, 2006–2011[3,7]

Phase	Factors potentially related to event			
	Human	Vehicle	Environment	
			Physical	Socio-economic
Pre-event	**Human Risk** - Driver's license/ health/behavior/ experience - Speeding - Distracting activity - Alcohol/drugs - Seat belt/helmet use - Wrong attitude	**Dangerous Vehicle** - Brake/light/tire - Modified vehicle - Vehicle visibility - Inspection of vehicle - Overloading - Seat belt/helmet availability and quality - Airbag	**Hazardous Environment** - Road/road surface - Street light - Hierarchy of road - Traffic light/traffic line/traffic direction - Tree - Weather **Safer Environment** - Motorcycle lane - Overpass - Crosswalk - Zebra crossing	**Environmental Obstacle** - Traffic sign - Shop on sidewalk - Community along the way
Event	**Human Tolerance of Energy Transfer** - Seat belt/helmet use - Child seat use - Passenger behavior - Driver decision - Road use	**Protection Device** - Seat belt - Airbag - Restraint system - Helmet - Vehicle structure	**Environment** - Safety zone - Roadside hazard	**Environment** - Rush hour - School zone - Community zone
Post-event	**Injuries Contribute to Disability or Death** - First aid - Rescue skill - Medical treatment	**Vehicle Contributes to Disability or Death** - Fire risk - Fuel leakage - Trapped in a car - Submerged car	**Environment Contributes to Disability or Death** - Ease of access - Ease of evacuation	**Environment Contributes to Disability or Death** - Emergency team - Rescue work - Rescue tools

prevention in each event. Key features of each MCI occurrence were also described to determine the overall causes of injuries and deaths for each person. A mixed approach was used to collect data, identify risk factors and determine preventions. This included review of surveillance data, physical investigation of scene, environment and vehicles, in-depth interviews of victims and eye-witnesses, and extraction of medical information from the responding health services (medical records from ambulance, clinic and hospital, and interviews with health staff).

Figure 1. Protocol developed for investigations of multiple casualty incidents (MCI) in this study, Thailand, 2006-2011

The MCI in this study was defined as an accident resulted in five or more deaths, or 15 or more injuries in the same event[8] from 2006 to 2011. The investigations were conducted by epidemiologists who gathered data from physicians, nurses, hospital records, public health officers, civil engineers and police. Cooperation with various agencies was carried out in conducting the investigations.

Ethics

The information was collected for official purposes, and data and events were anonymized in this report with no references to the provinces where the accidents occurred. No names, dates or identifying information were used. Permission to submit for publication was granted by the regional Office of Disease Prevention and Control 12, Department of Disease Control, Ministry of Public Health, Thailand.

Results

In Thailand, drivers are required, by law, to drive on the left side of the road. When driving on two or more traffic lanes in the same direction, the driver should drive on the outermost left-hand side lane or close to the bus lane, if there is one present. The vehicles traveling at low speed should keep to the curbside of the roadway as close as possible.[6]

Five MCIs in southern Thailand were investigated due to high number of injured persons and severity of the incidents. The events involved 113 persons in total, including 10 deaths.

Incident 1. An overturned bus crashing into trees

Upon seeing an elderly female pedestrian suddenly showing up in front of a bus on the traffic lane, the bus driver swerved to the left, yet side of the bus hit the pedestrian and the out-of-control bus then ran into a house on the roadside. Despite the bus driver's attempt to avoid the collision, the bus overturned and landed on its side. The rear of the bus crashed against a tree and then the roof of the bus slammed into a second tree, with four passengers trapped inside (Figure 2).

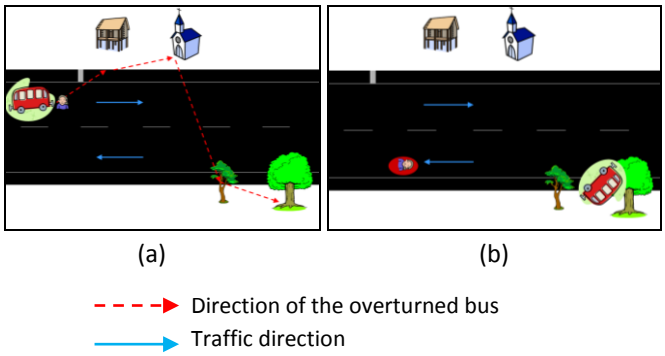
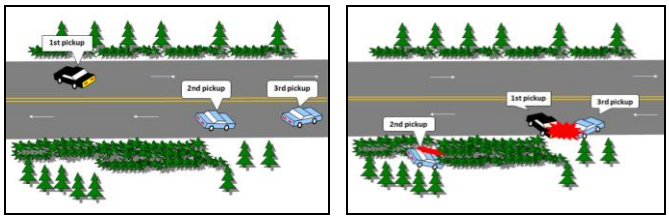


Figure 2. An overturned bus crashing into trees (a) before and (b) after the event in Thailand, 2006

This incident involved 26 persons. Two people were killed at the scene, including the elderly pedestrian, and a female passenger who was caught in between the tree and the bus. In addition, 16 others were injured. One passenger fastening the seat belt was not injured.

Incident 2. A pickup crashing into two other pickups

As the driver of a 4-door pickup truck fell asleep while driving, the vehicle crossed into the opposite lane and hit the extended cab of the second (2-door) pickup truck. Then, the first vehicle collided head-on with the third (2-door) pickup truck. As a result, the second vehicle drove into the margin of the road, rolled, and finally came to a halt on its side. A female passenger was trapped inside the vehicle (Figure 3).



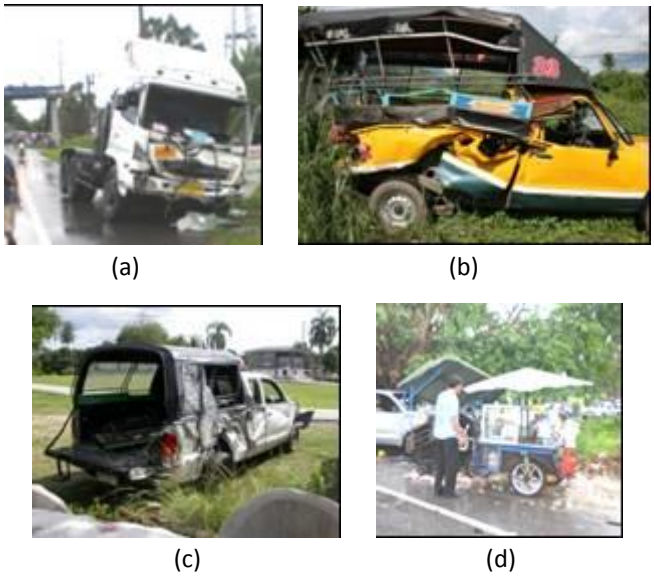
(a) (b)

Figure 3. A pickup truck crashing into two others (a) before and (b) after the event in Thailand, 2007

A total of 18 injured persons were involved: one in the first vehicle, 11 in the second, and six in the third. No pedestrians were involved. Two females riding in the cargo area of the second vehicle died: one at the scene and one in a hospital one day after the incident.

Incident 3. A multi-vehicle crash in front of a school zone

While the heavy rain changed to a shower, a person was driving a prime mover at a speed of about 45 km/hr on the drenched road. The vehicle had just rounded a curve in front of a school during the school dismissal time, yet the driver could not keep the vehicle within the lane and braked suddenly on the slippery road, causing the vehicle to skid uncontrollably. The vehicle then struck three public passenger vehicles (modified pickup trucks) and four motorcycles with sidecar, which were all parked on the edge of the road. Two of three public passenger vehicles was carrying students (Figure 4).

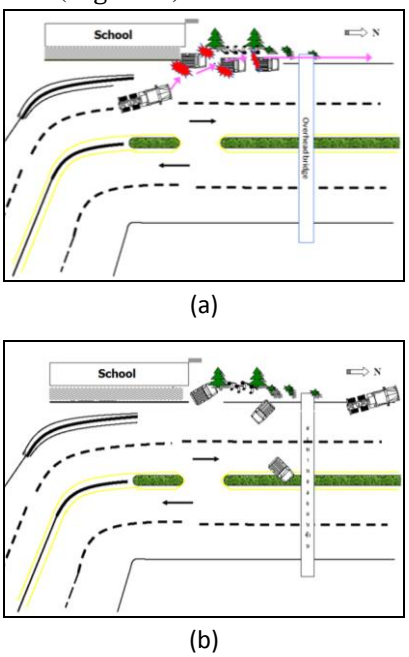


(a) (b)

(c) (d)

Figure 4. (a) A prime mover, (b) a public passenger vehicle, (c) a passenger vehicle for students, and (d) a sidecar motorcycle selling food, involved in a multi-vehicles crash in front of a school, Thailand, 2008

The prime mover (Figure 4a) first collided with a songthaew (2-row) public passenger vehicle (Figure 4c), hit a tree and collided with two motorcycles with sidecar. The prime mover then crashed into the second songthaew public transport vehicle (Figure 4b) which, due to force of the collision, hit a motorcycle with sidecar and two pedestrians before it came to rest on the pedestrian refuge area in the centre of the road. The prime mover continued crashing into a motorcycle with sidecar (Figure 4d) and the sidecar motorcycles then flipped over a pedestrian, and hit the third public passenger vehicle which again struck one pedestrian (Figure 5).



(a)

(b)

Point of impact

Direction of the prime mover

Sidecar motorcycle

Figure 5. A multi-vehicles crash (a) before and (b) after the event in front of a school, Thailand, 2008

This incident involved 40 persons. Table 2 described about those involved, injured and admitted to hospital. There were four pedestrians with sustained injuries: three on four sidecar motorcycles, 17 people from the first songthaew vehicle, 10 people from the second songthaew, four people from the third vehicle, and two people from the prime mover. Although there were no fatalities, 33 people were injured, including 31 students. One of the students had her leg amputated due to severe injuries sustained during the incident.

Incident 4. A school pickup crashing into a tree

In drizzling rain, a pickup truck carrying 17 school students (one in the passenger seat, five in the cab and 11 in the cargo area) ran off a curved section of a 4-lane highway, crashed into a tree and overturned in the depressed median strip. There was no roof or seat in the cargo area of the truck. Meanwhile, another pickup truck, travelling at a speed of 90 km/hr, was driving behind the first vehicle on the same road also ran off the road and ended up in the depressed

Table 2. Number of injured and admitted persons by usage of safety device and vehicles in a multi-vehicle crash in front of a school, Thailand, 2008

Vehicle	Type of person	Safety device	Number total	Number injured (%)	Number admitted (%)
One prime mover	Diver	No seat belt	1	0	0
	Passenger	No seat belt	1	0	0
3 public passenger vehicles	Driver	Seat belt	1	0	0
		No seat belt	2	1 (50.0)	1 (50.0)
	Passenger in cargo area	No safety device	25	23 (92.0)	11 (44.0)
	Passenger on rear platform	No safety device	3	3 (100.0)	3 (100.0)
4 sidecar motocycles	Diver	No safety device	2	1 (50.0)	0
	Passenger	No safety device	1	1 (100.0)	0
Pedestrian			4	4 (100.0)	2 (50.0)
Total			40	33 (82.5)	17 (42.5)

median strip, following the first vehicle. One child from the first vehicle was trapped underneath and killed at the scene. All 17 people (16 children and the driver) in the first vehicle were injured, yet no one in the second vehicle was injured (Figure 6).

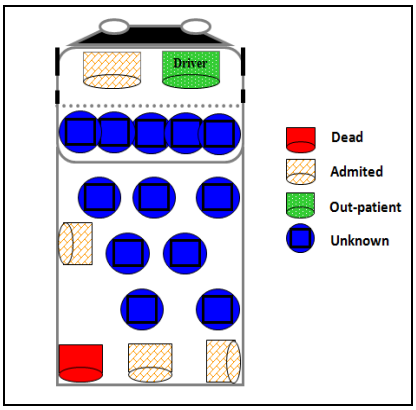


Figure 6. People affected in a school pickup truck after crashing into a tree in Thailand, 2009

Incident 5. A car running off the road and colliding with a prime mover truck

While the driver of one car tried to overtake a pickup truck which was travelling at 70-80 km/hr, the car made contact with the side of the truck, veered off the road, ran into the depressed median strip and tossed in the air. It then hit the ground and collided head-on with another prime mover truck which was a heavily loaded flatbed semi-trailer (Figure 7) traveling in the right-hand lane from the opposite direction. The car spun around, hit a tree and came to a stop. Smoke from the car engine was witnessed by a passerby who sprayed the car engine with a fire retardant. The accident involved eight people, including six in the car, one in the pickup truck and one in the prime mover truck. Five people in the car were killed, including two children and one pregnant female who died at the scene, and the car driver who died on the way to a hospital.

(a) (b)

Figure 7. (a) The car (front) and the prime mover truck pulling a semi-trailer loaded with lumber (back), (b) damaged head of the prime mover after an accident in Thailand, 2011

Discussion

Five investigations from this study revealed multiple risk factors in various phases of the events, which could be intervened to prevent severe injuries, disability and deaths. We identified modifiable factors related to risk-outcome relationship in each Haddon time period (pre-event, event and post-event).[7,9,10]

Our analysis revealed a variety of human factors: driver-vehicle inexperience, falling asleep while driving, overtaking and cornering with speed, driving too fast on wet and slippery roads, not wearing seat belts, and sitting or standing in the cargo area or rear platform of pickup trucks and songthaews. Some other pre-event factors were documented as overloading, poor tire treads, lack of safety devices (seat belts and rollover bars), use of bench seats and platforms in songthaew public passenger vehicles, trees growing near the road, and broken glass on the road. Furthermore, dim lighting, obstructed sidewalks, lack of traffic signs, lack of clear-school-community zones and lack of sidewalks were also noted.

Table 3. Meta-matrix analysis of interventions related to five multiple casualty accidents using Haddon matrix in Thailand, 2006-2011

Phase	Factors related to event			
	Human	Vehicle	Environment	
			Physical	Socio-economic
Pre-event	**National & Local Agencies** - Train drivers about speed limit, safety, rest, community and school zones, seat belt use and student drop off-pick up parking areas *(Incident 1, 2, 3, 4, 5)* - Train drivers about decisions and problems (swerve, slippery road) *(Incident 1, 3, 5)* - Educate people about road use, pickup-truck transport and seat belt use) *(Incident 1, 2, 3, 4, 5)* - Research transport safety in public passenger vehicles and standing on rear platforms *(Incident 2, 3, 4)* **Schools** - Educate students on dangers of standing on rear platforms or inside the vehicle and playing inside the vehicle *(Incident 3, 4)* - Educate passengers to use seat belt properly *(Incident 3, 4)* - Prohibit students from buying food from vendors setting up outside school boundaries *(Incident 3)*	**National Agencies** - Develop guidelines on appropriate vehicles for school transport, overload, third bench and platform of pickup trucks *(Incident 3,4)* **Local Agencies** - Enforce law on safety devices used, speed limits, overload and no occupants in cargo area *(Incident 1, 2, 3, 4, 5)* **Private Vehicles** - Checkup vehicle *(Incident 2, 3, 5)* - Install occupant restraints or other safety devices *(Incident 2, 3, 4, 5)* - Provide child restraint *(Incident 2, 5)*	**Local Agencies** - Construct pedestrian fencing and footpath *(Incident 1, 3)* - Set up traffic signs (community, school, school speed limits, flashing lights, road markings, parking) *(Incident 1, 3)* - Provide clear zone for road user *(Incident 1, 2, 4)* - Clear items obscuring or obstructing traffic signs (tree, heavy-vehicle, close-following traffic, building) *(Incident 1, 3)* - Ensure appropriate road and traffic systems in school zone *(Incident 3)* - Use pavement marking for parking in school zone *(Incident 3)* - Design safe drop off/pick up areas for students *(Incident 3)*	**National Agencies** - Develop guidelines and policies for community and school zone safety (speed limit, parking) *(Incident 1, 3)* **Local Agencies (Police, school)** - Ensure traffic safety in areas nearby schools *(Incident 3)* - Law enforcement on traffic safety of community and school zone (food vendor, parking, traffic sign) *(Incident 1, 3)*
Event	**Local Agencies** - Train drivers to solve problems when an accident occurs (driving skill) *(Incident 1, 3, 5)* - Educate people to protect themselves when an accident happens (use of restraints) *(Incident 1, 2, 3, 4, 5)* **Schools** - Educate students to protect themselves when an accident occurs (use of restraints) *(Incident 3, 4)*			
Post-event	**National & Local Agencies** - Educate and train the concerned people (witnesses, victims, students, teachers, parents) *(Incident 2, 3, 5)* - Improve access to ambulance hotline call (1669) when emergencies happen *(Incident 2, 3, 5)* - Train the concerned people about first aid *(Incident 2, 4, 5)* - Provide the manual on emergency response to rescue units and emergency teams *(Incident 2, 3, 4, 5)*			**National & Local Agencies** - Cutting equipment for rescue units *(Incident 1, 5)* - Communication tools for emergency teams and rescue units *(Incident 4)*

During the incidents, people were pinned inside or dislodged from seats and cargo areas out of the vehicles. Most casualties had multiple injuries. After the incidents, confusion often reigned for communication with emergency rescue units, limited skills on first aid measures, and frequent unmet need for cutting equipment. This caused delays in treatment beyond the "Golden Hour", substantially reducing chances of survival.[11]

The Thai experiences with MCI in this study were similar to other internal reports, publications, and observations in other countries.[12-16] Sleeping and inattention were important risks for drivers in Thailand as well as the United States of America. Approximately 4% of US drivers had an accident or near accident from dozing off behind the wheel.[17] Drowsy driving was a contributing factor in 3.9% of all accidents in the USA, with the most frequent consequence (8.3%) being running off the road.[18] People who worked long hours at night were at a 6-fold greater risk.[19]

The MCIs investigated in this study identified preventable injuries, disability and death. The Haddon matrix is a useful tool for structuring MCI investigations as it leads to the discovery of modifiable risk factors which may serve to reduce the burden of illness from MCI. The use of the Haddon matrix in five MCIs in this study suggested that there was much to be done in order to create a safer and modern road transportation system in Thailand.

Recommendations

The preceding meta-matrix analysis of five MCIs due to road traffic accidents identified possible interventions to prevent injuries or reduce the severity of injuries in the future (Table 3).

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