Measuring road safety advance by IW-EDAS-KNN: A case study for OAS countries

Jiale Yang
Fountain Valley School of Colorado 6155 Fountain Valley School Road Colorado Springs, Colorado 80911, USA
jyang23@fvs.edu

Abstract. Road Safety is an important aspect when considering the public health of a nation. Road Safety is becoming an increasing concern among nations, and road safety hazards remained a huge problem in some nations, causing financial loss and fatalities. Estimated results demonstrates that road traffic injuries cost the government approximately 3% of GDP, and up to 5% in low- and middle-income countries [1]. Since the road traffic incidence created substantial financial burden, it is necessary to control risk factors and improve the road safety advance. By evaluating the road safety conditions of each individual states, or by comparing the road safety status of a group of states, we can identify the potential strengths and weaknesses of each state hence give suggestions for future improvements. This paper looks at a ten-year data (2009-2019), source from the World Health Organization, the Pan American Health Organization, and the Traffic Safety Data and Analysis Group. The aim of this research is to evaluate and benchmark the road safety conditions of the members states of the Organization of American States by applying Evaluation Based on Distance from Average Solution, a Multi-Criteria Decision-Making (MCDM) technique for classification; identify the continuity in development and advancement of road safety conditions for each state; group the member states of OAS into classes by applying K-Nearest Neighbor Analysis, an algorithm for classification and regression that group objects into classes based on its k nearest neighbors; and make suggestion for future improvements for each member states with respect to their group members. It is concluded that certain indicators are underperformed by a majority of OAS members, which allowed policymakers to identify the potential weakness in road safety performance and offer effective intervention. Additionally, suggestions are made for under-performing countries of the OAS to refer to the road safety procedure from the best-performing nations for future road safety advances.

Keywords: Road safety advance; Safety management; Multi-Criteria Decision-Making (MCDM); Soft computing; Organization of American States (OAS)

1. Introduction

Road safety is one of the most crucial indicators of the public health in a nation. However, road safety still exist as a major challenge for the world. According to the data from the World Health Organization, the road fatalities worldwide remains “unacceptably high”. Approximately 1.3 million road traffic death and 50 million injuries arise every year according to the Global Status Report on Road Safety in 2018. Most importantly, the nations from Americas is responsible for a large portion of those numbers. For instance, the estimated road fatalities worldwide in 2013 is 1.28 million, and the Americas’ road death that year reached 154,089, which present approximately 12% of the world’s total fatalities [2]. At the same time, the number continue to rise both globally and in the region of Americas. The estimated road fatalities worldwide in 2016 is 1.35 million, and the Americas’ road death that year reached 154,997 [3].

Focusing solely on the region of America and the member states of OAS, pedestrians, motorcyclists, and cyclists make up 48% of the road traffic death in the region in 2016, highlighting the fact that those more vulnerable road users should be better protected. Furthermore, there exists significant variation in road safety conditions in each state. For example, the lowest traffic death rate is 6 per 100,000 population in Canada, while the largest is 29.3 in Dominican Republic [2]. Similar trend still exists in the year of 2016, the lowest traffic death rate is 5.6 per 100,000 population in Barbados, while the highest is 35.4 per 100,000 population in Saint Lucia [3].

To explain such a unequally distribution, income level and motorization are inevitable factors. According to the data from the Pan American Health Organization in 2013, 73% of the road traffic death occur in middle-income countries (MIC) and 26% in high-income countries (HIC), disproportion to their level of motorization (37% in MICs and 63 in HICs). Similarly, in 2016, 69.7% of the road traffic death occur in MICs and 29% occur in HICs [3]. Understanding those facts will better support the results in the grouping sections.

At the same time, since 2014, most nations in the America adopted implemented road safety legislations in order to control the risk factors. The current five main risk factors involved in traffic incidences are speeding, drink-driving, nonuse of motorcycle helmet, nonuse of seat-belt, and child restraint use. Without proper enforcement, such risk factors could be devastating; with proper enforcement, the risk of death and injuries reduced dramatically. According to the World Health Organization Fact Sheet on Road traffic injuries, every 1% increase in mean speed cause a 4% increase in fatal crash risk and a 3% in serious crash risk, and the death risk for pedestrians hit by car fronts rises 4.5 times from an average speed of 50 km/h to 65 km/h. The correct use of helmet can lead to a 42% reduction in the risk of fatal injuries and 69% reduction in the risk of head. Similarly, wearing a seatbelt reduce the risk of death of front seats by 45 – 50%, and the use of child restraint can lead to a 60% reduction in death [1]. However, the enforcement of legislations on those five main risk factors still remained as a major challenge. According to the PAHO Status of Road Safety in the Region of the Americas (2019), in total, 21 countries met the best practice for at least one of the five key risk factors, but none of the countries met the best practice for all five key risk factors.

2. Literature review

Road safety evaluation is crucial for the public health in a country. Currently, road fatalities and injuries are an increasing global issue, and the result from road safety evaluation identified underlying weaknesses for the road safety performances, therefore, give advices for future improvement and advancement. Previous studies had investigated and evaluated the road safety performing in regions such as Asia and Europe, and gave valuable suggestions for road safety improvements. A 2018 study on road safety performance across Europe evaluation, which applied the Envelopment Analysis (DEA) and DEA-Cross Efficiency Model (DEA-CEM), provides valuable insights into the cross-sectional assessment of road safety levels between EU countries by considering the target-setting methodology for each country before and during a period of financial turmoil in Europe. The study took into account the socio-economic and demographic background which is a useful methodology [4]. Furthermore, a 2017 study on road safety development at southeast Asia region identified areas of underperformance, potential problems and delays. The results enable decision makers to better understand their own road safety progress [5].

Previous studies regarding road safety advance and performance applied various models. In the field of road safety, Data Envelopment Analysis (DEA) has been successfully applied to road safety assessment as a powerful and mainstream decision-making method. There are also studies that applied the modified version of conventional decision-making approaches. In a 2020 study that evaluate road safety in a case of Iran, a modified DEA model is applied with group best-worst method (BWM) that successfully compensate for the shortcoming from weight flexibility [6]. Moreover, a 2012 study on road safety performance evaluation applied an improved hierarchical fuzzy TOPSIS approach that are combined with experts' knowledge [7].

Currently, in the field of road safety research, the scope still exists as a limitation. According to a 2021 study that researched road safety in the context of low- and middle-income countries, it is estimated that slightly less than 10% of the road safety research has been undertaken in the contexts of LMICs, which is extremely disproportionate considering the fact that most road traffic deaths and injuries occur in LMICs ([8]).

While this study applied a new model, the IW-EDAS-KNN model to evaluate the road safety performance and advance, the study also provide insight into a region with little previous investigation, the region of Americas. This study will aim to evaluate the road safety advance and performance of the OAS member states in the region of Americas and give advices for policymakers regarding the underperforming and less developed indictors.

3. Data collection

Data for the indicators is collected from the World Health Organization (WHO) database, WHO Global Status Report on Road Safety [9-12]. The data covers all the OAS member states, and the countries that are taken into considerations are: Antigua and Barbuda (AG), Argentina (AR), Barbados (BB), Belize (BZ), Bolivia (BO), Brazil (BR), Canada (CA), Chile (CL), Colombia (CO), Costa Rica (CR), Cuba (CU), Dominica (DM), Dominican Republic (DO), Ecuador (EC), El Salvador (SV), Grenada (GD), Guatemala (GT), Guyana (GY), Haiti (HT), Honduras (HN), Jamaica (JM), Mexico (MX), Nicaragua (NI), Panama (PA), Paraguay (PY), Peru (PE), Saint Lucia (LC), Saint Vincent and Grenadines (VC), St. Kitts and Nevis (KN), Suriname (SR), The Bahamas (BS), Trinidad and Tobago (TT), United States (US), Uruguay (UY), Venezuela (VE). To evaluate the overall road safety condition of the member states of OAS, we create 10 data criteria for computations: Road fatalities per 100,000 population (A1), Road fatalities per 10,000 registered vehicles (A2), Share of pedestrian fatalities out of the total fatalities (%) (A3), Change in number or road death (%) (A4), Seatbelt wearing rates in front seats (%) (B1), Seatbelt wearing rates in rear seats (%) (B2), Enforcement score on speed limit law (C1), Enforcement score on drink-driving law (C2), Enforcement score on seatbelt law (C3), Enforcement score on helmet use law (C4), and Human Development Index (HDI). A1 and A2 are found directly in the Road safety category of Global Health Observatory data section under road traffic mortality topics [13]. A3 is found directly in the Global Status Report on Road Safety [9-12]. B1 and B2 are found in the Road safety category of Global Health Observatory data section under national legislation topics [14]. C1, C2, C3, and C4 are found in the Global Status Report on Road Safety [9-12]. The data from the A4 is calculated based on a 9-year span, using the number of road fatalities data in the year of 2019, 2009, and 1999 from the Global Status Report on Road Safety [9-12]. Unfortunately, there exists a lack of information for seatbelt wearing rates in front and rear seat (B1 and B2). As a result, most of the seatbelt wearing rates are estimated results. Except for the data in criteria B1 and B2, other missing data are also being estimated according to the data from other OAS member states with similar HDI.

4. Methodology

4.1 IW-EDAS-KNN model

In this research, we constructed an IW-EDAS-KNN model to evaluate the road safety condition for the member states of OAS. Such a model is performed in the following step:

Step 1. Weighing indicators

Weighing is important in deciding criteria priority and in solving Multi-criteria decision-making problems. In this IW-EDAS-KNN model, we applied Independence Weighing (IW) as our weighting algorithm. IW is a method for indicator weighing based on its strength of its covariance with other indicators. In order to evaluate the strength of covariance of a certain indicator, the multiple correlation coefficient of that indicator is calculated, which reflect the degree of correlation between a dependent variable and a set of independent variables (two or more); the greater the multiple correlation coefficient of the criteria, the stronger the covariance, the more repeated information there is, the less weight should be given to this indicator.

The Regression function in Excel Data Analysis Toolbox is used to calculate the multiple correlation coefficient for each indicator. The normalization of the reciprocal of multiple correlation coefficients gives the weight coefficient that will be used to calculate the weighted sum for positive and negative distances in the EDAS approach.

Step 2. Evaluate multiple criteria

MCDM approach is crucial in many cases that involve risk assessment, selection, or ranking. Evaluation Based on Distance from Average Solution (EDAS) was introduced by Mehdi KESHAVARZ GHORABAEE in 2015 [15] as a new method for MCDM process. Positive and negative distances are calculated from the average solution for both beneficial and nonbeneficial criteria. EDAS is an effective way for evaluating and managing a large data source. Further studies demonstrates that EDAS is also consistent with other MCDM methods such as TOPSIS, VIKOR, and SAW [15]. We used MATLAB to code the algorithm for EDAS.

Step 3. Group member states

K-Nearest Neighbor Algorithm (KNN) was first developed by Evelyn Fix and Joseph Hodges in 1951 [16] as a classification method based on the nearest training example, or the nearest neighbor. KNN Algorithm is usually applied to find out similar solutions with several given categories, and once a new solution is added to the data set, it can be placed into a category based on the existing nearest neighbors. KNN Algorithm can also be used to predict a category for each solution based on existing data.

We used IBM SPSS to complete the classification of K-Nearest Neighbor Algorithm. We used a k value of 3, meaning each member state is grouped based on its 3 nearest neighbors. The KNN Algorithm results in SPSS gives a predicted category for each member state of OAS. Multiple categories are then combined to form 4 larger groups: very high, high, medium, and low group. The nations in the same group will have similar traits hence better to refer to each other in terms of future road safety advances.

4.2 Model specification

Independence Weighing (IW) is a method to weight indicators based on its strength of covariance with other indicators. The multiple correlation coefficient “R” represents the degree of covariance a certain indicator share with others.

Step 1. Calculate the multiple correlation coefficient (R):

$$R = \frac{\sum(y - \overline{y})(\hat{y} - \overline{y})}{\sqrt{\sum(y - \overline{y})^2(\hat{y} - \overline{y})^2}}$$

Where $\hat{y}$ is the expected value from the multiple regression, and $\overline{y}$ is the mean of the indicator.

Step 2. Calculate the weight coefficient:

$$w_j = \frac{\frac{1}{R}}{\Sigma\frac{1}{R}}$$

Since the greater the R is, the less weight it has, we take the reciprocal of R, and normalize to obtain the weight coefficient.

Evaluation Based on Distance from Average Solution (EDAS) is a MCDM method that evaluate each solution based on its positive and negative distances from the average solution for both beneficial and nonbeneficial criteria. The best solution will have the greatest positive distance and the least negative distance from the average solution of a beneficial criteria; at the same time, it will have the least positive distance and greatest negative distance from the average solution of a nonbeneficial criteria.

Step 3. Determine the average solution (AV_j) for each criteria:

$$AV_j = \frac{\sum_{i=1}^{n} X_{ij}}{n}$$

Step 4. Determine the positive distance from average (PDA_{ij}) and negative distance from the average (NDA_{ij}). When the individual value of the criteria is lower than the average solution, PDA_{ij} has a value of zero; when the individual value of the criteria is higher than the average solution, NDA_{ij} has a value of zero:

For beneficial criteria:

$$PDA_{ij} = \frac{max\ (0, (X_{ij} - AV_j))}{AV_j}$$

$$NDA_{ij} = \frac{max\ (0, (AV_j - X_{ij}))}{AV_j}$$

For nonbeneficial criteria:

$$PDA_{ij} = \frac{\max\ (0, (AV_j - X_{ij}))}{AV_j}$$

$$NDA_{ij} = \frac{\max\left(0, (X_{ij} - AV_j)\right)}{AV_j}$$

Step 5. Determine the weighted sum of PDA_{ij} and NDA_{ij}, where SP_i is the weighted sum of PDA_{ij} and SN_i is the weighted sum of NDA_{ij} :

$$SP_i = \sum_{j=1}^{m} w_j PDA_{ij}$$

$$SN_i = \sum_{j=1}^{m} w_j NDA_{ij}$$

Where w_j is the result from IW.

Step 6. Normalize SP_i and SN_i, where NSP_i is the normalized value for SP_i and NSN_i is the normalized value for SN_i :

$$NSP_i = \frac{SP_i}{max_i(SP_i)}$$

$$NSN_i = 1 - \frac{SN_i}{max_i(SN_i)}$$

Step 7. Calculate the overall assessment score (AS_i), where the score is a number from 0 to 1:

$$AS_i = \frac{1}{2}(NSP_i + NSN_i)$$

5. Results

5.1 Weighting results

In 2009, indicators A1, A3, and A4 appeared to be the most weighted; B2, C1, and C4 appeared to be the least weighted. In 2019, indicators A1, A3, and C3 appeared to the most weighted; B1, B2, and HDI appeared to be the least weighted. Overall, A1 and A3 are the most weighted indicators; B1 and B2, mostly estimated, are the least weighted indictors due to the relatively large amount of missing data.

Table 1 The results of multiple correlation coefficient (R).

Year	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4	HDI
2019	0.651	0.727	0.608	0.739	0.843	0.849	0.692	0.753	0.581	0.751	0.824
2009	0.622	0.727	0.653	0.610	0.769	0.828	0.785	0.743	0.756	0.821	0.749

Table 2 The results of weight coefficient (w_j).

Year	A1	A2	A3	A4	B1	B2	C1	C2	C3	C4	HDI
2019	0.100	0.090	0.107	0.088	0.077	0.077	0.094	0.087	0.112	0.087	0.079
2009	0.106	0.091	0.101	0.108	0.086	0.080	0.084	0.089	0.087	0.080	0.088

5.2 Ranking results

In 2009, Canada had the highest assessment score of 1.000, and Paraguay had the lowest assessment score of 0.0038; in 2019, Canada still had the highest assessment score of 0.9915, and Saint Lucia had the lowest assessment score of 0.0620.

Table 3 The results of EDAS assessment score (AS_i).

Year	AG	AR	BB	BZ	BO	BR	CA	CL	CO	CR	CU
2019	0.561	0.601	0.672	0.253	0.366	0.806	0.992	0.547	0.519	0.585	0.554
2009	0.694	0.494	0.790	0.565	0.329	0.653	1.000	0.632	0.563	0.681	0.735

Table 4 The results of EDAS assessment score (AS_i).

Year	DM	DO	EC	SV	GD	GT	GY	HT	HN	JM	MX	NI
2019	0.414	0.123	0.553	0.469	0.524	0.223	0.144	0.407	0.487	0.384	0.568	0.540
2009	0.444	0.448	0.176	0.522	0.699	0.061	0.705	0.398	0.454	0.482	0.470	0.460

Table 5 The results of EDAS assessment score (AS_i).

Year	PA	PY	PE	LC	VC	KN	SR	BS	TT	US	UY	VE
2019	0.540	0.513	0.447	0.062	0.446	0.651	0.661	0.731	0.777	0.845	0.754	0.389
2009	0.668	0.004	0.328	0.547	0.493	0.531	0.558	0.650	0.408	0.923	0.566	0.384

5.3 Grouping results

In 2009, Costa Rica, Panama, Suriname, Barbados, Chile, Cuba, Grenada, St. Kitts and Nevis, Antigua and Barbuda, Canada, and the United States are the best-performing nations; Paraguay, Ecuador, Haiti, Nicaragua, and Trinidad and Tobago are the underperforming nations. In 2019, Brazil, Trinidad and Tobago, Canada, the United States, and Uruguay are the best-performing nations; Dominican, Saint Lucia, Dominica, Peru, Guatemala, and Honduras are the underperforming nations.

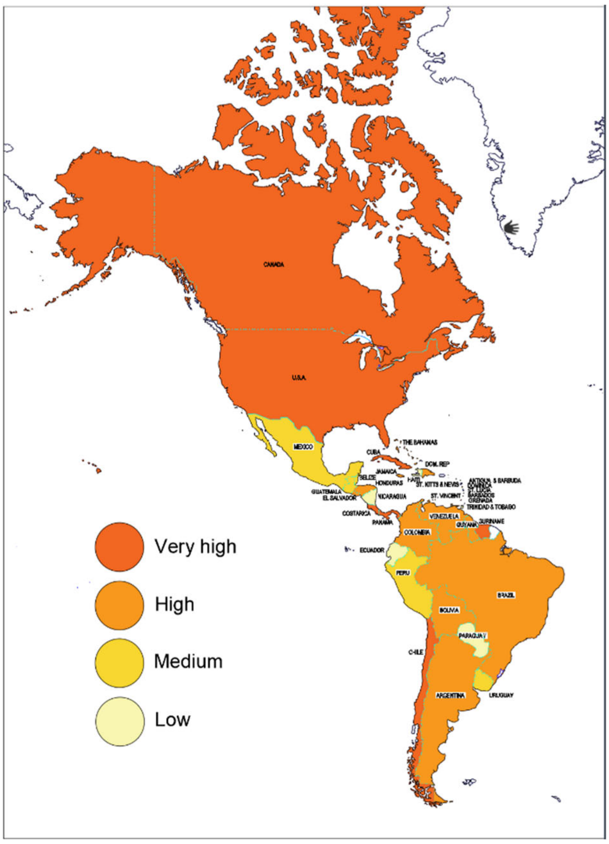


Figure 1. 2009 KNN grouping result

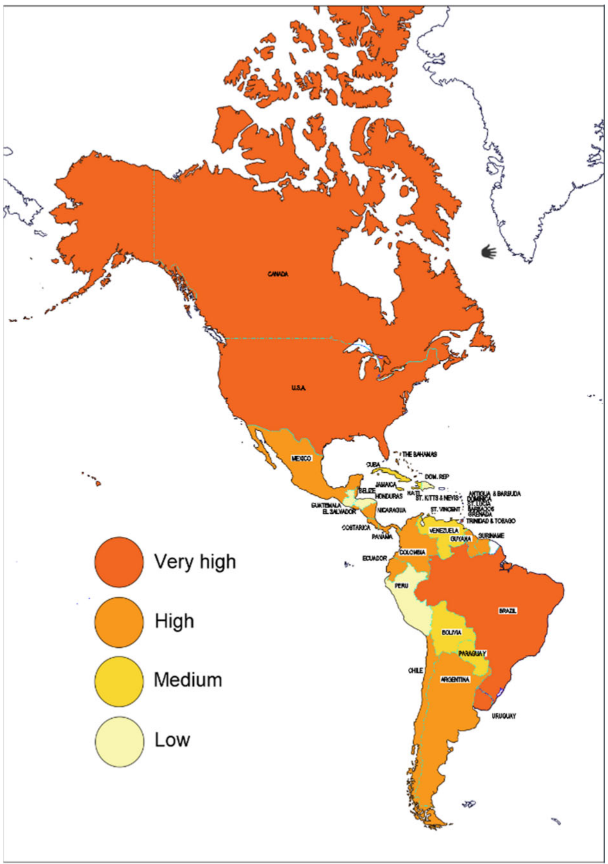


Figure 2. 2019 KNN grouping result

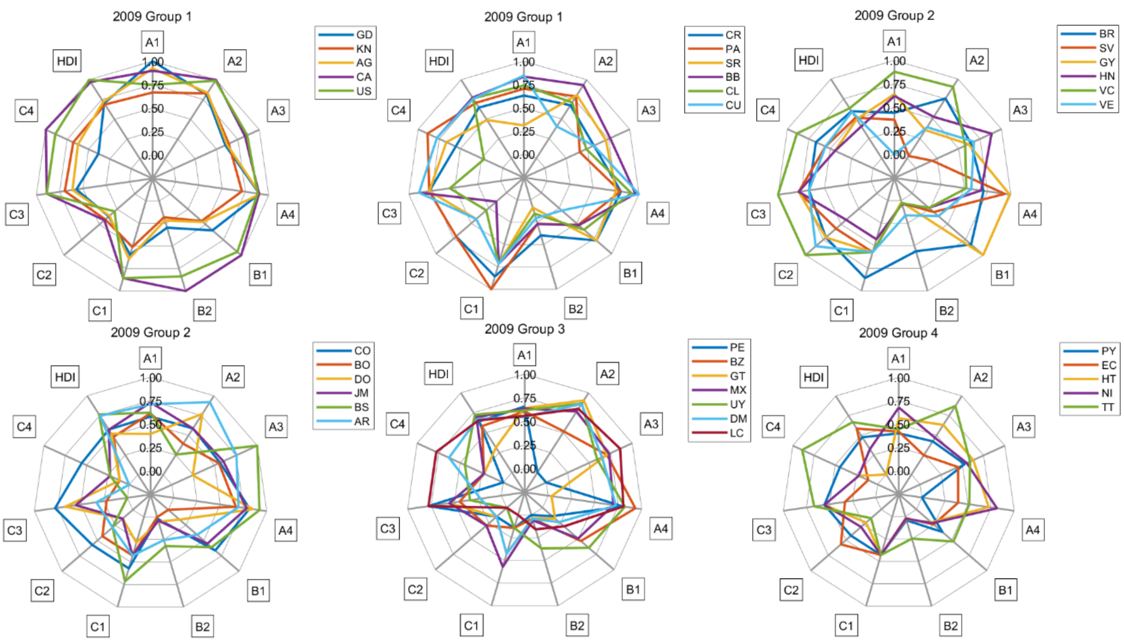


Figure 3. Radar Graph of each indicator for 2009 Groups

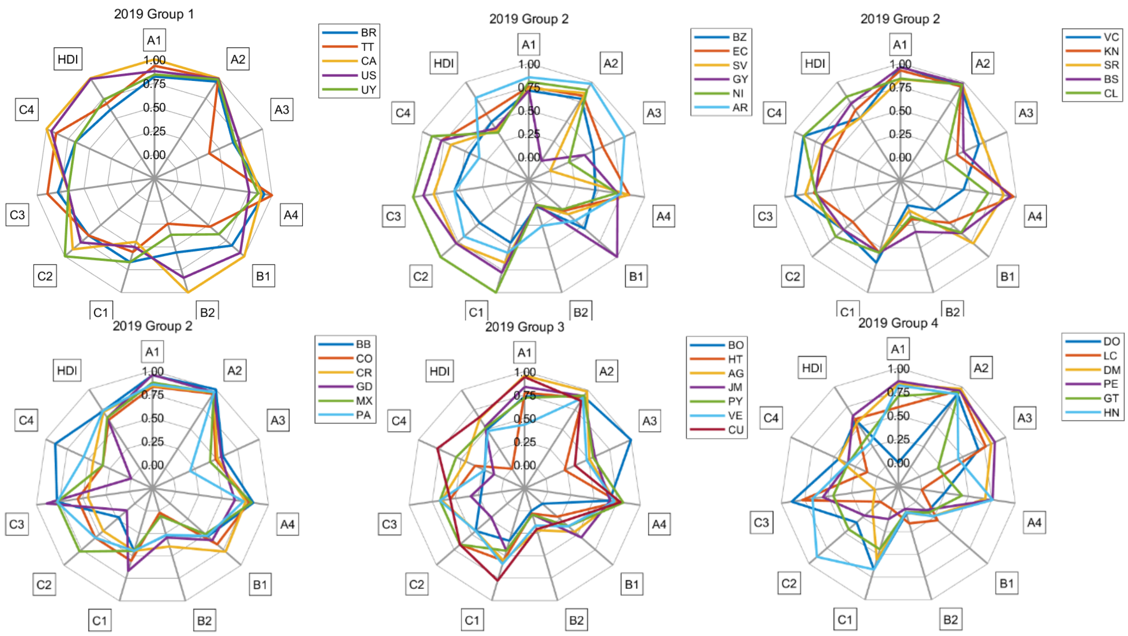
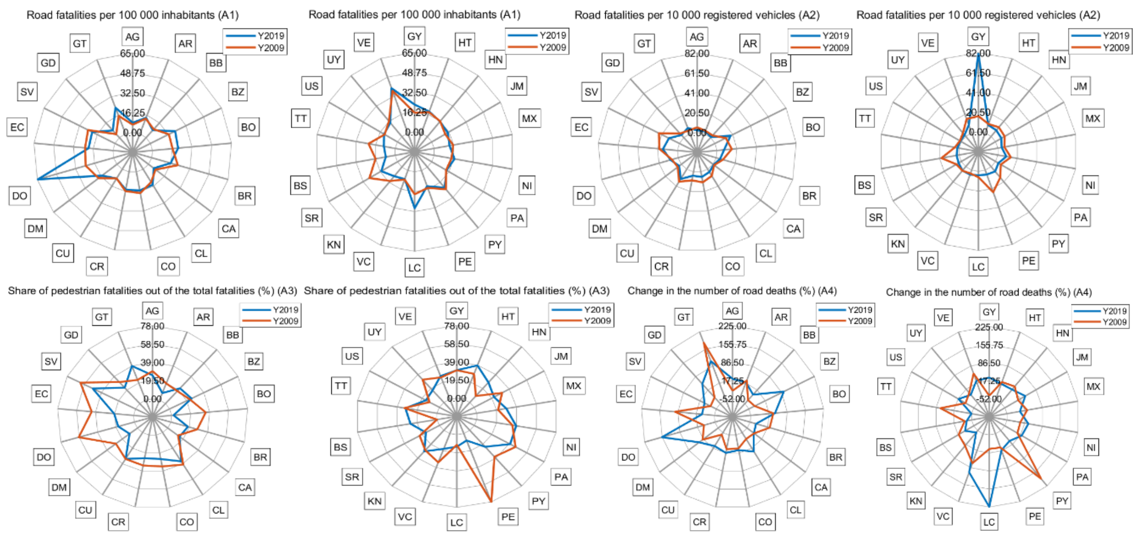
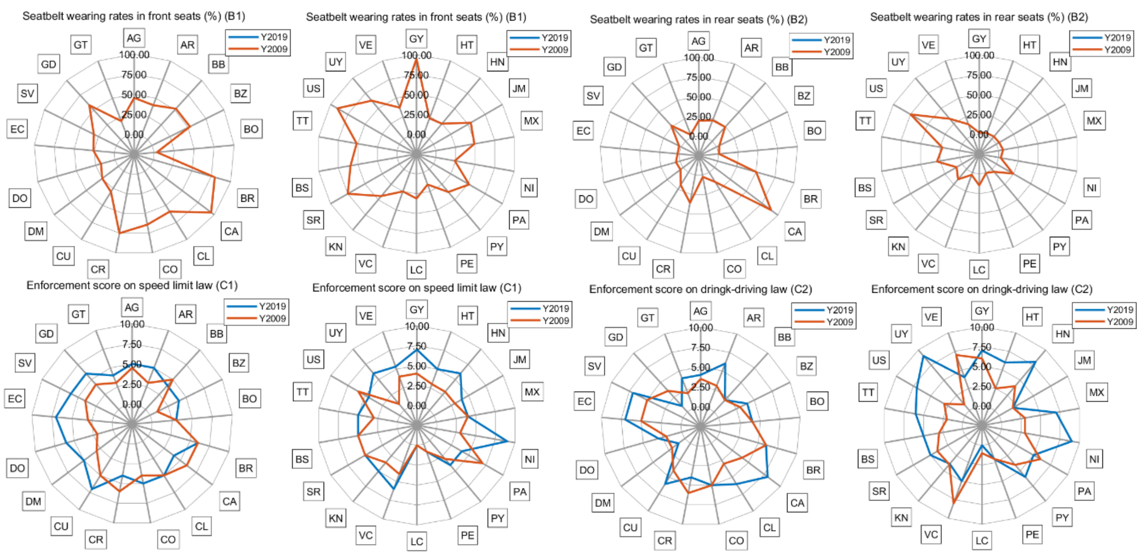


Figure 4. Radar Graph of each indicator for 2019 Groups

Non-beneficial indicators:



Beneficial indicators:



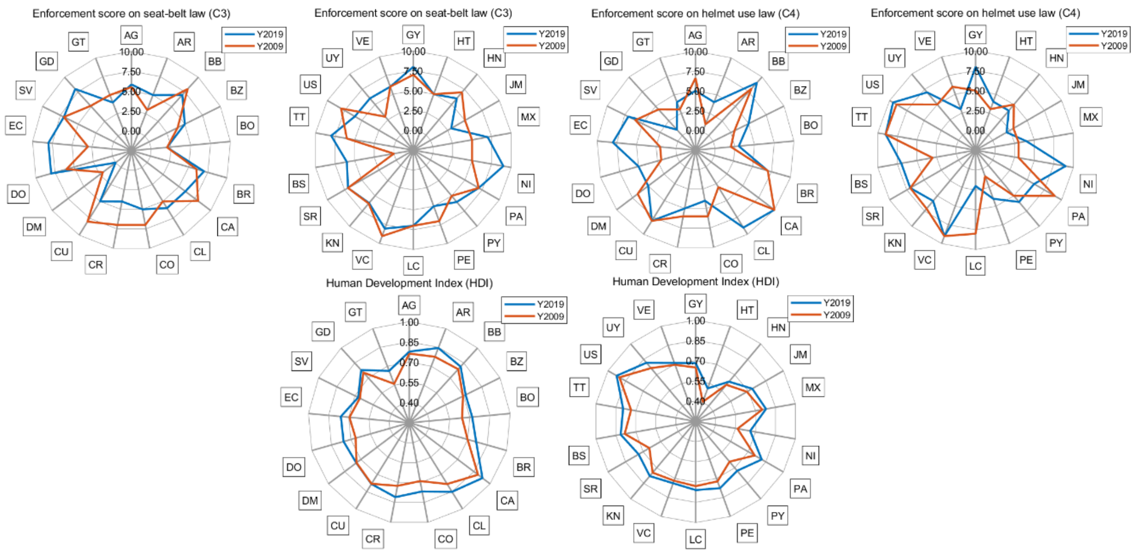
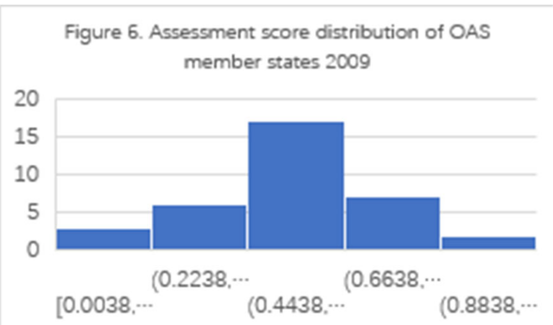


Figure 5. Radar Graph demonstrating trends in development of each indicator for OAS member states

6. Discussions

The evaluation of the overall road safety performance is achieved based on a ten year data from 2009 to 2019. Table 3, Table 4, and Table 5, shows the EDAS assessment score of road safety performance of the member states of OAS. From the results of EDAS assessment scores, in the year of 2009, Canada had the highest assessment score of 1.000, and Paraguay had the lowest assessment score of 0.0038; in the year of 2019, Canada still had the highest assessment score of 0.9915, and Saint Lucia had the lowest assessment score of 0.0620. It can be concluded that there exist a huge divergence in the overall road safety performance between the extremes. Furthermore, the assessment score of the OAS member states in 2009 has a standard deviation of 0.203, and the assessment score of the OAS member states in 2019 has a standard deviation of 0.201. Apparently, such a discrepancy in road safety performance exists not only between the extremes but also among the OAS members in 2009 and 2019 given the high standard deviation. These results are anticipated as other factors such as income level, HDI, literacy rates, and motorization level varied to a large extent among the OAS member states. These factors will inadvertently affect the overall road safety performance and public health condition of a nation. Meanwhile, the distribution of the assessment score in 2009 is approximately normal; whereas the distribution of the assessment score in 2019 is slightly right skewed, possibly meaning that more member states are underperforming according to the best performing states in 2019 (as shown in Figure 6 and Figure 7)



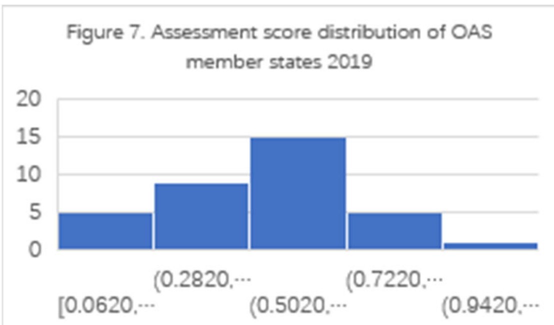


Figure 6,7. Assessment score distribution of OAS member states in 2009 and 2019.

According to the result of KNN grouping in Figure 1 and Figure 2, it can be concluded that in 2009, Costa Rica, Panama, Suriname, Barbados, Chile, Cuba, Grenada, St. Kitts and Nevis, Antigua and Barbuda, Canada, and the United States are the best-performing nations; Paraguay, Ecuador, Haiti, Nicaragua, and Trinidad and Tobago are the underperforming nations. In 2019, Brazil, Trinidad and Tobago, Canada, the United States, and Uruguay are the best-performing nations; Dominican, Saint Lucia, Dominica, Peru, Guatemala, and Honduras are the underperforming nations. Furthermore, the KNN group results made insight into improvement within each group. In 2019, the most recent year, the best-performing country in the very high group is Canada, with EDAS assessment score of 0.9951; the best-performing country in the high group is the Bahamas, with EDAS assessment score of 0.7308; the best-performing country in the medium group is Antigua and Barbuda, with EDAS assessment score of 0.5612; the best-performing country in the low group is Honduras, with EDAS score of 0.4870. Therefore, the member states in the very high group can refer to the road safety practices from Canada; the member states in the high group can refer to the road safety practices from the Bahamas; the member states in the medium group can refer to the road safety practices from Antigua and Barbuda; the member states in the low group can refer to the road safety practices from Honduras. Again, the member states in the same KNN group have more similar traits hence better to refer to each other for future road safety advances.

Next, radar graphs are created for each KNN group, and data for each indicator are standardized using min-max and put into those radar graphs. By analyzing the radar graphs and finding out the concaves for each graph, we can identify the indicators under performed by most nations relative to other indicators. As shown in Figure 3 and Figure 4: in 2009, group 1 had weakness in A3, B2, and C2 indicators; group 2 had weakness in A3, B2, and C4 indicators; group 3 had weakness in B2 and C2 indicators; group 4 had weakness in B2 indicator. In 2019, group 1 had weakness in A3 and C1 indicators; group 2 had weakness in A3, C4, and B2 indicators; group 3 had weakness in B2, and C4 indicators; group 4 had weakness in B1, B2, C2, and C4 indicators. Overall, in 2009 and 2019, indicators A3, B2, C2, and C4 appeared to be major challenges to the OAS member states compared to other indicators. The weakness of A3 indicator, which is the Share of pedestrian fatalities out of the total fatalities, highlighted the need for better protection for the more vulnerable road users. Solution to this issue include both environmental improvement and law enforcement, such as better road designs and more public education. The weakness of B2 indicator, which is the seat-belt wearing rate in rear seat, emphasized the requirement and better enforcement for seat-belt legislation not only in the front seat but also in the rear seat. Wearing a seat-belt reduce the risk of death among rear seats passengers by 25% [3]. Such a weakness is also anticipated since according to the PAHO Status of Road Safety in the Region of Americas, only 19 of the 29 countries in the region of Americas are aligned with the best criteria of requiring compulsory use of seat-belts among all car occupants [3]. The weakness in C2 and C4 indicator underscored the need for better enforcement on drink-driving and helmet use laws. Similarly, only 7 out of the 29 countries in the region align with the best criteria on helmet law; only 8 of the 29 countries in the region align with the best criteria for drink-driving law. The incorporation of random breath-testing for alcohol and requirement for helmet to be fastened and adhered are proper solution to those weaknesses. Similarly, looking for the bulges in the radar graph enabled us to identify the strength for OAS member states: in 2009, group 1 had strength in A1, A4, and C1 indicators; group 2 had strength in C3 and C2 indicators; group 3 had strength in A2, A3, A4, and C3 indicators; group 4 had strength in A1, A3, C1, and C3 indicators. In 2019, group 1 had strength in A1, A2, and A4 indicators; group 2 had strength in A1, A2, and A4 indicators; group 3 had strength in A1, A2, and A4 indicators; group 4 had strength in A2 indicator. Overall, most states performed well on A1, A2, A4, C1, and C3 indicators in 2009 and 2019. These results also give suggestions for improvements among groups. For example, the low group should follow the policies related to the strength indicators from medium group, high group, and very high group.

Meanwhile, radar graphs are also created for each indicator to demonstrates the continuity in development of individual OAS member state's road safety performance relative to other member states between 2009 and 2019. According to Figure 5, over the ten years from 2009 to 2019, 17 countries had improvements for A1 indicator; 29 countries had improvements for A2 indicator; 21 countries had improvements for A3 indicator; 13 countries had improvements for A4 indicator; 22

countries had improvements for C1 indicator; 21 countries had improvements for C2 indicator; 15 countries had improvements for C3 indicator; 18 countries had improvements for C4 indicator. As a result, A2 is the most improved indicator, and A4 is the least improved indicator. Moreover, a majority of the OAS member states showed improvement in A2, A3, C1, C2, and C4 indicators, while less than half of the member states showed improvement in A1, A4, and C3 indicators.

These results provide insight into the road safety advances over the ten years from 2009 to 2019. Moreover, in order for future advancement and development, the OAS member states should raise awareness for and put more efforts into controlling road fatalities (A1 and A4) and better enforcement on seat-belt wearing laws (C3).

7. Conclusions

Road traffic fatalities and injuries continue to be an essential public health issue presenting to the OAS member states. As previously mentioned, in the region of the Americas, there were approximately 154,089 road traffic fatalities in 2013 and 154,997 in 2016. The main objective of this study and modeling is to gauge the road safety advance and performance for the OAS member states. This study applied the IW-EDAS-KNN model to evaluate road safety performance and identify continuity in development in road safety conditions for the member states of OAS. The IW-EDAS-KNN model have three steps: weighing indicators using IW; assessing solutions using EDAS approach; group solutions using KNN Algorithm. This model is effective when handling a large data source, and give predictive results for grouping individual states.

The result of EDAS assessment score for the OAS member states on road safety performance suggests that there exists discrepancy in road safety performance between the extremes and among the member states. Meanwhile, the results from the KNN Algorithm identified the best-performing groups in 2009 (Costa Rica, Panama, Suriname, Barbados, Chile, Cuba, Grenada, St. Kitts and Nevis, Antigua and Barbuda, Canada, and the United States) and 2019 (Brazil, Trinidad and Tobago, Canada, the United States, and Uruguay), as well as the underperforming group in 2009 (Paraguay, Ecuador, Haiti, Nicaragua, and Trinidad and Tobago) and 2019 (Dominican, Saint Lucia, Dominica, Peru, Guatemala, and Honduras). The grouping results allowed suggesting for future improvements within the group. For instance, the underperforming individual states should follow the road safety strategies from the best performing individual states within the group.

After putting the standardized data into radar graphs for each KNN group, the major weakness of each individual or all of the KNN group can be identified. The result shows that indicators A3, B2, C2, and C4 appeared to be major challenges to the OAS member states compared to other indicators. Meanwhile, the major success in road safety performance can also be identified using the radar graphs: most states performed well on A1, A2, A4, C1, and C3 indicators in 2009 and 2019. The grouping results also allowed suggesting for future improvements among groups. For instance, the low group should follow the policies related to the strength indicators from medium group, high group, and very high group.

The other set of radar graphs, which demonstrates data for each indicator over the ten years from 2009 to 2019, highlighted the trend in advancement or deterioration of the OAS member states for each indicator. A majority of the OAS member states showed improvement in A2, A3, C1, C2, and C4 indicators, while less than half of the member states showed improvement in A1, A4, and C3 indicators.

One way to ensure a consistent future road safety advance is to raise awareness on the indicators that are underperformed by most nations or the indicators that demonstrate the least progression over the ten years. Meanwhile, underperforming states should re-evaluate their current road safety performance, and follow the practices from the best-performing states. At the same time, individual states can also refer to the best-performing states in their KNN group, and each KNN group, as a whole, can refer to the effective practices of road safety of a higher level group.

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