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Research paper

Technical Determinant of Road Accident: A Systematic Review

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Abstract

Road accident statistics has been reported increasing over the years and become one of the significant death contributors worldwide. In response towards this issue, appropriate countermeasures need to be outlined. Proposing a preventive plan requires comprehensive understanding on factors behind the occurrence of road accident. Therefore, this review paper aimed at investigating the factors behind the occurrence of road accident focusing on the technical factors. A review over five academic databases such as Emerald, ScienceDirect, Scopus, Web of Science and Wiley Online Library has been conducted leading towards an overall finding of 2462 related records. After screening and reviewing the records, only 38 studies were included. The result of the review indicated several technical factors in terms of road and vehicle faulty toward the occurrence of road accident.

Keywords: *Road accident; technical factor; road faulty; vehicle faulty*

1. Introduction

Every year, more than 1.25 million people died due to road accident [1]. This figure is expected to increase over the years and without a proper preventive action plan, road accident is projected to become the seventh leading death contributor by the year 2030 [1]. World Health Organization (WHO) further reported that people within the age of 15 to 29 years old were among the most involved in fatal traffic crash with 73% of them are males [1]. It has been also reported that every year, nearly 20 to 50 million people suffer from non-fatal injuries with most of them experiencing disability due to road accident [1]. Resulting from road accident, most countries around the world were reported to spent at least 3% of their gross domestic product to bear the medical cost, road damages and loss of human productivity [1]. Road accident mainly occurs due to three factors; human factors, environmental factors and technical factors. Review over literatures mostly reported that 90% of the road accident around the globe occurred due to human factors, whereas the remaining 10% can be explained through environmental and technical factors [2, 3]. In contrast with environmental factors, most of the technical factors are preventable factors. Therefore, these factors should be highlighted in addressing the increment of road accident.

Technical factors can be divided into road and vehicle faulty. There are several technical roads faulty that could lead toward the occurrences of road accident. The factors are the quality of the road surface, the road condition, the geometric design of the road and the type of the roadways. It has been reported that asphalt-paved road and uneven road are among the road surface that lead to accident causation. Moreover, the unavailability of proper road facilities is also one of the leading causes of road accident. To deal with this issue, government is accountable to provide the road facilities such as street light, footpath, pedestrian crossing, emergency lane, traffic light and rest area. These facilities will indirectly help to overcome the occurrence of road accident.

Apart from that, it been reported that drivers also play a major role in dealing with the vehicle faulty. Study showed that vehicle age can significantly influence the accident involvement [4]. The faulty over vehicles increased as the age of the vehicle increases. Therefore, road accident statistics involving old vehicles were reported high compared to new vehicles [4]. As a result, drivers are required to make regular service to ensure that their vehicles are technically safe to drive. In overall, technical factors indeed play a predominant role behind the occurrence of road accident. Therefore, this paper was aimed to systematically review the factors behind the occurrence of road accident focusing on the technical factors.

2. Methodology

A systematic review has been conducted toward five academic databases of Emerald, ScienceDirect, Scopus, Web of Science and Wiley Online Library. To undertake the review process, several terms such as “determinant”, “factor”, “cause”, “road accident” and “traffic crash” has been used by the researchers. The researchers did not apply any language and date restriction during the search process. All the retrieved findings were then exported to EndNote X7 (reference management software). Next, the researchers screened and reviewed each of the related findings only included the relevant studies that matched with the inclusion and exclusion criteria. The criteria are as below:

Inclusion criteria:-

1. Type of study: Cross-sectional studies, observation, case series, case control studies, meteorological data and in-depth analysis.

2. Target person/sample: All types of respondents who either involved in a road accident or not and accident case data.
3. Outcomes: Any studies that investigate the factors toward the occurrence of road accident focusing on the technical 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 environmental factors.

During the reviewing process, a total of 58 full text articles are unable to be retrieved from the databases. Therefore, the researchers either personally emailed each of the authors or requested articles through ResearchGate account. As a results, a total of 37 full text articles have been successfully retrieved from the authors. The remaining 21 full text articles were excluded from this study.

3. Results and Discussion

3.1. Search Result

Table 1 shows the findings gathered from each academic database. A total of 2462 findings was extracted from five databases and after undergoing the detect duplication process, a total of 271 duplicates findings were removed. Subsequently, in the screening title process, the researchers eliminated 1344 irrelevant titles and the remaining 847 related titles were then undergone the abstract review process. In this process, the researchers read each of the abstract and eliminated 579 unrelated abstract. Afterward, the researchers extracted the full paper of the remaining 268 abstracts and read each of the papers. As a result, only 38 related studies that matched with the inclusion and exclusion criteria were included in this review paper. Figure 1 shows the PRISMA flow diagram for the review process.

Table 1: Search findings from five databases

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

3.2. Study Design

From the overall 38 included studies, 31 studies were categories as case series studies, two studies were cross-sectional studies, three studies were case control studies, one study was observational study and one study was an in-depth analysis study. Detail information on study design can be referred to Table 2.

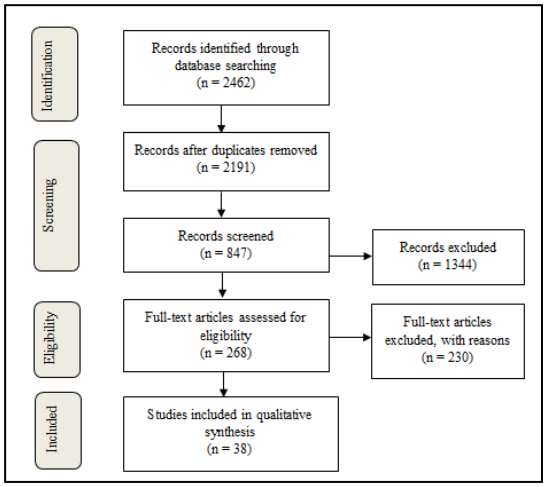

Fig. 1: PRISMA flow diagram for the review process

Table 2: Search findings from five databases

No	Study	Country	Sample size	Study Design	Determinant of Road Accident (Technical Factor)	
					Road	Vehicle
1.	Abdul Manan et al [17]	Malaysia	9176 motorcycle fatal traffic crash records	Case series	- Curve road sections - No road marking - Asphalt-paved road (smoother surface)	
2.	Adejugbagbe et al [21]	Ibadan, Nigeria	594 crash victims	Cross-sectional study	- Narrow road - Bad portions of tarred road	Break failure
3.	Adeoye et al [35]	Nigeria	571 road traffic victims	Case control study	Absence of road shoulders	
4.	Altwaijri et al [5]	Riyadh, Saudi Arabia	698,245 traffic crash cases (5 years data)	Case series	- Wet road surface - Dark lighting condition	
5.	Asefa et al [40]	Mekelle and Tigray (Northern Ethiopia)	712 taxi drivers (188 actual victim)	Cross-sectional study		Driving mechanically faulty taxi
6.	Chen et al [6]	New Mexico (US)	8677 accident cases	Case series	- Road curve - Wet road surface	
7.	Chen and Zhang [31]	Jiangxi and Shaanxi (China)	71,695 accident cases	Case series	- Sharp horizontal curves - Steep grades - Absence of tunnels and bridges	Overloading vehicle which cause break failure
8.	Chen et al [42]	China	189 accident cases	Case series	- Malfunctioning traffic light - Missing street lights	Overloading vehicle which cause break failure
9.	Das et al [29]	Louisiana, US	2651 crash victims	Case series	- Improper and inadequate pavement markings - Inadequate signs and alert systems	
10.	Haynes et al [22]	New Zealand	4058 fatal crashes cases	Case series	Dry surface	
11.	Híjar et al [7]	Mexico-	162 drivers who	Case control study	Wet pavement surface	

		Cuernavaca	involved in accident (subject) and 445 drivers (control group)			
12.	Islam Bin and Kanitpong [24]	Thailand	A case study	In-depth analysis	- Inadequate lane marking - Absence of street-light facilities - No speed limit sign	
13.	Laapotti and Keskinen [12]	Finland	338 males and 75 males fatal accident victims	Case series	Slippery road	
14.	Lankarani et al [13]	Iran	542,863 accident cases	Case series	- Slippery road - Narrow road - Flat straight road - Winding uphill/downhill road	
15.	Li et al [25]	Guangdong, China	1101 accident cases	Case series	Absence of street light	
16.	Marmor and Marmor [14]	Massachusetts, Connecticut, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and Maine (US)	34,501 accident cases	Case series	Slippery road	
17.	McGwin and Brown [33]	Alabama (US)	136,465 accident cases	Case series	Curve road	
18.	Mohamed et al [23]	Abu Dhabi	1,841 rear-end crashes and 8,967 severe crashes cases	Case series	Dry surface	
19.	Muhammad et al [26]	Shara-e-Faisal, Pakistan	8514 accident cases	Case series	- Absence of lane marking - Absence of street light - Hazardous road sections	
20.	Nunn [30]	Indiana (US)	601 fatal motorcyclist cases	Case series	Absence of street light	
No	**Study**	**Country**	**Sample size**	**Study Design**	**Determinant of Road Accident (Technical Factor)**	
					Road	**Vehicle**
21.	Rafi et al [27]	Shara-e-Faisal, Pakistan	8514 accident cases	Case series	- No lane marking - No street light - Hazardous road sections	
22.	Rakotonirainy et al [37]	Queensland, Australia	32,961 accident victim (older drivers)	Case series	- Crossroad - T-junctions	
23.	Ramli et al [15]	Klang Valley, Malaysia	177 fatal and 578 non-fatal accident cases	Case series	Detect roads:- - Potholes - Uneven surface - Slippery surface	
24.	Saha et al [16]	US	760,517 fatality cases (1994 to 2012)	Case series	- Slippery road - Poor light condition	
25.	Shen and Neyens [38]	South Carolina (US)	34,796 male and 43,374 female teens (accident victims)	Case series	Intersection junction	
26.	Vorko-Jović et al [39]	Zagreb, Croatia	528 accident victims	Case series	- Urban road links - Urban junction	
27.	Wong et al [34]	Hong Kong	262 signalized junctions (intersection crash)	Case series	Decrease in average lane width (bottleneck road)	
28.	Xi et al [18]	China	20,000 accident cases (curve road crash)	Case series	- Friction road surface - Asphalt-paved road (smoother surface)	
29.	Yuan et al [8]	Beijing, China	100 rear-end trucks crashes cases	Case series	- Express way roads - Ring roads - Straight line road - Wet road surface	
30.	Zhang et al [36]	Guangdong, China	384 accident cases (fatigue related crash)	Case series	Expresses road	
31.	Zhang et al [9]	Ontario, Canada	35.510 accident cases (older drivers)	Case series	- Intersection without traffic control - Wet road surface (snow or ice)	

32.	Zhang et al [19]	China	67,759 fatal accident victims	Case series	- Flat and straight road - Asphalt-paved road (smoother surface)	
33.	Chen et al [10]	Northglenn and Castle Pines, Colorado (US)	328,529 observations from 57 road segments	Observation	- Wet road surface - Slippery road surface	
34.	Devasurendra et al [32]	Sri Lanka	777,086 accident cases	Case series	Inadequate road network development to cater the increase of car ownerships	
35.	Lardelli-Claret et al [41]	Spain	57,472 accident cases	Case control study		Darker car colour (grey, red, black and blue)
36.	Mondal et al [11]	New Delhi, India	1928 accident cases and metrological data	Case series	Wet road	
37.	Yuan et al [20]	Beijing, China	100 accident cases	Case series	- Asphalt-paved road (smoother surface) - Absence of street light	
38.	Wang et al [28]	Harbin, China	8,036 fatal accident cases	Case series	- Road bottleneck - Weak lighting condition	- Brake failure

3.3. Research Setting

All included studies were undertaken in 17 countries all around the world with most of the studies (n = 9) were conducted in China, 8 studies conducted in the US, two studies conducted in three countries like Malaysia, Nigeria and Pakistan. Whereas the remaining 15 studies were conducted in Saudi Arabia, Ethiopia, New Zealand, Mexico, Thailand, Finland, Iran, Abu Dhabi, Australia, Croatia, Hong Kong, Canada, Sri Lanka, Spain and India. Detail information on study setting can be referred to Table 2.

3.4. Research Sample

From 38 included studies, 24 studies used the data from accident cases, nine studies used the sample of accident victims, one study is categories as in-depth analysis study, two studies used the data gathered from observation at road segment/junction/ramps, one study used the combined sample of accident victims and control group and finally one study used data from a case study involving bus and pickup truck accident case. Detail information on research sample can be referred to Table 2.

3.5. Determinant of Road Accident (Technical Factor)

3.5.1. Road Faulty

From the overall included studies, 36 studies specifically discussed on the impact of road faulty towards accident causation. From the review, the impact of road faulty towards the occurrence of road accident can be divided into quality of the road surface, road condition, road geometric design and type of roadways. Firstly in terms of the road surface quality, most of the studies (n = 7) conducted in several countries like Saudi Arabia, US, Mexico, China, Canada and India reported that wet road surface significantly caused road accident [5-11]. Apart from that, slippery road has been reported to lead the accident causation especially in US and several other countries like Finland, Malaysia and Iran [10, 12-16]. Moreover, three studies conducted in China and a study conducted in Malaysia reported that asphalt-paved road with smoother surface is also prone to cause road accident [17-20]. The accident severity can become even worst when driving on the wet, slippery and smoother road surface especially when the tires tread wear. Moreover, it has been reported that young drivers were the most involved in road accident when driving on these road surfaces since they have less driving skills to avoid their vehicles from crash [6, 7, 19]. Furthermore, road with bad portions of tarred and potholes causing the road to be uneven lead towards accident occurrence in countries like Nigeria and Malaysia [15, 21]. The situation is worsening for the motorcyclists since riding on uneven road can cause them to loss balance and fall from their motorcycles [15]. Finally, other road surface qualities such as dry and frictional surface can also significantly lead towards accident [18, 22, 23].

Secondly, in terms of road condition, most of the studies (n = 10) reported that driving on dark lighting road or road with no street light can significantly cause road accident in several countries like Saudi Arabia, China, Thailand, Pakistan and the US [5, 6, 8, 16, 20, 24-28]. Besides, nine included studies reported that the absence of road marking and other road signs as well as alert system such as the sign of speed limit have been reported to cause the occurrence of road accident [17, 20, 24-30]. Additionally, it has been recorded that malfunction traffic light did not only cause traffic jam in China, but also increased the accident risk [6]. Likewise, inadequate road network and absence of tunnels and bridges also significantly lead toward the occurrence of road accident [31, 32]. Inadequate road network in Sri Lanka to cater the increment of car ownership has caused massive traffic jam in the country, which subsequently led to a higher accident involvement rate [32].

Thirdly, in terms of road geometric design, most accidents have been reported to occur at curve and narrow roads [6, 13, 17, 21, 31, 33]. Young drivers were reported to be the most involved in road accident at the curve and narrow roads in several countries like Nigeria, China and the US [21, 31, 33]. Two studies conducted in Pakistan reported that accident usually occurred at hazardous road sections [26, 27]. It has been further reported that young motorcyclists especially male were those mostly involved in road accident at hazardous road sections in the country. Apart from that, two studies from China reported that accident commonly takes place at steep grades and bottleneck roads [28, 31]. Bottleneck road has significantly increased the conflict between vehicles and disrupt the traffic flow, which consequently increased the accident involvement in the country [28]. Similarly, a study conducted in Hong Kong reported that accident has mostly occurred at the bottleneck roads as road conflict increases due to the decrement of average lane width [34]. Finally, in Nigeria, it was reported that accident is more likely to occur due to the absence of road shoulder [35]. In addition, broken down vehicles have been reported to impede the traffic flow because the drivers were unable to move their car on the road shoulder, thus leading to the increased cases of crash risk at the country [35].

Finally, in terms of roadway type, most studies (n = 4) reported that accidents in China and Iran were prone to occur on expressway with flat and straight roads [8, 13, 19, 36]. Accident commonly occurred on these types of roadways since drivers were more likely to be fatigue and fall asleep when driving to their

destination [36]. In addition, several accidents have been reported to happen at crossroad and junction especially in the case where there is no traffic light on the junction [9, 37-39]. The occurrence of accident at junction mostly involved the young and male drivers as a result to their excessive speeding behavior [39]. Besides, a study conducted in China further reported that accident mostly occurred at the ring roads [8]. The increment of vehicle volume at the ring roads causes more conflict between the vehicles that subsequently increases accident risk. Finally, a study conducted in Iran highlighted that accident is prone to happen at winding roads [13]. Winding uphill at downhill roads was reported to contribute to most of the accident occurrences in the country as this type of roadways limits drivers' vision, thus subsequently causing difficulty for them to control their vehicles.

3.5.2. Vehicle Faulty

From the overall included studies, only six studies discussed on the impact of vehicle faulty towards the occurrence of road accident. From the review, the most significant vehicle faculty that caused accident was break failure [6, 21, 28, 31]. Two studies from China further emphasized that the cause of brake failure was due to the overloading vehicle [6, 31]. Subsequently, a study conducted in Ethiopia reported that taxi drivers' ignorant behavior of driving mechanically faulty taxi has significantly led towards accident involvement [40]. This is an avoidable accident as drivers are responsible to take care of their car through regular service especially when they are the public transport providers. Finally, besides vehicle faulty, vehicle color has been proved to lead the occurrence of road accident. A study conducted in Spain reported that drivers who drive darker car colors such as black, blue and grey are more prone to be involved in road accident compared to those with lighter car colors [41]. Darker car colors cause difficulties for other road users to see the incoming car especially when driving at a limited lighting roadway or during the midnight. Detail information regarding the technical factors that lead toward the occurrence of road accident can be referred to Table 2.

4. Conclusion

In overall, it can be summarized that accident mostly occurs due to poor road quality surfaces (slippery, wet, uneven, dry and smooth), poor road conditions (absence of street light and road marking, malfunction traffic light and inadequate of road network, bridge and tunnel), poor road geometric designs (curvy road, narrow road, hazardous road section, road bottleneck and steep grades) and certain types of roadway that are prone to the occurrence of road accident such as expressway with straight and flat roadway, winding road as well as road junctions without traffic light. Apart from that, vehicle faulty in terms of brake failure has been proved to be the significant accident causation. In addition, the color of vehicle seemed to influence accident involvement as darker vehicle colors reduce vehicle visibility to other road users. All the included studies were conducted in various countries around the world with most of the studies conducted in China and the US. This indicate that road accident is a critical issue faced by all countries worldwide.

All the presented findings can be considered as avoidable factors. Unlike the environmental factors that deal with Mother Nature, technical factors are highly related with the human behavior and transport master plan implemented by the government to develop the road network. In dealing with vehicle faulty, drivers are responsible to make sure that their vehicles are safe in terms of mechanical condition. Brake failure has caused a significant number of road accidents in the world and should be catered starting from now through educating and reminding the drivers to make regular service for a safe driving. Meanwhile, in dealing with the road factors, the government needs to revise back the transport master plan to cater the increment of the vehicle ownership. Apart from that, the government should maintain and overcome the road facility problems such as the absence of street light, malfunction traffic light, uneven road, missing signage and absence of road marking. Finally, when all the stakeholders such as the government, related authorities/ministry and drivers themselves play their roles effectively, road accident can be avoided.

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