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Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

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World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Driver's Road Accident Factor Prioritization using AHP in Relation to Mastery of Traffic Signs in the City of Manila

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Abstract

Road accident factor prioritization is a process where a sample size of driver respondents is taken and surveyed to determine the weight of importance of road accident factors. The procedure utilizes Analytic Hierarchy Process (AHP) to analyze the data and obtain the prioritization of the factors. Data gathered and processed is guided by the level of mastery of traffic signs by the respondents. Results of this study show that a high level of understanding of traffic signs generally results to a more accurate and reliable prioritization of road accident factors. Moreover, it is found out that the most prioritized factor among road accident factors is lack of knowledge of traffic signs while the least prioritized factor is bad driving behavior.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Analytic Hierarchy Process (AHP); Prioritization; Road Accident Factor; Level of Understanding; Traffic Signs

1. Introduction

Manila, the capital of the Philippines, serves as the capitol of the country. It is the busiest place in the Philippines which makes its transportation system crucial for the development of the country. This paper will focus on the drivers of the said city in relation to mastery of traffic signs and road accident factor prioritization. Manila is known for its number of road accidents. According to Metro Manila Accident Recording System (MMARAS), Metro Manila averages of 299 road crash incidents per day. Based from the MMARAS reports from 2010-2016, human error is the top cause of road accidents. In a presentation by Francisco and Rey (2017), it was reported that Manila had 11,101 incidents in 2015 where 83 were fatal, 1,338 resulted in injuries, and the rest were reported to be involved with damages to properties. The Metropolitan Manila Development Authority (MMDA) concluded that the high number of incidents in the city can be attributed to the high social and economic activities in the area.

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According to MMARAS reports in 2016, road crash incidents increases by 20 percent every year over the past 5 years. From the report of Francisco (2017), it is reported that a huge bulk of road crash incidents amounting to 105,734 cases are labelled as "no accident factor". Based on this scenario the research established that government officials and traffic engineers have failed in addressing the problem for over 5 years because of the lack of research and data to base designs and strategies to promote road safety and lessen the road crash incidents. Therefore, the researchers proposed a study concerning the road accident factor prioritization and level of understanding of drivers. The proposed study will be able to address the lack of data by knowing the drivers' mastery of traffic signs and which road accident factors are critical to the drivers to avoid accidents. The study aims to analyze how the mastery of traffic signs affect the road user's prioritization of the factors that causes road accidents. The objective of the research is to evaluate the respondents' mastery of traffic signs and to determine their prioritization of road accident factors using analytic hierarchy process.

2. Past Studies

The study, drivers' awareness of traffic signs in Manila, by Muhlrad (1993) conducted a survey in Manila, which is the same geographical location for this research, involved 175 drivers (55 drivers of light vehicles, 30 of buses, 30 of trucks, and 60 of jeepneys). The main findings were that very few drivers were unaware of the meaning of road signs and markings (5%), but most of them admitted to breaking regulations in certain instances. The survey of drivers' awareness of traffic signs referred to earlier indicated that, although most of the drivers were aware of what the Stop sign meant (92 %), 32 % of them stated that they usually merely slowed down in the absence of any visible traffic on the highway. This result suggested that awareness of regulations would not be the only factor for explaining observed behavior: the attitudes of road-users towards formal regulations are also important.

A study by Wang et al. (2018) tackled the application of AHP in for identifying important human error factors in emergency departments in Taiwan. In hospitals, the only criterion for understanding the distribution of error factors were the frequency of their occurrence. This measure of importance was deemed unreliable and vague. The types of error that occur most frequently in hospitals are not necessarily the most important (Wang et al., 2018). The study proposed that new human error factors should be established and determine the importance of each factor. The research utilized Human factors analysis and classification system to determine which are the most critical human error factors in emergency departments. After establishing the factors, the researchers used multiple criteria decision-making tools such as analytic hierarchy process and fuzzy to determine the importance of error factors. Results showed that decision errors, crew resource management, inadequate supervision, and resource management were the important human error factors related to ED adverse events.

In the field of manufacturing, risk assessment is a critical point in planning. A study by Dagˇsuyu, Kokangül, & Polat (2016) proposed to utilize the Analytic Hierarchy Process to determine the importance levels of the hazards in risk assessments. However, AHP method does not determine whether the hazards are at an acceptable level based on their risk points (Dagˇsuyu et al., 2016). As a solution to this problem, the researchers incorporated Fine Kinney method of assessing whether the hazards, which were established from the researcher's historical data, are at an acceptable level to be included in the analysis or to be neglected. With the AHP method incorporated with the Fine Kinney method, the researchers were able to create a new approach regarding the usability of the class intervals in the Fine Kinney risk assessment method for the results obtained with the AHP method.

The work of Albert, Lotan, Musicant, & Oppenheim (2016) about smartphone applications which may contribute to road safety is a study that uses the Analytic Hierarchy Process to determine the importance of the factors introduced in the said research. The purpose of this paper is to establish a blueprint for smartphone apps that will have the greatest potential to reduce injury crashes (Albert et al., 2016). The researchers of this literature surveyed thirty-seven experts to obtain valid evaluation of the applications, its safety features with respect to driving and acceptance concerns regarding to the app's users. The research resulted to the promotion of collision warning, texting prevention (both typing and reading), voice control and vehicle data recorder. The said features were proposed to promote a safer road and better driving experience. However, according to the research, such limitation to the users may not be acceptable to the public.

The work of Chayanan, Namee, Raksuntron, et.al (2015), utilized analytic hierarchy process to determine the most prioritized factor on road accidents. This study evaluates opinions regarding factors of road accidents using

pairwise comparison questionnaire to ask selected groups of policemen, health care staffs (physicians and nurses), highway department personnel, and academic and engineering staffs, with total 100 respondents. Their study was conducted in Thailand and it resulted to a successful study wherein the results concluded that safety management is the most prioritized factor and under the sub-criterion analysis law enforcement and knowledge of road rules were prioritized.

3. Significance

Traffic signs are guidelines for drivers and pedestrians while they are using the road. Certain roads may have specific rules and schemes which are unique to itself. These rules are conveyed to the road users via traffic signs. Road markings and traffic signs serve as silent speakers in the highway. They help road users when navigating the road until their desired location is reached (M&G Global ads, 2017).

The proposed study, Driver's Road Accident Factor Prioritization using AHP in Relation to Mastery of Traffic Signs, shall serve as a tool to improve the road safety in the city of Manila. By providing data for engineers and local government units (LGU), traffic issues in the study area will be addressed properly.

Traffic engineers and designers shall benefit from the results of the study. More effective traffic schemes could be developed through the determination of data such as drivers level of understanding of traffic signs. By obtaining the most prioritized factors that causes accidents, engineers will able to focus on a certain aspect of the road issue and eliminate the roots of the accidents. Also, the existing traffic signs could be improved so that majority of road users will be able to comprehend its meaning. Thus, reducing the possibility of road accidents.

4. Methodology

4.1. Descriptive Survey Method

The research used questionnaires to harness the respondent’s familiarization of traffic signs present in Manila and to establish prioritization on the cause of road accidents. These questionnaires were administered to random public and private vehicle drivers. In all 535 questionnaires were administered at various places in Malate, Manila during January to March 2018. Similar questionnaires are given to all respondents where one can choose between the English or Tagalog questionnaire. Since the drivers completed the questionnaires on the spot all questionnaires were retrieved.

A privacy statement is stated that no interviewer’s identity is collected. The pilot test questionnaire is conducted for 40 respondents to obtain feedbacks for improvements, such that each questionnaire question can be more clearly understood

The questionnaires are consisted of three sections. The first section had 30 multiple choice questions of different traffic signs which included 15 regulatory signs, 10 warning signs, and 5 informative signs. The second section sought to obtain information of the ranking of causes of road accidents from least likely to most likely. The causes of road accidents to be evaluated was based from the observations of the researchers and the study of the Waterdown Collision (2016) where the article showed the leading causes of road accidents namely, the lack of knowledge towards traffic signs of driver, lack of proper training of driver, bad driving behaviors of the driver, driver’s physical and emotional state, and distracted drivers. The last section is to determine the prioritization of the causes of road accidents define by pairwise comparisons. The number of pairwise questions are 10. Every question has two different cause of road accident with different levels of extremities.

4.2. Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a general theory of measurement. It is used to derive ratio scales from both discrete and continuous paired comparisons. These comparisons may be taken from actual measurements or from a fundamental scale which reflects the relative strength of preferences and feelings (Saaty, 1987). The analytic hierarchy process is utilized in this research to determine the most influential factors for road accidents.

The research established five road accident factors namely: bad driving behavior, distracted driver, lack of proper training, drivers' physical and emotional state and lack of knowledge of traffic signs. The study used a level 1 analytic hierarchy process to analyze these factors and achieve a prioritization as seen in Figure 1. A level 1 AHP approach is used in this research and no alternatives were presented since it would further lengthen the survey procedure for the drivers who lack time and training for such questionnaire. Also, using a level 1 AHP approach will eliminate possibilities of inconsistencies in the data gathered.

After data gathering, the prioritization of the respondents shall be obtained depending on their mastery of traffic signs. Each respondents AHP data is classified according to their mastery and analyzed per group to determine the relationship of the master of traffic signs and prioritization of road accident factors.

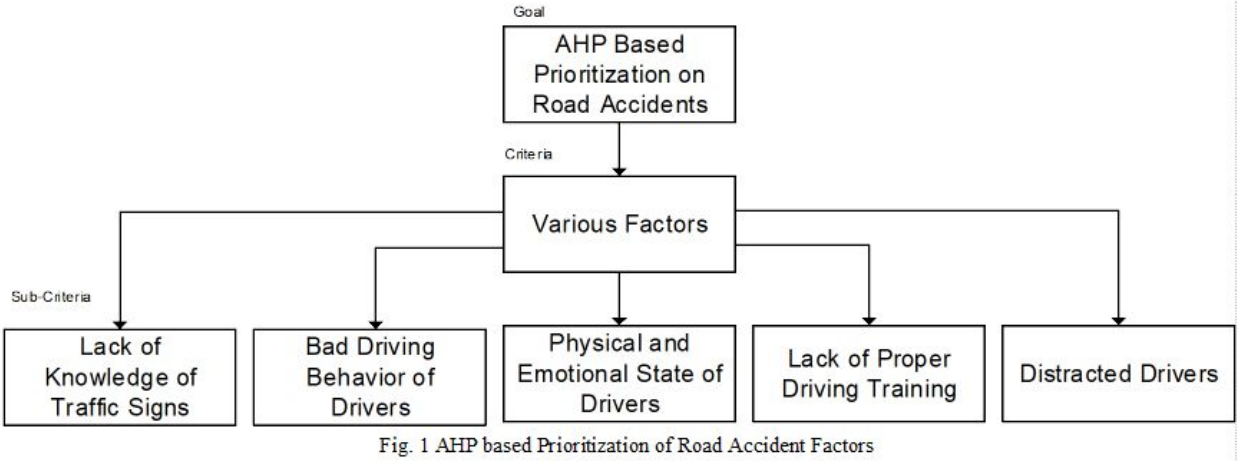

Fig. 1 AHP based Prioritization of Road Accident Factors

4.3. Pairwise Comparison

The questionnaire survey applies pairwise comparison. Pairwise comparison is used to study the preference of respondents. With pairwise comparisons, questions have two answers with different levels of extremities, written at opposite ends of a scale where respondents must mark their response anywhere between these two extremities, showing their opinion. The criterion entities in pairs are judged for relative importance of one criterion over another. The scale is the intensity of importance is seen and explained in Table 1. Table 2 shows the definition of the causes of road accident factors. Respondents are asked to give relative importance rating between two cause of road accident factor, as pairwise comparison, seen in Table 3.

Table 1. Intensity of Importance for Factors of Road Accident (adapted from Satty (1987))

Scale	Definition	Explanation
1	Equal	● Two criteria pay equally to the accident factor
3	Slightly Favors	● Experience and judgement slightly favor one criterion over another
5	Strongly Favors	● Experience and judgmental strongly favor one criterion over another
7	Very Strongly Favors	● A criterion is favored very strongly over another
9	Extremely Favors	● The evidence favoring one criterion over another is of the highest possible order of affirmation

Table 2. Explanation of Road Accident Factors

Cause of Road Accident Factors	Definition

Lack of Knowledge of Traffic Signs	• Characteristic of drivers wherein they have poor mastery of the existing traffic signs on the road
Bad Driving Behavior	• Drivers disobeying the traffic rules intentionally and does mannerisms that are not acceptable while driving
Physical and Emotional State of Drivers	• Physical state such as having an injury, lack of sleep, exhaustion, being in the influence of drugs or alcohol etc. and Extreme emotions of any kind, whether positive or negative
Lack of Proper Driving Training	• Drivers not having all the proper skills in driving along the streets and highways
Distracted Drivers	• Any activity that diverts the driver's attention from driving

Table 3. Relative Importance Scoring of Pairwise Comparison on Cause of Road Accidents Factors

Cause of Road Accidents A	Side A has more importance compared to Side B				Equal Importance	Side B has more importance compared to Side A				**Cause of Road Accidents B**
Lack of knowledge of Traffic Sign	9	7	5	3	1	3	5	7	9	Lack of Proper training of driver
Lack of knowledge of Traffic Sign	9	7	5	3	1	3	5	7	9	Bad driving behaviour of drivers
Lack of knowledge of Traffic Sign	9	7	5	3	1	3	5	7	9	Driver's physical & emotional state
Lack of knowledge of Traffic Sign	9	7	5	3	1	3	5	7	9	Distracted drivers
Lack of Proper training of driver	9	7	5	3	1	3	5	7	9	Bad driving behaviour of drivers
Lack of Proper training of driver	9	7	5	3	1	3	5	7	9	Driver's physical & emotional state
Lack of Proper training of driver	9	7	5	3	1	3	5	7	9	Distracted drivers
Bad driving behaviour of drivers	9	7	5	3	1	3	5	7	9	Driver's physical & emotional state
Bad driving behaviour of drivers	9	7	5	3	1	3	5	7	9	Distracted drivers
Driver's physical & emotional state	9	7	5	3	1	3	5	7	9	Distracted drivers

5. Data Analysis

5.1. Mastery of Traffic Signs

The respondents were grouped according to their mastery in traffic signs into five categories namely, poor, below average, average, above average and excellent mastery in signs. The criteria for each category is based from the scores of the respondents. Drivers who score 60% and below are considered to have poor mastery, 61-70%, 71-80%, 81-90% and 91-100% are below average, average, above average and excellent mastery, respectively. The categorization of respondents is to determine the difference of prioritization of road accident factors of those who understand traffic signs least to the respondents who understand it better. With the help of categorizing the respondents, the researchers would be able to show the respondents that understand traffic signs best has more reliable data. Also, the researchers would be able to display the validity of AHP.

Figure 2 presents the breakdown of the percentage of respondents per category. After tallying all respondents, the outcome resulted to 8% for poor, 11% excellent, 18% below average, 26% average and lastly 37% above average mastery. Majority of the respondents has above average understanding of traffic signs while poor mastery has the least number of respondents.

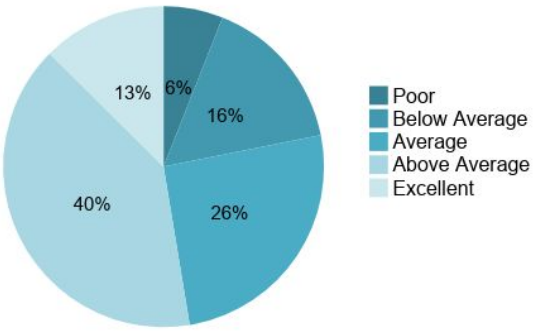

Fig. 2. Percentage of Mastery of Traffic Signs

5.2. Ranking of Cause of Road Accidents

Figure 3 shows the total ranking of the different factors of road accidents. The most likely factor chosen is bad driving behavior of drivers (1905), followed by lack of proper training of driver (1682) and distracted driver (1623). Next is the driver's physical and emotional state when driving (1244). And finally, the drivers chose lack of knowledge of traffic signs (1183) as the least likely to cause road accidents. It can be observed that the difference between the highest and lowest are greatly high. In addition to that, more than a hundred is the difference between the first factor to the second. Although, the difference of the fourth from the fifth is not as large, it is still a sizeable difference to solidify that the least likely to cause road accidents is the lack of knowledge of drivers towards traffic signs and that the most likely to cause road accidents is the bad driving behavior of the drivers, undeniably.

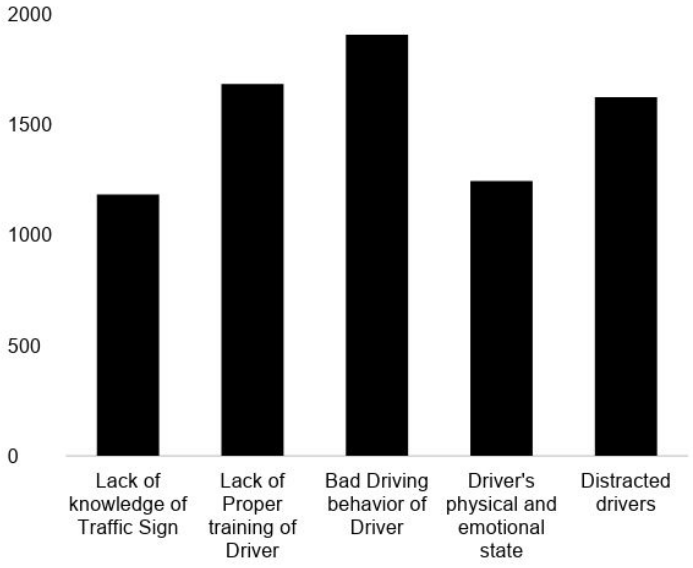

Fig. 3. Ranking of Different Road Accident Factors

5.3. Average Consistency Ratio per Level of Mastery of Traffic Signs of Drivers

The researchers decided on a criterion for a value of the acceptable consistency ratio of the respondents. The only respondent data accepted are from the respondents with a consistency ratio of 0.5 and below, this is to give consideration that the respondents are not experts about the study and several respondents will be unqualified for the study if not. In Table 4, the number of respondent data accepted for analysis of AHP results and the average consistency ratio for each category is presented.

It is shown that only 23 respondents, which are classified to have poor level of mastery of signs, qualified for AHP analysis. The average consistency ratio for poor mastery is 0.38. For respondents with below average mastery, 64 samples qualified with an average of 0.36 for the consistency ratio. Average mastery accepted 112 samples with an average of 0.31 for the value of consistency ratio. Above average mastery yielded the highest number of samples that qualified with a value of 181 respondents with a consistency ratio averaging 0.32. Lastly, the respondents with excellent mastery of traffic signs yielded 56 qualified samples with the best value for the consistency ratio of 0.23.

Table 4. Average Consistency Ratio Per Level of Mastery of Signs

Level of Mastery of Traffic Sign	Range of Average Percentage Score	Total Number of Respondents	Number of Respondents qualified	Average C.R.
Poor	60% and below	31	23	0.38
Below Average	61-70%	82	64	0.36
Average	71-80%	136	112	0.31
Above Average	81-90%	219	181	0.32
Excellent	91-100%	67	56	0.23
Total		**535**	**436**	**0.32**

5.4. Average Consistency Ratio per Level of Mastery of Traffic Signs of Drivers

The different priorities of road accident factors are shown in Figure 4 according to the different levels of mastery of the drivers. It is seen that having a mastery of less than average yielded somewhat similar priorities of the factors causing road accidents. Drivers that received poor and below average mastery of traffic signs prioritized the lack of knowledge of traffic signs most. All drivers whose mastery is average and above yielded the same ranking. Drivers with good understanding of traffic signs display identical priorities for road accident factors. A trend is seen that as drivers who understand traffic signs better, prioritizes the lack of knowledge of traffic signs as the cause of road accidents the least. Drivers who are knowledgeable about traffic signs prioritizes the cause of road accidents the opposite of drivers who are less knowledgeable.

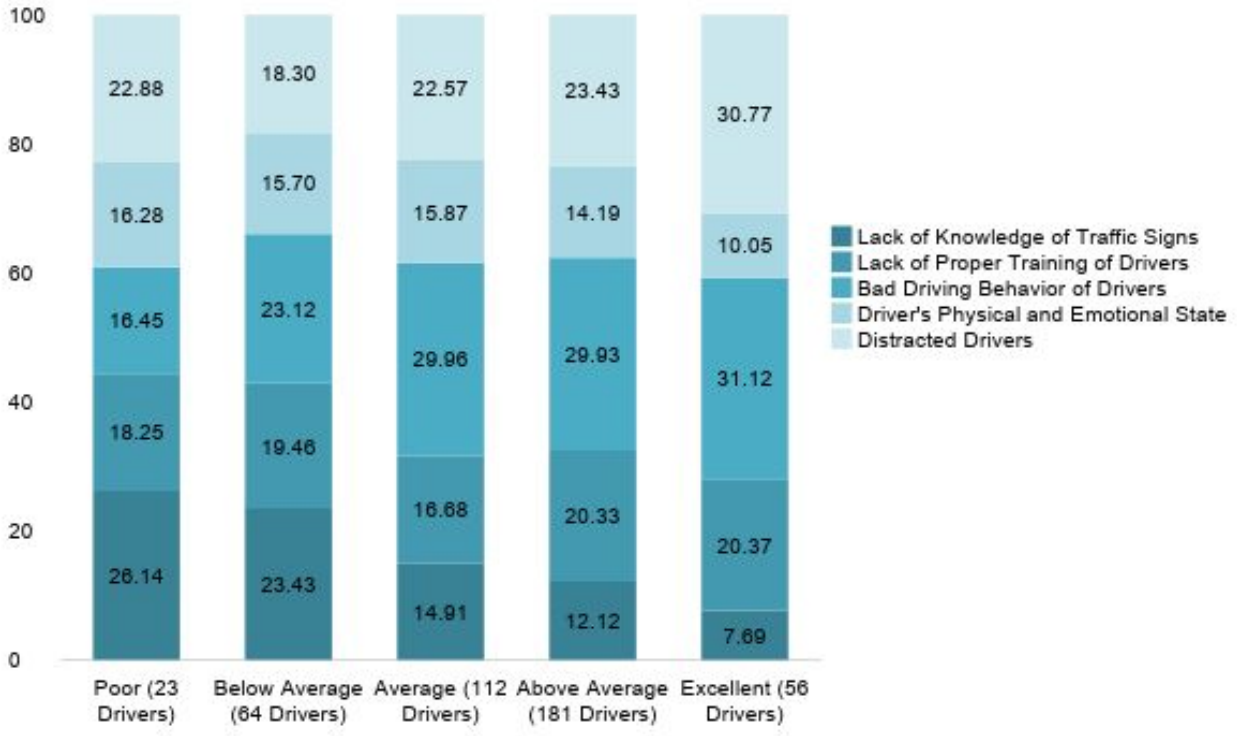

Fig. 4. Road Accident Factor Prioritization for Drivers with Different Level of Mastery of Traffic Signs

As seen in Figure 5, the ranking of the factors are as follows, lack of knowledge of traffic signs, driver's physical and emotional state, lack of proper training, distracted drivers, and bad driving behaviour, from most important to the least important respectively. The results of respondents with good understanding portrays an accurate representation of the prioritization of the whole sample size.

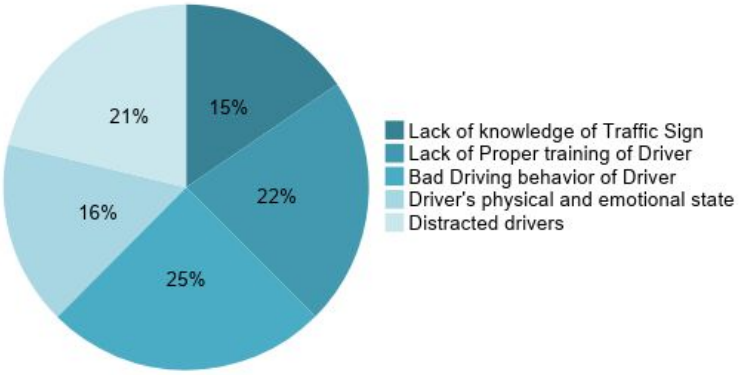

Fig. 5. Overall Road Accident Factor Prioritization of all Drivers

6. Conclusion

After data analysis, the researchers learned that the drivers with an average to excellent level of understanding of traffic sign agrees to one ranking of road accident factors. Meanwhile, respondents with below average mastery of

traffic signs displayed varying prioritization. Since drivers with enough understanding of traffic signs all agree to one course of prioritization while those below the average level give varying importance to the different factors, it is established that drivers understanding of traffic signs is a critical component to determine which factors are relevant. In conclusion, a high level of mastery of traffic signs will result to a more accurate and reliable prioritization of road accident factors.

With that information, the researchers decided that responses from drivers with below average level of understanding is unreliable and concluded that the valid prioritization of road accident factors is as follows, bad driving behavior, distracted drivers, lack of proper training, driver's physical and emotional state, and lack of knowledge of traffic signs, from most important to the least important respectively.

By comparing Analytic Hierarchy Process with the forced ranking method, it is observed that there was only a very slight difference. The results of the forced ranking method only differed in the 2nd and 3rd prioritized factor as compared to the AHP method. The researchers therefore conclude that although the results were close, forced ranking method lacks the depth of detail that the AHP method provides in terms of pairwise comparison of factors. This was only to verify the results of ranking generated from AHP. Forced ranking method may be a reliable substitute for obtaining the extremities of the prioritization of factors but it does not guarantee accurate representation of the importance of factors.

Lastly, after data analysis, it is safe to conclude that using Analytic Hierarchy Process to obtain a prioritization of road accident factor is an acceptable method. The advantage of using mastery of traffic signs to validate the prioritization is that inconsistent data will be eliminated and thus further reducing errors in the future use of the data. The proposed method important so that engineers, designers and everyone that would utilize the data set will be confident that the data is reliable and accurate.

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