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Road Safety Performance Index in Metro Manila, Philippines: 2011-2015

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RESEARCH ARTICLE

Abstract

Background and Objective: Road safety in the Philippines has been increasingly significant with the increasing level of industrialization and urbanization over the last decade. The main objective of the study was to determine the road safety performance for Metro Manila by computing for an index based on data and variables of road traffic over the past years.

Methodology: The variables for index calculation included speed, alcohol, infrastructure, vehicle defect, and other unsafe driver behavior were drawn from the Metro Manila Development (MMDA) database complemented with literature review from several sources. Equal Weighting method was utilized, as this is the simplest, yet, least biased measurement suitable for the data at hand.

Results and Conclusion: The Road Safety Performance Index for Metro Manila remains more or less constant over a five-year period, increasing and decreasing from 0.45 to 0.59 which means that Metropolitan Manila has fared poorly in all indicators. Metro Manila has a poor road safety performance as evidenced by the road safety index. There is a need to improve on all components of road safety identified in this study for the safety of road users.

Keywords: *road safety, road safety performance, Metro Manila, traffic condition, road mortality rate*

Introduction

According to the World Health Organization (WHO), road traffic injuries is one of the leading causes of deaths around the world. There are about 1.25 million deaths globally due to road traffic crashes, which is an estimated 3,400 deaths every day [1]. Half of these deaths happen among vulnerable road users who are the pedestrians, cyclists, and motorcyclists—those in the lower income group. It is also the leading cause of death globally among the productive ages of 15 to 29 years, which targets the young and work-productive population. For a broader perspective, the magnitude of road traffic deaths (1.25 M deaths annually), ranks second, following AIDS-related deaths (1.5 M deaths annually). The third is tuberculosis (affecting 900,000 deaths annually), followed by malaria (600,000 deaths annually) as the fourth leading cause of death in the 15 to 29 years age group.

The increasing risk exposure on individuals seeking mobility on roads and land transportation has led to the need to construct a road safety performance index in the Philippines. This index is a synthesis of different indexes on a set of variables with specific measurements, thus, giving a measure of success or failure of road safety. The index is usually constructed for the purpose of addressing gaps in current policy as well as for use in national and cross-country comparisons, including time series comparisons [2].

The challenge in road safety is the creation of a universal composite index that encompasses all aspects of safety of road users. Pioneer researches on road safety have focused on fatalities in crashes and measured it by the millions [2]. This has spurred researches on road safety for the development of appropriate policy measures, health impact indicators, and parameters for road regulations. The multidimensionality of the field cuts across geography, climate, behavioral science, road conditions, policy on traffic and its implementation, vehicle defect, socio-economic backgrounds, etc [3, 4, 5, 6].

The index used for this study is patterned after road safety indexes developed by different researchers in the field. Available government data is used to compute the scores. Numerous theories have been produced to create an ideal index for road safety.

Al-Haji proposed the road safety development index (RSDI) with three domains: product focus (fatality rates), people focus (road user behavior), and system focus (safer vehicles, safer roads, socio-economic level). This type of index makes use of exposure of the individual (system focus), accident risk (people focus), and injury severity (product focus). Unlike other road safety indexes, the RSDI takes into account socio-economic levels holistically, as a nation, and individually [7]. It is important to note that these affect the fatalities and morbidities of road crash victims. There is a negative correlation between fatality and economically well-off individuals. The same goes at the national level; the more developed the social welfare of a country, the higher the chance of survival of the victim.

Hermans on the other hand, constructed the Road Safety Performance Index with seven indicators: alcohol, speed, vehicle, infrastructure, visibility, protective systems, and trauma care. Hermans evaluates the index as a timeline—pre-crash and post-crash factors—that affect the survival of the victim. Alcohol, speed, vehicle maintenance (safety), infrastructure, visibility, and protective systems all comprise of pre-crash factors, while trauma care is composed of the post-crash factor [2].

Rosolino created a Risk Index with the following factors: road user behavior, road conditions, vehicle factors, traffic facility, and socio-economic factors. The authors studied a 60Km two-lane road network in Calabria, Italy. The study delved into gathering all features of the road, such as surface anomalies, accesses, and deficiencies in road signs and signals. Hence, an in-depth data gathering on road condition is necessary to construct a Risk Index patterned after Rosolino's Index [8].

There is also the emergence of a road safety awareness index (RSAI) which analyzes age and educational attainment and their relationship with traffic violations [9]. Safety Hazardous Index (SHI) is the analysis of safety factors through the analytical hierarchy process (AHP), which ranks hazardous road sites that harbor numerous fatalities and measures the weight of each safety factor involved [10]. The factors common to all the indexes are the identification of the type of vehicle, the road condition, and the behavior of the driver.

Different weighting methods have been devised to for the measurement of road safety. Hermans developed five weighting schemes: 1) factor analysis, wherein the indicators are "grouped" accordingly thus correlations may be spotted among indicators; 2) analytic hierarchy process, which includes both statistical analysis and key expert analysis in the results; 3) budget allocation, wherein the weight for each indicator is determined by the apportionment of budget to a specific indicator, hence an indicator with a higher budget allocation from the government will have a heavier weight compared to an indicator with a lower budget; 4) data development analysis, where weights of indicators arise from value judgments; and 5) equal weighting for all variables [2].

Different countries use different types of road safety performance indexes, comprising of different indicators and weighting methods. For the Philippines, insufficient data prohibits the use of a more complex weighting method. Hence, equal weighting method is the necessary first step in constructing a road safety index.

The main objective of the study was to show the road safety index of Metro Manila Philippines based on government data and variables of road traffic accidents over the past years.

Methodology

This research started with an appraisal of road safety index measures available in literature. The study proceeded to consider variables for road safety performance index. The variables for the index were drawn from the Metro Manila Accident Reporting and Analysis System (MMARAS) database of the Metro Manila Development Authority (MMDA) over an eleven-year period—2005 to 2015. This was complemented by literature review which covered researches and studies, gray literature, peer-reviewed journals, databases, and government statistics. However, the calculation of the injury and mortality rates considered only years from 2009 to 2015; and the construction of the road safety performance index was from 2011 to 2015 due to insufficient variables in particular years in the database.

The MMDA is a government agency that is mandated to monitor traffic and enforce traffic regulations in the metropolis. It has an electronic database of all traffic accidents in Metro Manila. The total number of traffic accidents reported in the database is as follows (Table 1):

Table 1. *Frequency per year for road crash in Metro Manila, Philippines.*

Year	Frequency
2005	65,111
2006	60,964
2007	63,072
2008	63,606
2009	67,695
2010	77,946
2011	77,110
2012	82,757
2013	86,565
2014	90,258
2015	95,615

Source: Metro Manila Accident Reporting and Analysis System 2005-2015

Table 1 shows an average of 75,518 (s.d.=11,608) road traffic accidents over an eleven-year period.

The site of the study is Metro Manila composed of seventeen (17) cities namely Caloocan, Las Pinas, Makati, Malabon, Mandaluyong, Manila, Marikina, Novatas, Muntinlupa, Paranaque, Pasay, Pasig, Pateros, Quezon City, San Juan, Taguig, and Valenzuela. Metro Manila, although geographically a small portion of the entire Philippines, is the economic and political hub of the country. It contains the capital, Manila, and the legislative, executive and judicial branches of government. Roads in the Metropolitan are the most frequently used than any other road in the country due to its rapid economic growth [11].

There are various measures for road safety performance index construction. For this study, the indicators for the road safety index in Metro Manila are enumerated and described in Table 2. Statistical analysis of the indicator only focuses on fatal and non-fatal crashes, excluding crashes resulting in damage to property. Crashes resulting in damage to property, while classified under non-fatal crashes, are often unreported as individuals involved tend to settle the matter amongst themselves, especially for minor scratches on the vehicle. Thus, there is severe underreporting of this type of vehicle crash and any estimate using such data would be biased. It would be appropriate to exclude such data in the statistical analysis.

Indexes for each of the indicators are determined by the proportion of their fatal and non-fatal (injurious) crash incidence with the estimated number of crashes. Hence, the highest possible measurement is 1.0 and the lowest possible score is 0. A score of 0 means that the use of roads pose little to no threat to the road users, as opposed to a score of 1 which means that the road becomes riskier. This research makes use of the equal weighting method with the following formula

Table 2. *Statistical indicators considered for the Road Safety Index*

Factor	Description
Speed	Collisions due to speeding vehicles
Alcohol	Alcohol suspected reason for collision
Road condition	Slippery road, open pothole, humps, scattered objects on the road
Vehicle defect	Defective brakes, tire explosion, electrical and mechanical errors
Unsafe road user behavior	Fatigue, inattentive, lost control, bad overtaking, avoid hitting another vehicle

$$Road\ safety\ performance\ index = \sum i/n$$

i: score of the specific indicator for road safety

n: number of indicators

Results

The mortality and injury rates (Tables 3 and 4) below show comprehensive data as it includes all accidents reported to the police. However, these two tables do not show information on whether crashes are caused by infrastructure, vehicle defect, speed, alcohol, or other unsafe driver behavior. Also, the data only show the years 2009 to 2015 as previous years do not have data on the required variables.

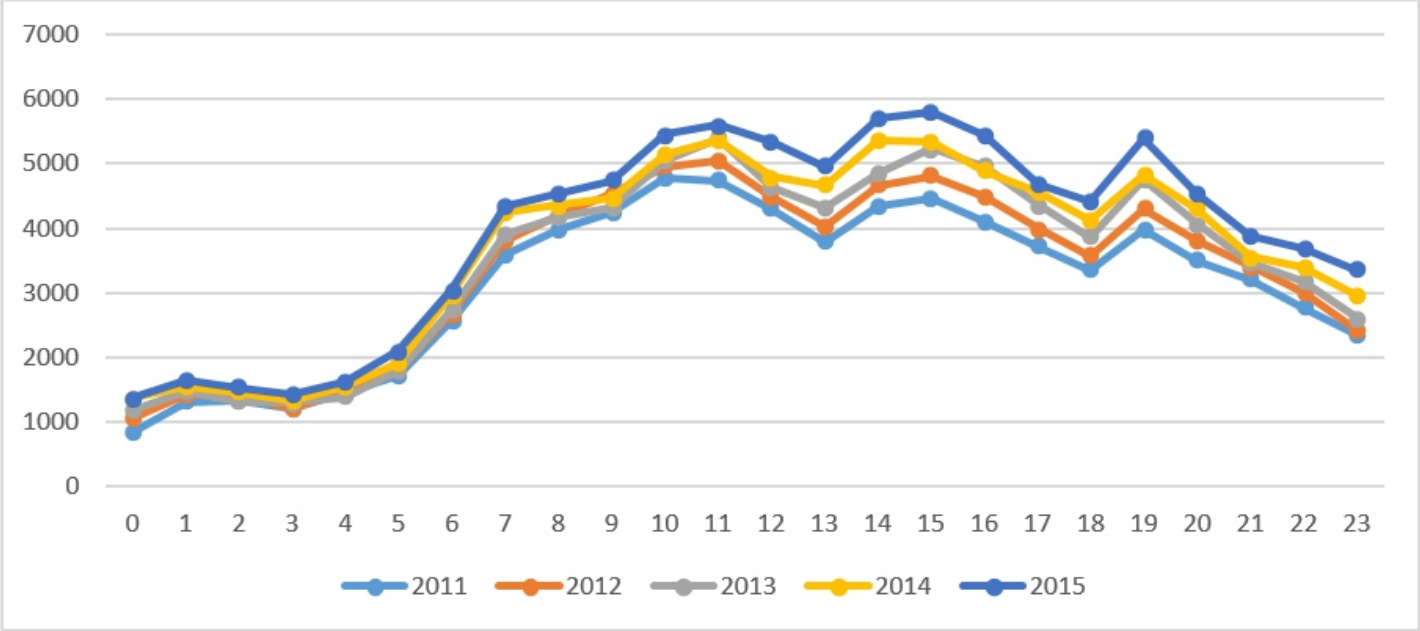
Table 3. *Injury rate of road crashes in Metro Manila*

Year	Non-Fatal Crashes per 10,000 inhabitants	Damage to Property per 10,000 inhabitants	Total Number of Crashes per 10,000 inhabitants
2009	10.4	46.5	57.1
2010	12.5	52.0	64.8
2011	13.3	51.4	65.0
2012	14.1	55.4	69.8
2013	14.1	58.5	73.0
2014	14.1	61.7	76.1
2015	13.3	60.6	74.2
Mean	13 (s.d.=1.24)	55 (s.d.=5.11)	75,518 (s.d.=11,608)

Table 4. *Mortality rate per million inhabitants in Metro Manila.*

Year	Fatal Crashes per 1,000,000 inhabitants
2009	23
2010	32
2011	31
2012	33
2013	34
2014	35
2015	40
Mean	32.57 (s.d.=4.75)

The graph below (Figure 1) shows the frequency of the total number of accidents in Metro Manila over the past eleven years. The prevalence is constantly increasing, together with the increasing purchasing power of Filipino households. Locals are most optimistic to acquire big-ticket items, such as real estate and motor vehicles [12]. In June 2014, the sales of private vehicles increased by 100 percent [13].

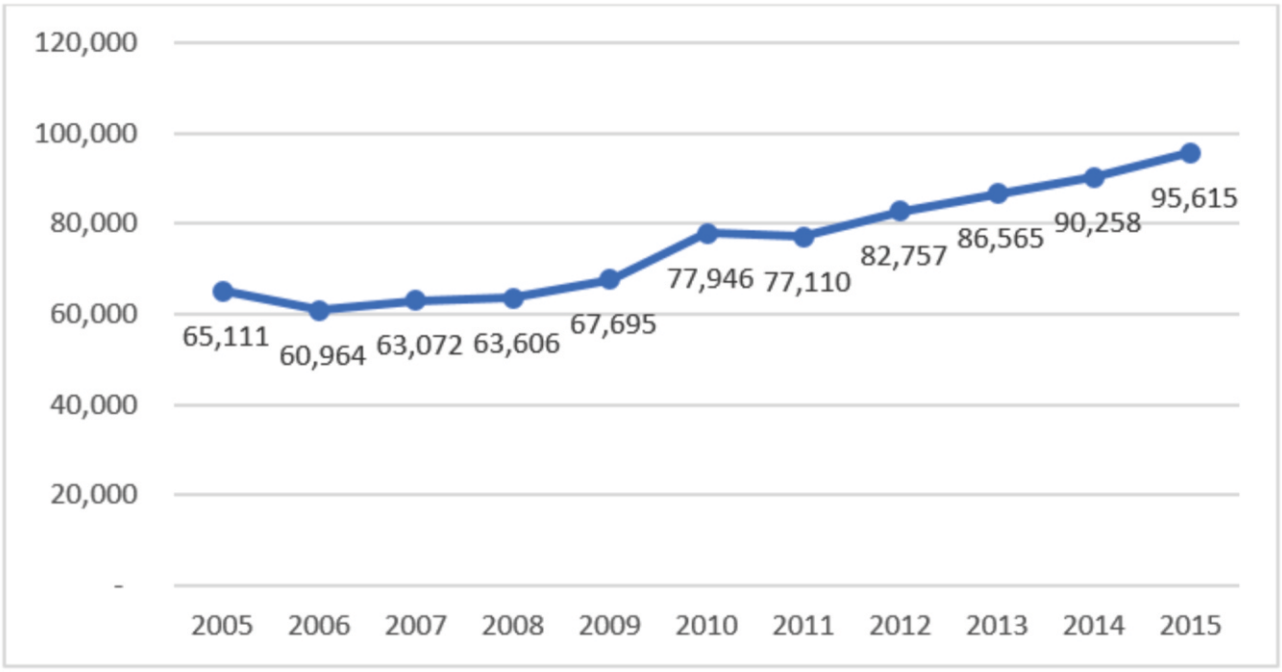


Source: Frequency from MMARAS (Metro Manila Accident Reporting and Analysis System)

Figure 1. *Frequency of road crashes by time of day: 2011-2015*

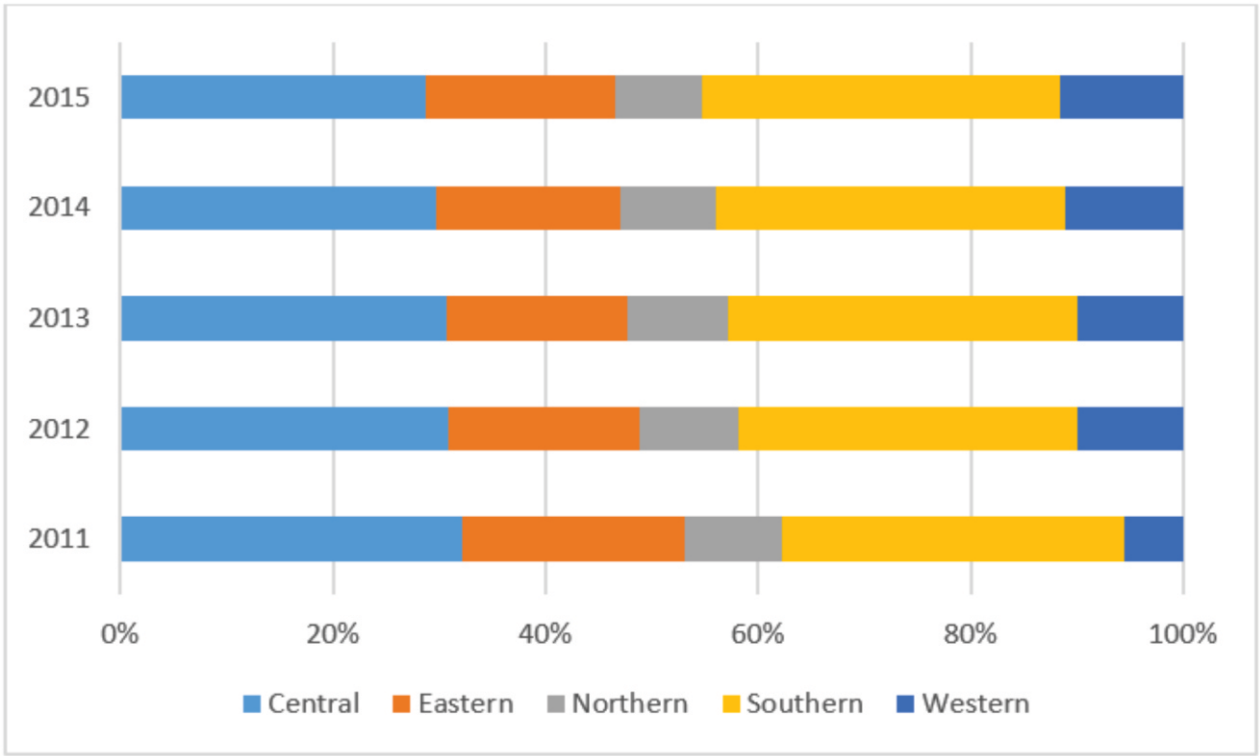
Road safety index for Metro Manila using the equal weighting method

The Metro Manila Accident Reporting and Analysis System records road crashes within the metropolitan area. This database is constructed using police blotters and newspaper clippings. The data is from 2005 to 2015 (see Figure 2 for frequency of road crashes from 2005 to 2015), however only variables from 2011 to 2015 can be utilized to create an index. The observations are recorded per road crash regardless of the number of vehicles or victims involved. Severity of injury is included as one of the variables and is classified as follows: damage to property, non-fatal injury, and fatality crashes.



Source: Frequency from MMARAS (Metro Manila Accident Reporting and Analysis System)

Figure 2. *Frequency of road crashes by year: 2005-2015*



Source: Frequency from MMARAS (Metro Manila Accident Reporting and Analysis System)

Figure 3. *Percent of road crashes in each district, by year 2011-2015*

Road safety performance index is based on the entire population of the region as they are the ones affected by the traffic accidents-either drivers, passengers, or pedestrians. The index is based on the fatality and injury caused by the road crash. The scores per indictor for the years 2011 to 2015 are shown in Table 5.

Table 5. *Indicators and corresponding Safety Performance Indexes*

Indicator	2011	2012	2013	2014	2015
Speed	0.71	0.48	1.00	0.58	0.86
Alcohol	0.56	0.50	0.55	0.43	0.63
Road Condition	0.72	0.50	0.67	0.74	0.56
Vehicle Defect	0.37	0.38	0.28	0.42	0.63
Unsafe road user behavior	0.32	0.37	0.32	0.29	0.27

Discussion

The Philippine Road Safety Action Plan 2011-2020 indicates the national situation of road safety in the country. The first two years of the National Action Plan focuses on reinforcing local capacities on road development and legislation enforcement. It is based on the Safe Systems Approach established by the World Health Organization. The overall goal is to reduce fatalities and morbidities caused by road crashes by 50% in the year 2020.

The current Philippine situation on road safety has not substantially improved. There is still no national agency that gathers holistic road crash data. The Department of Health (DOH) collects data from public hospitals. This indicates that road crash data from DOH only includes road crashes that have resulted in physical injuries to either one or all of the parties. Only Metro Manila has a somewhat holistic idea of road crash incidents based on MMDA data.

Based on existing national data and Metro Manila data, road crash incidence has steadily increased. This is opposite of the goal of the Philippine Road Safety Action Plan to reduce the rate of growth to 50%.

Collisions Due to Speed

Only a few of the roads in Metro Manila have speed limits. These include Commonwealth Avenue, North Luzon Expressway (NLEX), and South Luzon Expressway (SLEX). NLEX and SLEX are inter-province highways with speed limits of 100 km/hr and minimum speed of 60km/hr. Commonwealth Avenue and Macapagal Boulevard are the only main roads in the Metropolitan area that have a speed limit of 60km/hr.

Collisions due to speed are recorded in the MMARAS, however, drivers going over the speed limit have not been monitored religiously in the areas where speed limits are implemented. Therefore, the index created for this cannot take into account the mean speed and standard deviation that will make the index more meaningful.

Even if speed limits are not imposed throughout the metropolitan area, injuries and fatalities are high. This is not only due to over speeding vehicles, but also to uneven speeds on roads. Speed homogenization is crucial in areas where speed limits are not implemented. This is one of the major causes of road crashes due to speed. Differentials in speed affect the mortality rates [14]. Speed homogenization should also be included in the index as majority of the roads in the metropolitan area do not have speed limits. Hence, a greater disparity in speed among cars increases the risk of collision.

Alcohol-Suspected Collisions

Several studies show that drinking and driving increase the risk of road crash and the likelihood that death or a serious injury will result. In a large case-control study, it was noted that car crash risk increases significantly at a blood alcohol concentration (BAC) of 0.04 g/dL [15]. Currently, laws that establish BACs of 0.05g/dl or below are effective in reducing the number of alcohol-related crashes [1].

Road crashes where alcohol is suspected can be analyzed, albeit with caution as there are no random checkpoints in the country to check the blood alcohol concentration. Furthermore, the data only reports the collision as “alcohol suspected” when the investigator assigned has probable

cause to believe that the driver had been drinking prior to the crash. It cannot be measured with absolute certainty as Breathalyzers are not available for police use.

In 2013, the Anti-Drunk and Drugged Driving Law was passed. It imposes a stricter penalty on violators compared to simply being penalized similarly as reckless driving or beating the red light. This law still has not been dramatically felt by the general public as traffic enforcers do not have the proper equipment to measure the blood alcohol concentration (BAC). They still rely on the appearance, behavior, and smell of the driver. This leaves a room for error, as drivers can deceive law enforcers when there is no objective way of determining the blood alcohol concentration. Hence, the score for this indicator is higher than reported.

Crashes Due to Infrastructure and Road Condition

This indicator will be analyzed similarly with visibility, as there are no readily available data collected by the government that can be analyzed for the purpose of creating a road safety performance index. Road signs and signals are present in major roads around the metropolitan area. However, like the other measurements for the other indicators, only accidents caused by road defect, such as roadblocks, potholes, roadworks, slippery roads, or due to humps. This indicator cannot take into account the appropriate road network for a specific area as there is no data available to create such measurement.

Collisions Due to Vehicle Defect

Vehicles in the Philippines are registered with the Land Transportation Office every year. This applies to vehicles that have been on the road for more than three years. The purpose of registration is to check for environmental compliance and road safety compliance. Some of the requirements for registration of a vehicle are as follows: 1) the vehicle to be free from smoke belching, 2) compliance with the presence of an early warning device to be in the vehicle at all times (Letter of Instruction No. 229); 3) properly working signal lights, brake lights, and head lights; 4) presence of a seatbelt inside a four-wheel vehicle. Crashes due to vehicle defects occur due to poor inspection of vehicles combined with individuals not complying with mandatory registration of vehicles.

Crashes Due to Unsafe Driver Behavior

Use of mobile phones may cause visual, auditory, manual and cognitive distraction. Text messaging was shown to reduce driving performance with young drivers at particular risk [16]. Drivers talking on a mobile phone are approximately four times more likely to be involved in a crash than those who are not; with no noted significant difference between hands-free and handheld phones [1]. Fatigue-related crashes also contribute to the large values of the index on unsafe driver behavior, especially for fatal crashes [17]. Fatigue driving increases the risk of a road crash due to its undesirable effects on the driver's reaction time. Fatigue can occur due to the following: 1) sleep loss, 2) circadian rhythms, or 3) time spent driving/working, etc.

Road Safety Performance Index

Figure 4 shows the plot of the computed safety performance index for Metro Manila in the years 2011 to 2015. The index remains more or less constant over a five-year period, increasing and decreasing from 0.45 in 2012 to 0.59 in 2015. The closer the value of the index is to 1, the riskier it is for road users, while a value close to 0 denotes safer roads.

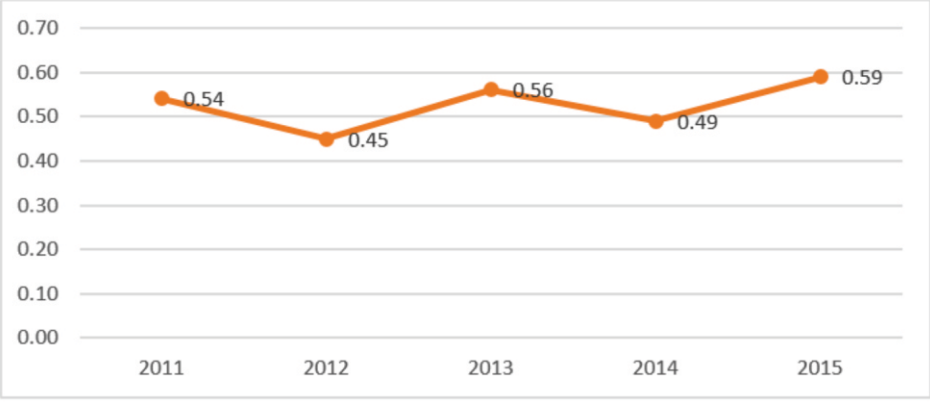


Figure 4. Road Safety Performance Index (SPI) for Metro Manila, Philippines: 2011-2015

For example, in the year 2015, when a crash occurred due to alcohol, speeding, road condition, vehicle defect, or other unsafe driver behavior, there was a 59% chance on the average that the collision resulted to bodily injuries or even death. The roads in Metro Manila are definitely risky in terms of the five indicators.

There are other indicators that may be included in future studies, such as post-crash response. In many low-income and middle-income countries, weak public health infrastructure is a major risk factor. In low-income countries, most of the population do not have access to even the most basic form of emergency medical service, and/or do not possess health insurance or social security. This contributes to the relatively high values for the index. There is a noted disparity in trauma treatment between high-income countries and low-income countries. High-income countries have well-trained practitioners in their chain of care. On the other hand, in low-income countries, the post-impact chain of care is delivered by personnel lacking in formal trauma training. Other risk factors noted were lack of surgeons and medical equipment in low-income countries [18].

An index for protective systems cannot be constructed as data is available only for those violating the Seatbelt Use Act of 1999. The presence of items that can reduce fatalities inside the vehicle cannot be accounted for, such as airbags, as it is still not mandatory in the country that all vehicles must have airbags installed therein. Furthermore, child restraints are not mandatory, hence children have an increased risk compared to adults.

Overall, the index shows that Metro Manila roads can be considered hazardous despite the passage of two additional road safety laws. These laws include penalizing drunk and drugged driving, as well as imposing speed limits of in "killer" highways. The increased risk can be attributed to the ineffective implementation of the law.

With all of the factors involved in road safety, the final outcome ultimately boils down to the behavior of the person behind the wheel. There are three stages in driver behavior in road collisions that can be analyzed. Firstly, pre-driving behavior is the checking of vehicles for defects, determining the driver condition—whether the person is fit to drive properly. These are actions that a driver can engage in before going behind the wheel to ensure safe and proper conditions for driving. Second is the driving proper behavior. It includes speeding, traffic violations, and other acts the driver engages in while driving the vehicle. Third is the knee-jerk reaction of the driver right before collision. This can be delved into in future researches in the study of the human behavior aspect of road safety.

The Philippines still lacks a centralized data collection and surveillance agency for road crashes. The Metro Manila Development Authority is one of the few agencies with a holistic approach to gathering variables. Even so, the said agency still lacks valuable variables, such as data on post-crash care. Given a more detailed data, the SPI can provide information to policy-makers as to what policy measures are necessary to bring down road crash injuries and fatalities. An index based on seven indicators is desired for the country, as it will enable legislators to formulate effective policies that will reduce risks.

Supranational organizations, such as the Asian Development Bank (ADB) and World Health Organization (WHO), have also collaborated with the Philippine government to advance road safety in the country. Both organizations have been funding workshops and conferences for stakeholders to achieve a 50% reduction in road crashes by the year 2020.

Further research can be done through the use of similar variables, albeit with different weighting, as the importance of the indicators depend on its strength to increase the risk of road users, as well as how much a policy measure can decrease such risk [2]. Equal weighting can still be an option given more variables to be analyzed.

As shown, there is no updated national data on road crash and traffic injuries. Only Metro Manila data is viable for statistical analysis. Yet, the variables measured and recorded are limited only to five factors—alcohol, speed, unsafe driver behavior, vehicle, and infrastructure. Even with the limited data, it can be used as an initial road safety performance index measure.

Conclusion

The study has shown that road traffic accidents in Metro Manila from 2005 to 2015, is on the average, 75,518 per year. Based on the statistical analysis of speed, alcohol, road condition, vehicle defect and unsafe road user behavior, the output of the study was the construction of road safety index. As was shown in the study, Metro Manila roads are not safe because they claim 40 lives per 1,000,000 in Metro Manila alone, and cause injuries of 14 in every 10,000 road users, as of 2015. In other words, in 2015, given the

population in Metro Manila which is 12 million, about 400 individuals have died in that year due to road crash. This is far from the zero approach to road fatalities.

The road safety performance index for Metro Manila has shown that the Philippines is far from achieving the goal of reducing fatalities by 50% in the year 2020. Speed, alcohol, and vehicle defect contribute the most in road crash fatalities. Hence, efforts should be focused on these three indicators.

Road safety is a shared responsibility among the wide array of road users, including drivers, passengers, motorcyclists, pedestrians, legislators, and government agencies. Efforts to create a road safety index is imperative. This is to shift attention towards safer use of roads, creation of safer road networks, and infusion of budget for post-crash response and trauma care.

Acknowledgments

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