Environmental Factor and Road Accident: A Review Paper

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Abstract

Road accident is a predominant agenda that keep increases over the years. It has been also reported as among the death contributors worldwide, which requires an urgent respond from all countries around the world. Therefore, to overcome this issue, a comprehensive understanding on the reasons behind the occurrence of road accident is required. This review paper aimed to investigate the determinants of road accident specifically on the environmental factors. A systematic review process was conducted through five academic databases of Emerald, ScienceDirect, Scopus, Web of Science and Wiley Online Library. A total of 2462 findings were identified through database searching process. After several screening and reviewing processes, a total of 45 studies were included in this review. The results of the review indicated that bad/adverse weather and night time driving were the most common environmental factors contributing to road accident. Based on the findings, appropriate countermeasures can be outlined to curb these issues.

Keywords
Road accident, environmental factors

1. Introduction

Road accident is among the worst health hazard killing more than 1.25 million people every year (World Health Organization, 2018). Road accident statistics increases every year despite various preventive measures outlined by the government (national level) or World Health Organization (WHO) (international level). It has also been reported that approximately, 90% of the road fatalities occurred in low and middle income countries. India has been reported to lead the world road fatalities statistics with an estimation of 17 people dying every hour. This alarming rate caused a significant loss to the family, society and the government. Those considered as "vulnerable"

road users such as motorcyclists, cyclists and pedestrians have mostly died as a result of road accident. Moreover, it has also been reported that young drivers within the age of 15 to 29 years old are among those highly involved in road accident (World Health Organization, 2018). Road accident usually occurs due to three factors namely human factors, environmental factors and technical factors. Several studies reported that 90% of the road accident occurred because of the human factors while another 10% happened due to environmental and technical factors (Haghi, Ketabi, Ghanbari, & Rajabi, 2014; Uchida, Kawakoshi, Tagawa, & Mochida, 2010). Despite the fact human factors have led the major causation of road accident, the impact of environmental and technical factors cannot be ignored. Therefore, this paper aimed at systematically reviewing the road accident determinants by mainly focusing on the environmental factors.

2. Literature Review

When dealing with Mother Nature, environmental factors can be considered as the most difficult accident causation factor. Adverse and bad weathers such as heavy rain, foggy, windy and storm can dramatically affect the drivers' sights (Aron, Billot, Faouzi, & Seidowsky, 2015; Jaroszweski & McNamara, 2014). Most studies around the world reported that rainy weather is among the main environmental factors that result in road accident (Asefa, Ingale, Shumey, & Yang, 2015; Edwards, 1998; Wang, Huang, Xiang, & Pei, 2011). On the other hand, in countries with four seasons, snowfall has been reported to lead the occurrence of road accident (Eisenberg & Warner, 2005; Wang et al., 2011; Xi, Liu, Cheng, Zhao, & Ding, 2014). Apart from windy and foggy weather, dust storm has been also reported to cause road accident especially in the Middle East countries including Iran (Lankarani et al., 2014; Tezangi, 2016). These poor weather conditions have significantly reduced drivers' visibility and subsequently increased accident risk. Nevertheless, driving in a fine weather also contributes toward accident causation (Ismail, Aram, Aminzadeh, & Rahmat, 2011; Lardelli-Claret et al., 2002). Drivers were reported to drive faster and violate more traffic rules and regulation in fine weather since they do not need to be more cautious compared to that in bad weather. In overall, although environmental factors can be sometime beyond the human control, but the final decision making to drive or not during the adverse weather is made by the drivers themselves.

3. Research Methodology

Systematic reviews over literatures were conducted through five academic databases of Emerald, ScienceDirect, Scopus, Web of Science and Wiley Online Library. To undergo the review process, the researchers used several terms such as "determinant", "factor", "cause", "road accident" and "traffic crash". Apart from that, the researchers also did not apply any restriction over type of language and date for the search process. Next, the retrieved findings were exported to EndNote X7 (reference management software). Subsequently, the researchers have undergone the screening and reviewing process in order to extract the relevant papers to be included in this review study. To assist the researcher to finalize the relevant papers, several inclusion and exclusion criteria were formulated as below:

Inclusion criteria:-

1. Type of study: Cross-sectional studies, observation, case series, case control studies and weather/meteorological report
2. Sample/Data: All types of respondents either who involved in an accident or not, accident data cases and meteorological data.
3. Outcomes: Any studies that investigate the determinant or factors toward the occurrence of road accident mainly focus on the environmental factors.

Exclusion criteria:-

1. Type of study: Any meta-analysis study, review paper, student's thesis or dissertation and governmental report
2. Research focus: Determinant of road accident in term of human factors and technical factors.

3. Results and Discussion

3.1. Search Result

Table 1 shows the result of search findings from each database. Through the search, a total of 2462 findings were extracted. From the overall findings, the researchers undergo the detect duplication process and eliminate 271

duplicates findings. Next, the researchers screened the title of the remaining 2191 records and eliminate a total of 1344 unrelated titles. Then, the researchers read the abstract of the remaining 847 titles and a total of 579 irrelevant abstracts were removed. Finally, the researchers find the full text for the remaining 268 relevant abstract and eliminate a total of 223 unrelated full texts after applying the inclusion and exclusion criteria. In overall, only 45 studies were included in this review study. Figure 1 shows the PRISMA flow diagram for the review process.

Table 1. Search Findings from Four Databases

Databases	Timespan	Search fields	Language	Returns
Emerald	1951 - 2018	All field	English	128
Science Direct	1993 – 2018	All field	English	855
Scopus	1990 – 2018	All field	English	789
Web of Science	1990 - 2007	All field	English	549
Wiley Online Library	1973 - 2018	All field	English	141

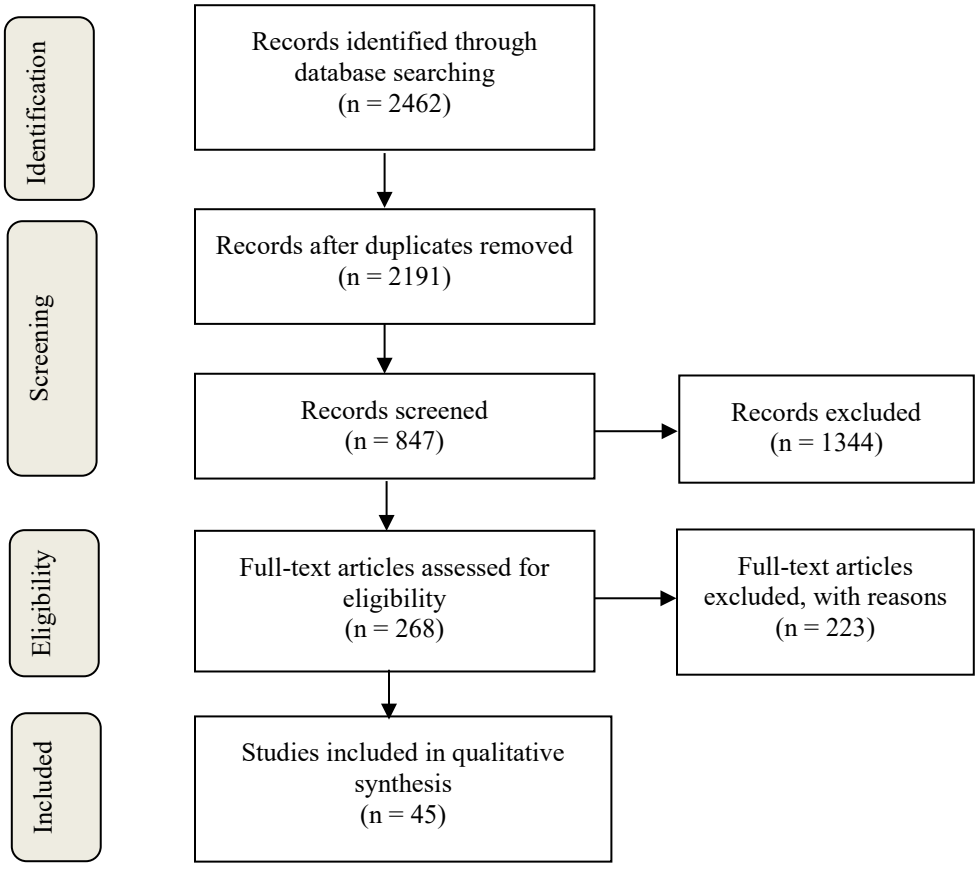

Figure 1. PRISMA flow diagram for the review process

3.2. Study Design

From the overall 45 included studies, 33 studies were categories as case series studies, three studies were cross-sectional studies, two studies were case control studies, three studies used the combination of case series and weather/meteorological data, three studies were observational studies and finally one study used the combination of case series and observation. Detail information regarding the study design of all included studies can be referred to Table 2.

3.3. Research Setting

All 45 included studies were undertaken in 20 countries all around the world with most of the studies (n = 12) were conducted in US, seven studies conducted in China, three studies conducted in Australia and Finland, two studies conducted in several countries like UK, Sweden, Iran and Spain, one study conducted in 11 countries such as French, Ethiopia, New Zealand, Mexico, Abu Dhabi, Japan, Croatia, India, Italy, Canada and Malaysia and finally one study conducted in combination of two countries namely Thailand and US. Detail information regarding the study setting of all included studies can be referred to Table 2.

3.4. Research Sample/Data

All included studies employed various research sample with majority of the study (n = 21) used the data from accident cases, 15 studies used the sample of accident victims, six studies used the combined data of accident cases and weather/meteorological data, two studies used the data gathered from observation at road segment/junction/ramps and finally one study used the combined sample of accident victims and control group. Detail information regarding the research sample of all included studies can be referred to Table 2.

3.5. Determinant of Road Accident (Environmental Factors)

Environmental factors can be divided into weather and time when the accidents are prone to occur. In terms of weather, seven studies reported that accident usually occurs during rainy weather (Aron et al., 2015; Asefa et al., 2015; Black, Villarini, & Mote, 2017; Jaroszweski & McNamara, 2014; Mitchell, Driscoll, & Healey, 2004; Mondal et al., 2011; Saha, Schramm, Nolan, & Hess, 2016). Most of the researchers reported that rainy weather has significantly reduced the drivers' visibility and increased accident involvement (Jaroszweski & McNamara, 2014; Mondal et al., 2011; Saha et al., 2016). Moreover, three studies conducted in the US reported that driving during inclement weather (wet and cold) can more likely cause accident (Chen, Chen, & Ma, 2018; Das, Brimley, Lindheimer, & Zupancich, 2017; Legree, Heffner, Psotka, Martin, & Medsker, 2003). Nine studies reported that accident is also prone to occur during snowy, cloudy, windy and foggy weathers (Chen & Zhang, 2016; Edwards, 1998; Eisenberg & Warner, 2005; Híjar, Carrillo, Flores, Anaya, & Lopez, 2000; Li, Yamamoto, & Zhang, 2018; Perrels, Votsis, Nurmi, & Pilli-Sihvola, 2015; Ponnaluri, 2016; Wang et al., 2011; Xi et al., 2014). Similarly, accidents are prone to occur during these weathers due to the decline in drivers' visibility. Two studies conducted in Iran reported that accidents occur in the country because of dust storm, which not only drastically reduce drivers' visibility, but also cause respiratory problems including asthma (Lankarani et al., 2014; Tezangi, 2016. Apart from adverse and bad weather, accident is also highly occurs during good weather. Seven studies reported that most of the accidents occurred during fine weather (Haynes et al., 2008; Ismail et al., 2011; Lardelli-Claret et al., 2002; McGwin & Brown, 1999; Mohamed, Mohamed, & Al-Harthi, 2017; Radun & Radun, 2006; Tanishita & van Wee, 2017). Majority of the accidents occurred during fine and clear weather because the drivers were reported to drive at higher speed and being less caution compared to that during adverse or bad weather (Haynes et al., 2008; McGwin & Brown, 1999; Mohamed et al., 2017; Tanishita & van Wee, 2017). Young drivers have been reported to commit speeding violation when driving during fine weather because they are perceived to be risk takers despite their lack of driving skills, whereas older drivers are mainly involved in road accident during fine weather because of several driving errors while changing lane and the failure to foresee unseen objects on the road (McGwin & Brown, 1999). Moreover, drivers have been also reported to fall asleep when driving at fine and clear weather, which subsequently increased accident risk (Radun & Radun, 2006).

Subsequently, accident has been reported to occur at certain period of time. Nine studies reported that accident causations were prone to happen at night (Das, Dutta, Jalayer, Bibeka, & Wu, 2018; Hasselberg & Laflamme, 2009; Lam, 2004; Pino, Pelosi, & Baldari, 2013; Roeper & Voas, 1998; Vorko-Jović, Kern, & Biloglav, 2006; Yuan, Dai, & Wang, 2016; Zhang, Yau, Zhang, & Li, 2016; Zhang, Fraser, Lindsay, Clarke, & Mao, 1998). This was because the drivers were reported to fall asleep from feeling tired (Pino et al., 2013; Yuan et al., 2016; Zhang et al., 2016). On the other hand, several researchers also reported that drivers tend to speed during the night due to fewer vehicles on the road (Hasselberg & Laflamme, 2009; Lam, 2004; Vorko-Jović et al., 2006; Yuan et al., 2016). Driving too fast causes the drivers to loss control over their vehicles and unable to respond promptly when sudden thing happen on the road. Moreover, accidents also prone to occur at night time especially when drivers are

driving alone. A study conducted in Australia reported that taxi drivers who drive alone without any passenger at night time have involved in more accidents compared to taxi drivers with passengers (Lam, 2004). The situation was even worst when drivers were driving during night time with worst condition. A study conducted in Spain reported that drivers were prone to be involved in accident when driving at night especially during twilight condition (Redondo-Calderon et al., 2001). In addition, four studies reported a mixed finding as accident usually happened at night and fine weather (Lam, 2003b; Öström & Eriksson, 2002; Shen & Neyens, 2017; Zhang et al., 2013). Apart from driving at night time, driving during late afternoon and evening can also contribute to the occurrence of road accident (Kasantikul & Ouellet, 2005; Laapotti & Keskinen, 1998). A study conducted in Los Angeles, US reported that 60% of drivers were reported consuming alcohol as early as 2 p.m. resulting in more accidents at late afternoon and in the evening (Kasantikul & Ouellet, 2005). Finally, a study conducted in Minnesota, US highlighted that the daylight saving time in the state has significantly helped to reduce accident rate because longer daylight provides better visibility to the drivers (Huang & Levinson, 2010). Detail information regarding the environmental factors that lead toward the occurrence of road accident can be referred to Table 2.

Table 2: Determinant of Road Accident (Environmental Factors)

No	Study	Country	Sample size	Study Design	Determinant of Road Accident
1.	Aron et al. (2015)	French	292 accident cases	Case series	Rainy weather
2.	Asefa et al. (2015)	Mekelle and Tigray (Northern Ethiopia)	712 taxi drivers (188 actual victim)	Cross-sectional study	Rainy weather
3.	Chen and Zhang (2016)	Jiangxi and Shaanxi (China)	71,695 accident cases	Case series	- Rainy weather - Snowy - Foggy - Night time
4.	Das et al. (2017)	Florida, US	Combination of Florida crash data (2010-2012) and weather data	Case series	Inclement weather (cold and wet)
5.	Das et al. (2018)	Louisiana, US	2651 crash victims	Case series	Night time
6.	Edwards (1998)	England and Wales	Combination of England and Wales crash data (1980-1990) and weather data	Case series	- Rainy weather - Windy weather - Fog
7.	Eisenberg and Warner (2005)	US	1.4 million fatal crashes cases, 13.5 million nonfatal-injury crashes and weather data	Case series	Snowy weather
8.	Hasselberg and Laflamme (2009)	Sweden	2448 accident victims	Case series	Night time
9.	Haynes et al. (2008)	New Zealand	4058 fatal crashes cases	Case series	Fine weather
10.	Híjar et al. (2000)	Mexico-Cuernavaca	162 drivers who involved in accident (subject) and 445 drivers (control group)	Case control study	- Rainy weather - Fog
11.	Huang and Levinson (2010)	Minnesota	Accident data cases from 2001 to 2007	Case series	Daylight saving time provide better visibility reduce accident
12.	Jaroszweski and McNamara (2014)	Manchester and Greater London	Combination of accident cases (2008-2011) and weather data	Case series and meteorological data	Rainy weather
13.	Laapotti and Keskinen (1998)	Finland	338 males and 75 males fatal accident victims	Case report	Evening and night time
14.	Lam (2003a)	New South Wales, Australia	3981 crash victims (young drivers)	Case series	- Night time - Fine weather
15.	Lam (2004)	New South Wales, Australia	7923 accident victims (taxi drivers)	Case series	Night time
16.	Lankarani et al. (2014)	Iran	542,863 accident cases	Case series	- Dusty weather - Sunrise and

					sunset
17.	Li et al. (2018)	Guangdong, China	1101 accident cases	Case series	Cloudy weather
18.	McGwin and Brown (1999)	Alabama	136,465 accident cases	Case series	Fine weather
19.	Mitchell et al. (2004)	Australia	543 fatal work-related accident victims	Case series	Rainy weather
20.	Mohamed et al. (2017)	Abu Dhabi	1,841 rear-end crashes and 8,967 severe crashes cases	Case series	Fine weather
No	**Study**	**Country**	**Sample size**	**Study Design**	**Determinant of Road Accident**
21.	Öström and Eriksson (2002)	Sweden	157 snowmobile fatality cases	Case series	- Night time - Fine weather
22.	Perrels et al. (2015)	Finland	72,000 meteorological data and accident data	Observation and Case series	Windy weather
23.	Ponnaluri (2016)	Florida, US	999,456 crash cases	Case series	Foggy weather
24.	Redondo-Calderon et al. (2001)	Spain	151,364 accident cases	Case series	- Twilight - Night time
25.	Roeper and Voas (1998)	California	33,614 accident victims	Case series	Night time
26.	Saha et al. (2016)	US	760,517 fatality cases (1994 to 2012)	Case series	Rainy weather
27.	Shen and Neyens (2017)	South Carolina	34,796 male and 43,374 female teens (accident victims)	Case series	- Night time - Fine weather
28.	Tanishita and van Wee (2017)	Japan	78 accident cases	Observation	Fine weather
29.	Tezangi (2016)	Yazd, Iran	2861 accident cases	Case series and meteorological data	Dust storm
30.	Vorko-Jović et al. (2006)	Zagreb, Croatia	528 accident victims	Case series	Night time
31.	Wang et al. (2011)	Xi'an, China	3038 accident victims	Case series	- Cloudy - Rainy - Foggy - Snowy - Heavily windy
32.	Xi et al. (2014)	China	20,000 accident cases (curve road crash)	Case series	Snowy weather
33.	Zhang et al. (2016)	Guangdong, China	384 accident cases (fatigue related crash)	Case series	Night time
34.	Zhang et al. (1998)	Canada	49,035 accident victims	Case series	Night time
35.	X. J. Zhang et al. (2013)	China	67,759 fatal accident victims	Case series	- Night time - Fine weather
36.	Chen et al. (2018)	Northglenn and Castle Pines, Colorado	328,529 observations from 57 road segments	Observation	Inclement weather (cold and wet)
37.	Ismail et al. (2011)	Malaysia	5 crash black-spot interchange ramps	Observation	Fine weather
38.	Kasantikul and Ouellet (2005)	Thailand and Los Angeles	Thailand: 969 accident cases Los Angeles: 900 accident cases	Case series	Late afternoon and night time
39.	Lardelli-Claret et al. (2002)	Spain	57,472 accident cases	Case control study	Fine weather
40.	Legree et al. (2003)	US	127 soldiers involved in accidents and 424 soldiers not involved in accident	Cross-sectional study (Questionnaire)	Inclement weather (cold and wet)
41.	Mondal et al. (2011)	New Delhi, India	1928 accident cases and metrological data	Case series	Rainy weather

42.	Pino et al. (2013)	Parma, Italy	1489 accident cases	Case series	Night time
43.	Radun and Radun (2006)	Finland	Study I: 101 accident victims Study II: 1464 accident victims	Cross-sectional study (Interview)	Fine weather
44.	Yuan et al. (2016)	Beijing, China	100 accident cases	Case series	Night time
45.	Black et al. (2017)	Arkansas, Georgia, Illinois, Maryland, Minnesota & Ohio	28,000 traffic crashes and 12,000 injury cases	Case series and meteorological data	Rainy weather

4. Conclusion

From the review, it can be summarized that most of the accidents occurred due to adverse weather of raining that consequently reduces the drivers' visibility. Apart from that, rainy weather also causes difficulty for the drivers to control their vehicle as the road becomes more slippery. The situation is even worst in the case where the drivers poorly maintain their vehicle's tires, which increases the probability for the drivers to involve in road accident. Apart from that, road accident also tends to occur during fine and clear weather. As compared to adverse weather, drivers tend to be less cautious when driving in a good weather. Moreover, the result of the review also highlighted a high number of accidents that happened at night. In addition to feeling tired and drowsiness during night, drivers also tend to increase their speed due to less number of vehicles. This situation has significantly contributed toward the accident risk. The results of the review were presented from all countries around the world with most of the studies conducted in Western countries like the US. Besides, most of the included studies used the data of accident cases retrieved from police or governmental databases. These data comprised of various information that can be used to disclose the antecedence of road accident.

In overall, road accident is indeed a critical issue faced by all countries around the world. The number of road accident seems to incline in accordance with the increment of car ownership worldwide. To curb with this issue, the most appropriate preventive measure need to be outlined. Nevertheless, dealing with Mother Nature is sometime beyond the human control. For instance, the meteorological department can forecast the weather, but the severity of the weather condition is sometime unpredictable. Therefore, the countermeasures that have already been outlined at the first place may not work. Likewise, in the case of night driving, even though the government has made the effort to install street light to increase the drivers' visibility, but the drivers' bad driving attitude of breaking the speed limit has significantly put them in danger. Although the government is responsible to drew and execute the accident preventive measures, these actions would be ineffective if the drivers do not abide with the traffic rules and regulations. As a conclusion, drivers are responsible to change their driving attitude and along with the government preventive measures which can further minimize the road accident problems.

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