

Strategic Indicators for Targeted Road Safety Index

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Abstract – Road safety has become one of the most hazardous threats to human kinds since 1.25 million road traffic deaths occur every year, with young people between the age of 15-29 mostly died from road traffic death. As this figure continues to increase steadily each passing year, concerns on developing strategic road safety planning have been taken into the picture. Governments, including Malaysia, refer to outputs from road safety indexes to assess their performance and improve local conditions. Several road safety indexes have included Malaysia in their list, which is stratified according to income status, continents, and the number of populations, to name a few. However, the competitions were seen to be unfairly played as each and every country are unique and different from each other thus ideal comparisons are very challenging. This paper aims to shed light on this issue by suggesting suitable and strategic indicators to be used in a targeted road safety index to allow a fair comparison between countries. Any related articles available on the internet were scoured so that the fundamentals of a targeted road safety index could be developed. The results show that the development of a road safety index requires careful and distinctive works as the road safety index was meant to compare countries and work as planning and monitoring tools. Also, other road safety indexes are showing different outputs between countries. To overcome this, new and targeted road safety indicators were proposed according to each pillar in the United Nations Decade of Action 2015-2020. Developing the proposed road safety index can provide an alternative road safety index and a tool to encourage and motivate countries to improve their local road safety conditions.

Keywords: Road safety indicators, road safety index, safety performance index

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1.0 INTRODUCTION

Traffic crash statistics such as crash frequencies, crash severities, number of fatalities, and amount of material damages are common types of road safety indicators that are acceptable worldwide (Lu, 2006). These indicators have been used for so many years to reflect the safety status of a country, states, and the road itself. However, in recent years, there have been arguments between road safety experts on the accuracy and reliability of these indicators in

explaining the whole situation of crashes, and it has been currently accepted that crash is the outcomes of a sequence of scenarios (Hermans et al., 2008; SafetyNet, 2009; Wilmots et al., 2009; Hassan et al., 2012).

Realizing that, several new research has been conducted as an effort to develop a new road safety index by looking at other indicators that include the percentage of road users using front and rear seat belts and safety helmets, percentage of road users using child restraining system, rate of road user under the influence of alcohol and usage of mobile phone while in traffic and most recently on the fatigue of professional drivers (Davidović et al., 2020) These indicators were mostly developed by comparing or categorizing countries within the continents, regions, and countries income status. This has led to several arguments since it was found out that individual countries may have been mistakenly categorized due to factors such as improper data management, especially in low-income countries.

In this paper, underlying issues of road safety index in the world were explored. The paper will list all the most renowned road safety indexes previously and currently been used worldwide, followed by examining any indicators that may have been lacking in those indexes. Further, the paper will discuss Malaysia's standing in almost all road safety indexes available and suggest new indicators targeting several countries sharing similar traits. Having a more targeted road safety index will not only be meant for comparing countries but can also be used to strategize road safety efforts, which will be beneficial for all.

2.0 BASIC CONCEPT OF ROAD SAFETY INDEX

Road crash is suspected to be contributed by various factors, so examining a single factor at one time is insufficient. A single system that can capture all those factors as a whole can be further used to elaborate the process leading to the crash and suggest a countermeasure is believed to be the best solution. In compliance with that, the European Transport Research Council (ETSC) in 2001 has come out with an idea of road safety performance indicators when the outcome in terms of assertions/facts/measures and road safety performance index that the outcome is a single value (ETSC, 2001). According to the report, the safety performance index (SPI) was defined as a measure to reflect the road traffic system's operational conditions, influencing the system's safety performance.

The main characteristic of the safety performance index during its early stage is the index's ability to reflect the theoretical considerations on the mode of operation involved in road safety areas. In summary, the primary outcome that could be achieved from the safety performance index is the ability of the Safety Performance Index (SPI) in giving out a complete picture of the road safety status and can also point to the emergence of developing problems at an early stage, before these problems show up in the form of accidents (Hakkert & Gitelman, 2007). In short, a safety performance index needs to satisfy the following credibility:

- i. To reflect the current safety conditions of a road traffic system (i.e., they are considered not necessarily in the context of a specific safety measure, but in the context of specific safety problems or safety gaps);
- ii. To measure the influence of various safety interventions;
- iii. To compare different road traffic systems (e.g., countries, regions).

Not only that, more profound research done by Tingvall et al. (2010) and his team have concluded that the concept of SPIs can form an intermediate phase between actions and outcomes in terms of casualties in road crashes. Since it was first introduced 20 years ago, SPI has been developed for various road safety areas such as speed, car-occupant protection, alcohol and drugs, and vehicle safety. In most cases, SPIs were used to indicate road safety performance and compare countries' achievements. The process leading to accidents was recognized, and consequently, the best measures to reduce them were initiated (Assum & Sørensen, 2010).

One of the crucial characteristics embedded in the definition of SPIs is that it can be used as a measurement or a road safety index by targeting the road traffic system's specific operational conditions, which influence the system's safety performance. An SPI should ideally reflect the operational conditions of road traffic (Assum & Sørensen, 2010). Taking this opportunity, SPI was then used to evaluate the road safety status and guide progress towards safe systems (Tingvall et al., 2010). Other than that, SPI can provide details on risk factors and trends to identify potential approaches for reducing this kind of accident. Therefore, SPI's conceptual framework can be adapted to be used as a road safety index, especially in evaluating the risk generated from specific road traffic aspects in the targeted dimensions. By doing this, proposed countermeasures were also pointed at the particular road aspects.

Realizing SPI's prospect as a road safety index, this concept has been increasingly used as a new instrument for the planning and monitoring of safety progress. Results from several studies that had applied the concept of safety performance index showed considerable modifications to the targeted indicators, and the results had helped for substantial improvements in the selected dimension. However, to enhance the applicability of the road safety index and to analyze the contributions of various factors towards crash occurrences collectively, an index that can combine multiple crash factors is essential.

3.0 EXISTING ROAD SAFETY INDEXES

Comparing countries' road safety performance has started the usage of a composite index in the evaluation of road safety status. Countries' road safety status in terms of their performance in preventing crashes has become the main focus of most of these researchers. Most studies centered on indicating the severity of countries road safety situations (Ghazwan, 2007), developing a standard procedure for safety comparisons between countries (Wegman & Oppe, 2010), and evaluating countries' performance based on several crucial crash factors (Hermans et al., 2008; Gitelman et al., 2010).

Most road safety indexes worldwide are based on crash data (e.g., numbers of fatalities, serious injuries), country-level income (i.e., low, middle, or high), populations, gross national income per capita, total registered vehicles, and kilometers traveled apart from data such as road traffic death per 100,000 populations, road traffic death per 100,000 vehicles, road traffic death per vehicle kilometers traveled. Examples of road safety ratings used worldwide are listed below.

- i. In 2006, the International Road Assessment Programme (iRAP) developed a methodology based on road inspection to produce Star Rating and countermeasure programs called Safer Road Investment Plan (iRAP, 2017). In most low and middle-

income countries, reliable and detailed crash data is often not available. To date, iRAP has been used in many countries such as:

- a) AusRAP (Australia)
 - b) BrazilRAP
 - c) ChinaRAP
 - d) EuroRAP (Europe)
 - e) IndiaRAP
 - f) KiwiRAP (New Zealand)
 - g) MyRAP (Malaysia)
 - h) SARAP (South African)
 - i) ThaiRAP (Thailand)
 - j) usRAP (United States)
- ii. SUNflower's first project was established to compare road safety strategies and developments between Sweden, the United Kingdom (UK), and the Netherlands (abbreviated as "SUN"). The project aimed to determine the underlying elements in road safety policy and strategies to ensure a good road safety level of these countries and to identify policy improvements in order to produce casualty reductions. (SWOV, 2002). SUNflower approach also inspired a project conducted in 2015-16 by the International Transport Forum to benchmark road safety performance in Latin American countries. The objective of this project was to develop a methodology to assess road safety performance in Latin America and to identify areas deserving policy attention. (OECD/ITF, 2016).
 - iii. Ibero-American Road Safety Observatory (OISEVI), established in 2012 by the directors for road safety from 18 Latin American and Caribbean countries share relevant information about road safety indicators and best practices concerning policy-making, planning, and other topics related to road safety. The program also linked the participating countries to the IRTAD resources on harmonized data collection methods (Raffo et al., 2014).
 - iv. Road Safety Performance Index (PIN) was created by the European Transport Safety Council (ETSC) for countries in Europe. Since 2006, ETSC publishes cross-country comparisons on a range of different road safety indicators in so-called PIN Flashes, on subjects like pedestrian safety, impaired driving, and safety of roads
 - v. Austroads Road Safety Engineering Toolkit is a reference tool created for road infrastructure and road services practitioners. The Toolkit outlines the best-practice, low-cost, high return road safety engineering treatments to reduce the severity and frequency of crashes involving road environment factors. It draws together existing road safety engineering knowledge as far as possible into one Toolkit for easy access by practitioners. The presented knowledge has been updated with recent experience from various local and state government agencies of Australia and New Zealand and with the results of comprehensive road safety research reviews.
 - vi. Highway Safety Manual (HSM), first published by AASHTO in 2010, is an analytical tool and technique that can quantify the effects of changes to the roadway environment on safety and facilitate improved decision-making based on safety performance. The HSM provides tools for measuring, estimating, and evaluating roadways in terms of crash frequency per year and crash severity. The expected outcome of this manual is to offer transportation professionals present knowledge regarding highway safety information.

4.0 DEFICIENCY IN EXISTING ROAD SAFETY INDEXES

The road safety index does not reasonably quantify each country since certain countries may easily be a champion leaving other countries behind based on a single aspect. For example, a single index for one region that comprises low, middle, and high-income countries may portray wrong information on middle-income countries' road safety performance, let alone the low-income countries. An index that focused on specific sets of countries so that fair comparisons could be developed.

More parameters such as capability of pre, on-site and post-crash medical care of the country, conditions of road's infrastructures (road surface, signages, marking, a non-transferable object such as lightning poles and billboard), and also countries level of road safety awareness, law and enforcements should be introduced to make sure that countries comparisons could be made in fair trade.

Middle-income countries have accounted for more than 78 percent of road traffic deaths globally than low and high-income countries. So far, no specific index targeted at middle-income countries was developed to stratify road traffic death factors in middle-income countries that could be expanded to a comprehensive road safety index comparing road safety situations in middle-income countries. An improved and targeted road safety index must be equipped with these elements, such as quantifiable and measurable, time-control, clear outcomes, and clearly defined.

As mentioned above, most of the road safety index available is most generated from road death. These parameters were used as leading indicators to compare countries' performance in road safety. The essential things that the data must have are accuracy and accountability. Sadly, in most middle-income countries, let alone the low-income countries, these two aspects are often neglected. Most data in low and middle-income countries are not robust, inaccurate, and misleading, which resulted in much lower and unrepresentative road safety situations in the affected countries. This might be because of the behavior or the well-being of the community in low and middle-income countries who often left the crash unreported, which led to the under-reporting of the crash data itself.

5.0 MALAYSIA IN EXISTING ROAD SAFETY INDEXES

The implementation of road safety audit introduced in Malaysia as early as 1997 aims to instill road safety into road networks by detecting deficiencies in road safety measures and auditing the road condition (Karim et al., 2003). While the execution of road safety audit is very beneficial for the newly proposed road project, the contribution of this method in bringing up the overall safety status of existing road networks is relatively low since, in most cases, the road safety audits on existing roads will be carried out in road sections that are heavily burdened by accident issues (Karim et al., 2003; Pietrantonio & Bornshtein, 2010).

One of the earliest studies done in Malaysia using crash data in forecasting the road safety status was carried out by Radin Sohadi and Hussain (1998). By employing multivariate analytical techniques to project fatalities and crashes in Malaysia, they have successfully developed crash models for Malaysian conditions as follows:

$$\text{Death} = 2289(e0.00007 \text{ Vehicle.Population.Road})(e0.2073 \text{ Data Collection System}) \quad (1)$$

$$\text{Crash} = 43478(e0.00011 \text{ Vehicle.Population.Road})(e0.2447 \text{ Data Collection System}) \quad (2)$$

Using these models, the first projection of Malaysia's road safety status was made. The results concluded that crashes and fatalities in Malaysia are increasing following an increase in exposures to crashes. Besides using a road safety audit, a method called iRAP was introduced in Malaysia in 2006. iRAP was established with considerable objectives to tackle road crashes' social and economic costs in developing countries like South Africa, Chile, and Malaysia (SafetyNet, 2009). A star rating concept is introduced in iRAP, where roads are rated from 1 to 5 depending on the safety level, which is built-in to the road. However, Star Rating is also based on infrastructure related to crashes by focusing on the risk posed by road infrastructures (iRAP, 2009).

While there are various road safety indexes, the Global Status Report on Road Safety by the World Health Organization (WHO, 2018) is one of the most referred indexes by multiple parties. Numerous international organizations refer to the WHO report, including the Organisation for Economic Co-operation and Development (OECD) and Association of Southeast Asian Nations (ASEAN) in developing the OECD Road Safety Annual Report (OECD, 2017), and ASEAN Regional Road Safety Strategy (ASEAN, 2016) respectively. In other words, WHO's Global Status Report on Road Safety is an internationally recognized road safety index.

WHO illustrates a country's level of traffic safety based on the modeled number of deaths per population. Malaysia averages around 24 deaths per 100,000 population between 2007 and 2016 (Figure 1). On the other hand, the average for that same index based on 176 countries reported 16.8 deaths per 100,000 population. These results illustrate that Malaysia has higher than average traffic-related deaths per population. Various local and international media outlets used that finding to paint a picture that Malaysia was a dangerous nation to drive.

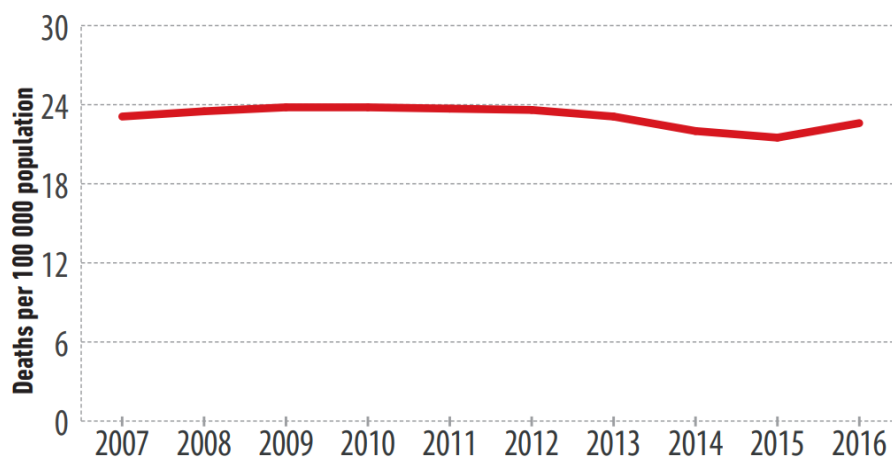


Figure 1: Trends in road traffic deaths in Malaysia (WHO, 2018)

While Malaysia's traffic-related deaths per population are higher than in most countries globally, Malaysia is not different from other ASEAN nations. Using the same data source (WHO's Global Status Report on Road Safety), as shown in Table 1, 60% of ASEAN nations, specifically 67% of middle-income nations in ASEAN, have high fatalities per population (>15

deaths/100,000 population). Only two out of the ten ASEAN countries, Brunei and Singapore, had low fatalities per population (<10 deaths/100,000 population). In other words, most ASEAN countries, including Malaysia, have similar characteristics that might result in a high number of deaths per population.

Table 1: Road safety in ASEAN context (ASEAN, 2016)

Fatalities per 100,000 population	Low Income	Middle Income	High Income
Low (<10)	-	-	Brunei Singapore
Medium (10-15)	-	Philippines Lao DPR	
High (>15)	Cambodia Myanmar	Indonesia Malaysia Thailand Viet Nam	

To improve local road safety, Malaysia's Ministry of Transport uses the Death Index to compute the number of deaths per 10,000 registered vehicles. The results (see Table 2) indicate that while Malaysia's death per population remains consistent in the WHO report, Malaysia's Death Index is decreasing from 3.21 in 2011 to 2.59 in 2016, achieving the ministry's key performance indicators (KPI) of reducing the nation's Death Index to less than 2.66 by the year 2014. These findings indicate that Malaysia's road safety is improving gradually and different countries might be using different road safety indexes in their decision-making process.

Table 2: Death index of Malaysia from 2011 to 2016 (MOT, 2017)

Year	Deaths	Total Number of Registered Vehicles	Index
2011	6,877	21,401,269	3.21
2012	6,917	22,702,221	3.05
2013	6,915	23,819,256	2.90
2014	6,674	25,101,192	2.66
2015	6,706	26,301,952	2.55
2016	7,152	27,613,264	2.59

On the other hand, other third-party indexes also exist. For example, the Waze Driver Satisfaction Index analyses its users' driving experience from the data collected through the company's mobile application (Waze, 2016). The overall satisfaction index has multiple criteria, including a road safety index computed based on the density of accidents, density of dangers, and weather quality from the number of reports on accidents, dangers, and bad weather. Based on the analysis, Malaysia has a higher road safety index (6.59) than those other countries with lower traffic deaths per population, including Singapore (6.32), Belgium (6.61), and Portugal (5.04). These findings indicate the choice of criteria for a road safety index can result in different outputs.

In summary, misinformed parties that focus solely on WHO's Global Status Report on Road Safety might illuminate Malaysia as a nation with high and increasing traffic-related

deaths. However, Malaysia's deaths per population were significantly consistent, not increasing nor decreasing. Besides, the deaths per total registered vehicle were declining. On the other hand, other road safety indexes are showing different outputs between countries. Specifically, local characteristics might influence the results of these countries. Therefore, a country's road safety index should be illustrated through multiple criteria rather than just one measure, for example, deaths per population.

6.0 TARGETED ROAD SAFETY INDEX – A WAY FORWARD

The chosen indicators are the most crucial part of a composite index. In a composite index, an indicator is defined as a specific statement in determining a certain phenomenon's status or specific issues chosen as the research themes (Hermans et al., 2008). Indicators can be measured in terms of a percentage, a rate, exact values, or even a level of qualitative statements such as very good, good, and poor (Ghazwan, 2007). A well-illustrated and well-designed indicator can express scientific knowledge in an understandable and relevant manner.

From literature (Ghazwan, 2005; Nardo et al., 2005; Ghazwan, 2007; Hermans et al., 2008), it appears that indicators can be used in several ways, such as:

- i. Measuring relative performance or benchmarking: indicators derived from a series of observed facts that can reveal relative positions of subjects in a given area.
- ii. Drawing attention to particular issues: indicators are suited for communication purposes, such as tools in informing policymakers and the general public and stimulating the public alertness on some instances that needs appropriate attention.
- iii. Identifying trends: If an indicator is measured at regular intervals, the directions of change (e.g., in risk) over time and across different subjects can be pointed out.
- iv. Predicting problems: indicators can serve as a warning signal for policymakers and are important guidelines for governments and authorities.
- v. Presenting comprehensively: indicators can offer a large amount of information transparently. Indicators can also be used for visualizing the current situation of targeted areas.

The road safety index focused on human capitals development of the nations such as improvement in terms of skills and knowledge on road safety among road enforcement officers, a number of road safety experts in the countries should also be acknowledged as one of the achievements in road safety as this may help to improve nation's road safety situation in the long run.

The targeted road safety index for different types of vehicles and road users is also barely used. Based on various reports from Global Safety Reports, nearly half of the road traffic deaths were generated from vulnerable road users (pedestrians, motorcyclists) and passengers in public transport. These factors should be the point of reference when developing a new road safety index was planned. Index theme, according to the United Nations (UN) Decade of Action Plan (2015-2020):

6.1 Pillar 1: Road Safety Management

A report prepared by ESCAP in 2019 has summarized the analyses of the road safety data for ESCAP member countries under road safety management pillars in the UN Decade of Action Road Safety (2011-2020). The population of middle-income countries within the

ESCAP region forms around 74% of the world population. Based on that, 97% of road traffic deaths came from 93% of the middle-income population in ESCAP regions. Meaning that if an improvement in terms of road safety management in middle-income countries in ESCAP regions could be successfully achieved, a considerable reduction of road safety deaths in the world could be recorded. Malaysia is part of a middle-income country within the ESCAP region. Thus, a selective road safety index targeted at the middle-income countries within the ESCAP region only should be made available. Using this index, countries that fall within the group of middle-income countries of ESCAP could work together, learn from each other's methods and weaknesses, and race between each other to reduce road traffic death in a more targeted manner. The suggestion of the road safety parameters that could be introduced among middle-income ESCAP countries as listed in Table 3.

Apart from that, mismanagement of road crash data could be improved by making some amendments to the insurance policy to avoid unreported crash cases. Improvement of crash data registration should be made easier to encourage local police and road crash victims to report their crash cases.

6.2 Pillar 2: Safer Roads and Mobility

Safer roads and mobility have long been one of the most critical road safety features studied by road safety experts as a strategy to reduce crash cases. WHO has also been very active in recording data related to safer roads and mobility such as data on formal audits for new road construction, inspections on existing roads, policies to promote walking/cycling, investment in public transport, and separation of VRUs from other road users. An initiative such as iRAP has been introduced to promote safer roads and mobility. However, one of the most challenging factors in each country's uniqueness, making one index for safer roads that fit all countries is impossible. In overcoming these issues, planning for a targeted road safety index by clumping all countries having similar geographical conditions could be proposed.

6.3 Pillar 3: Safer Vehicles

Safer vehicle initiatives also have become an interest to many countries as one of the strategies to accomplish the UN Decade of Actions. The framework for safer cars in Malaysia has been discussed thoroughly by a group of researchers from the Malaysian Institute of Road Safety Research (MIROS) in an article published in 2016. Jawi et al. (2016) suggested that there will be growing demands for safer vehicles that would make car manufacturers progressively meet market demands. Apart from that, establishing the NCAP program is also expected to help minimize crash cases caused by faulty vehicles using automobile safety ratings. This initiative was expected to promote up-to-date safety technologies in passenger cars. ASEAN NCAP that targets ASEAN countries aims to be a corrective measure for the region's more developed countries and a preventive measure for less developed countries to overcome their road safety issues involving vehicles.

6.4 Pillar 4: Safer Road Users

This pillar is mainly concerning with the well-being of the road users, especially the driver. Studies have shown a significant linkage between road users' behavior and road traffic crashes. Realizing the need to instill road safety awareness to all road users, Malaysia has extensively planned for various programs targeting to convey road safety awareness. Sadly, although many crash preventions and crash reduction programs have been initiated, those programs seem insufficient in reducing the number of crashes on Malaysian roads. Despite the

number of campaigns being held, Malaysian appears to disregard the government's efforts, and these programs failed to transform the people's behavior and perceptions towards road safety (Musthar et al., 2013).

As this pillar focuses on shaping safer road users' behavior, specific indicators that could be used to motivate road users, non-governmental agencies, and all public members of society to play the role of bringing forth safer road users are suggested in Table 3.

Table 3: Suggested indicators

Pillar	Pillar's Name	Suggested Indicators
1	Road Safety Management	<ul style="list-style-type: none"> i. Existence of road safety agencies ii. Number of new road safety policies approved / year iii. Number of road safety experts / countries iv. Number / size / type / of road safety database developed / countries v. Improvement of data management system / countries
2	Safer Roads and Mobility	<ul style="list-style-type: none"> i. Number of inspections on road infrastructure conditions (road surface, signage, marking, non-transferable objects such as lightning poles and billboards) / year ii. Number of road inspection on existing roads conditions / year iii. Budgets for road improvement works given / year iv. Road users' satisfaction for road conditions
3	Safer Vehicles	<ul style="list-style-type: none"> i. Condition of vehicles ii. Number of newly registered cars vs. the number of existing cars on the road
4	Safer Road Users	<ul style="list-style-type: none"> i. Population age group ii. Numbers of new road users' policies / years iii. Numbers of responds / campaign iv. Reduction of drunk drivers / period of time
5	Post-crash Response	<ul style="list-style-type: none"> i. Ratio of doctors at emergency dept. vs. population ii. Emergency care system – ambulance time to reach the crash site, SOP for the emergency team, number of emergency personnel iii. Emergency response team efficiency protocol / countries

6.5 Pillar 5: Post-crash Response

Post-crash responses mainly deal with giving better services to the crash victims to avoid preventable death from occurring. As a fatal crash is defined as any crash with its victims dead either on the scene or within 30 days after the crash, full attention for the crash victims within the time frame of 30 days should be provided at its best to ensure that crash fatalities are reduced. However, an immediate post-crash right after a crash occurred played a significant role in saving the victims' lives. Chang (2020) reported that trucks and car drivers' victims were generally associated with lower rates of injury but higher fatality rates giving explicit instruction that whenever a crash involving trucks and heavy vehicles took place, an immediate post-crash response must be directly utilized.

A list of all suggested indicators to be used in the targeted road safety index with a mission to clump countries with similar traits so that fair comparisons could be made were listed in Table 3. This list is based on a desktop review in the project's first phase that will continue to evolve as the study progresses.

7.0 CONCLUSION

To position the importance of developing alternative road safety indexes, this paper discussed potential issues of existing international and national indexes by reviewing the transportation safety body of knowledge. The main findings from the analysis include: (1) developing road safety indexes requires careful and distinctive works; (2) the distinct criteria of road safety indexes produces different rankings between countries; and (3) misinterpretation of road safety indexes' outputs might paint a wrong image of a nation's road safety conditions.

In addition to providing additional insights to the transportation safety body of knowledge, researchers and industry practitioners can use this study's findings to justify the need to develop alternative road safety indexes that reflect the local government's aims and policies. Thus, this study's lessons would help the industry plan and monitor local road safety that results in a better transportation environment. This study's fundamental theoretical contribution is by conveying a better understanding of the impact of the similarities and differences between existing road safety indexes.

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