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 and included in 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 result, 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 process. In this process, the researchers read each of the abstract and eliminated 1579 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.

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.

### 3.1. Search Result

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Sample size</th>
<th>Study Design</th>
<th>Determinant of Road Accident (Technical Factor)</th>
<th>Road</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Abdul Manan et al [17]</td>
<td>Malaysia</td>
<td>9176 motorcycle fatal traffic crash records</td>
<td>Case series</td>
<td>- Curve road sections</td>
<td>- No road marking</td>
<td>- Wet pavement surface</td>
</tr>
<tr>
<td>2. Adejugbagbe et al [21]</td>
<td>Ibadan, Nigeria</td>
<td>594 crash victims</td>
<td>Cross-sectional study</td>
<td>- Narrow road</td>
<td>- Bad portions of tarred road</td>
<td>Break failure</td>
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<tr>
<td>3. Adeoye et al [35]</td>
<td>Nigeria</td>
<td>571 road traffic victims</td>
<td>Case control study</td>
<td>Absence of road shoulders</td>
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<tr>
<td>5. Asefa et al [40]</td>
<td>Mekelle and Tigray (Northern Ethiopia)</td>
<td>712 taxi drivers (188 actual victims)</td>
<td>Cross-sectional study</td>
<td>Driving mechanically faulty taxi</td>
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<tr>
<td>6. Chen et al [6]</td>
<td>New Mexico (US)</td>
<td>8677 accident cases</td>
<td>Case series</td>
<td>- Road curve</td>
<td>- Overloading vehicle which cause break failure</td>
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<tr>
<td>7. Chen and Zhang [31]</td>
<td>Jiangxi and Shaanxi (China)</td>
<td>71,695 accident cases</td>
<td>Case series</td>
<td>- Sharp horizontal curves</td>
<td>- Overloading vehicle which cause break failure</td>
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<tr>
<td>8. Chen et al [42]</td>
<td>China</td>
<td>189 accident cases</td>
<td>Case series</td>
<td>- Steep grades</td>
<td>- Missing street lights</td>
<td></td>
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<tr>
<td>9. Das et al [29]</td>
<td>Louisiana, US</td>
<td>2651 crash victims</td>
<td>Case series</td>
<td>- Absence of tunnels and bridges</td>
<td>- Improper and inadequate pavement markings</td>
<td></td>
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<tr>
<td>10. Haynes et al [22]</td>
<td>New Zealand</td>
<td>4058 fatal crashes cases</td>
<td>Case series</td>
<td>Dry surface</td>
<td></td>
<td></td>
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<tr>
<td>No</td>
<td>Study</td>
<td>Country</td>
<td>Sample size</td>
<td>Study Design</td>
<td>Determinant of Road Accident (Technical Factor)</td>
<td>Road</td>
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<tr>
<td>13</td>
<td>Laapotti and Keskinen [12]</td>
<td>Finland</td>
<td></td>
<td>Case series</td>
<td>In-depth analysis</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Lankarani et al [13]</td>
<td>Iran</td>
<td>542,863 accident cases</td>
<td>Case series</td>
<td>- Slippery road - Narrow road - Flat straight road - Winding uphill/downhill road</td>
<td></td>
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<tr>
<td>15</td>
<td>Li et al [25]</td>
<td>Guangdong, China</td>
<td>1101 accident cases</td>
<td>Case series</td>
<td>Absence of street light</td>
<td></td>
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<tr>
<td>17</td>
<td>McGwin and Brown [33]</td>
<td>Alabama (US)</td>
<td>136,465 accident cases</td>
<td>Case series</td>
<td>Curve road</td>
<td></td>
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<tr>
<td>18</td>
<td>Mohamed et al [23]</td>
<td>Abu Dhabi</td>
<td>1,841 rear-end crashes and 8,967 severe crashes cases</td>
<td>Case series</td>
<td>Dry surface</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Muhammad et al [26]</td>
<td>Shara-e-Faisal, Pakistan</td>
<td>8514 accident cases</td>
<td>Case series</td>
<td>Absence of lane marking - Absence of street light - Hazardous road sections</td>
<td></td>
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<tr>
<td>20</td>
<td>Nunn [30]</td>
<td>Indiana (US)</td>
<td>601 fatal motorcyclist cases</td>
<td>Case series</td>
<td>Absence of street light</td>
<td></td>
</tr>
</tbody>
</table>

**Study Design**
- In-depth analysis
- Case series
- Decrease in average lane width (bottleneck road)
- Crossroad
- T-junctions
- Intersection junction
- Detect roads:
  - Potholes
  - Uneven surface
  - Slippery surface
- Urban road links
- Urban junction
- Friction road surface
- Asphalt-paved road (smoother surface)
- Express way roads
- Ring roads
- Straight line road
- Wet road surface
- Expresses road
- Intersection without traffic control
- Wet road surface (snow or ice)
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 lose 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 ownerships 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 brake 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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References
