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Promoting Public Health and Safety: A Predictive Modeling Software Analysis on Perceived Road Fatality Contributory Factors

[1, 2] O.O. Oluwagbemi
[1]Department of Computer and information Sciences
College of Natural and Applied Sciences
Covenant University, Ogun State, Nigeria, West Africa.

[2]Johns Hopkins Bloomberg School of Public Health
Johns Hopkins University
Baltimore, MD 21205, USA.
E-mail: olu.oluwagbemi@covenantuniversity.edu.ng and ooluwagb@jhsph.edu

[1]Correspondence:
Tel: +2348066533717.

ABSTRACT
Extensive literature search was conducted to computationally analyze the relationship between key perceived road fatality factors and public health impacts, in terms of mortality and morbidity. Heterogeneous sources of data on road fatality 1970-2005 and that based on interview questionnaire on European road drivers' perception were sourced. Computational analysis was performed on these data using the Multilayer Perceptron model within the dtreg predictive modeling software. Driver factors had the highest relative significance. Drivers played significant role as causative agents of road accidents. A good degree of correlation was also observed when compared with results obtained by previous researchers. Sweden, UK, Finland, Denmark, Germany, France, Netherlands, and Austria, where road safety targets were set and EU targets adopted, experienced a faster and sharper reduction of road fatalities. However, Belgium, Ireland, Italy, Greece and Portugal experienced slow, but little reduction in cases of road fatalities. Spain experienced an increase in road fatalities possibly due to road fatalities enhancing factors. Estonia, Slovenia, Cyprus, Hungry, Czech Republic, Slovakia and Poland experienced a fluctuating but decreasing trend. Enforcement of road safety principles and regulations are needed to decrease the incidences of fatal accidents. Adoption of the EU target of -50% reductions of fatalities in all countries will help promote public health and safety.

Keywords- Fatality factors, public health, road fatality, road safety.

1. BACKGROUND

Road fatalities are currently one of the major problems of public health. It represents one of the major problems in many European countries associated with high rates of mortality. The impact of this menace ranges from mild to increasingly alarming and devastating consequences, which acts as potential threat to public health. Road fatalities incidence among European countries has been a major concern over the years due to perceived contributory and other causative factors [1-5].
One of the ways to effectively control road fatalities is to identify and control the key causative and perceived contributory factors.

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Despite concerted efforts by governmental agencies, public and private non-governmental health agencies to offer effective control measures to eradicate road fatalities, the problem still persists. Over the years, computational insights have been applied on developing control measures for road accidents and fatalities [6-9]. The aim of this survey was to conduct computational analysis on perceived road fatality causative factors among some European countries towards promoting public health. The objectives were to provide for better understanding of the importance of key classified underlying perceived road accident contributory factors in explaining the number of road fatalities at country level and to explain the impact of reducing fatalities and its effects on public health, based on survey results. This study explored the application of a computational approach towards classifying perceived road fatality contributory factors, based on available heterogeneous sources of data. The results presented in this research and the recommendations thereafter, were intended to facilitate the promotion of public health and safety among the countries studied.

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2. RELATED LITERATURE

Driving, as a complex process, requires physical, emotional, social, psychological skills and composure [13]. However, over the years, there have been incidences of road accidents and fatalities as a result of some contributory factors. In the research conducted by Brodie and colleagues [14], the causative factors for road injuries and fatalities were classified into environmental factors, driver factors, vehicle factors and occupational factors. In a tri-level US study of pre-crash factors, human errors were determined to be fully or partially responsible the definite cause of 92.6% of road crashes, while environmental factors accounted for 33.8% and vehicular factors were only responsible for about 12.8% of the crashes [15]. According to Treat, vehicular factors had the least due to poor vehicle maintenance by the drivers. Previous researches have estimated that in 95% of all traffic accidents, human or driver factors, either alone or in combination with other factors have significantly contributed to road accidents and fatalities [15-16].

Over the years, road traffic accidents have constituted a major problem to public health. Three major factors have mostly contributed to road accidents. These are: the human factors or driver factors, vehicular factors and the environmental factors. Over speeding accounted for 32.8%, dangerous driving accounted for 16.0%, and mechanical defects of vehicles (vehicular factors), accounted for 13.3% [17]. Death and injury from car accidents have been a most unpalatable experience [18]. However, such incidences are not without cause [19]. Contributory factors have their relevance in the cause of road fatalities [20]. Road fatalities have been attributed to both risk and exposure contributory factors [21]. These factors have played major role as infringement on public health. In the Victoria speed camera program [22], it was reported that three contributory factors were responsible for road fatalities namely; road conditions (environmental), vehicle performance, and road user behavior (driver behavior).

This section described studies on relative importance of the constituents of the major road fatality contributory factors earlier mentioned, and their corresponding impacts on public health [23][24][25][26][27]. One of the leading causes of road fatalities is driver factors. A major component of driver factor is speed. Over speeding is one of the major contributory factors to fatal crashes and fatalities [28][29], which has resulted in the deaths of many. Some literatures have revealed the negative impact of over speeding on public health [30][31][24]. Mehmood conducted a study on the impact of speeding behavior of drivers [32]. The evolution of top speed in the last twenty years and possible future policies were also enumerated in another study [33]. Evidence from evaluation studies revealed the relationship between speed, road safety and its corresponding impact on public health [34][35]. In Denmark, from 1968-2004, speed was identified as a major contributory factor to road fatalities [36].

Studies on individual data in Spain revealed that over-speeding and use of alcohol constitute a threat to public health [37][38]. Actual incidences of injury fatalities in France showed that excessive speed was one of the contributory factors [39]. Excessive speed has been a major contributory factor to the death and injury of many [40] in USA and the UK. Over-speeding was also noted as a major threat to public health in Sweden [41]. Among 15-17 European countries, excessive speed by drivers was identified as one of the major factors responsible for increased accident frequency and severity [42]. Other studies also revealed the effects of over-speeding on public health [17][43][44][45].

Second, health conditions and status of drivers have been a major concern to public health [46][47]. Use of alcohol and harmful drugs are among issues of concern among drivers. The negative impact and detrimental effects of psychoactive drug usage among drivers, in some countries of the world, cannot be underestimated. This has posed danger to public health by causing road fatalities. Several drugs have been known to interfere with a driver's ability to drive and subsequently increase the risk of road traffic injury. Alcohol is the most well studied of these [48][49]. Other psychoactive substances, including illicit and licit drugs, also increase the risk of road traffic injuries by affecting driver alertness, visual acuity, reaction time, judgment and the decision making of a driver [50][51] thus endangering public health.

Third, driver personality characteristics can have detrimental effects on public health. The role personality plays in traffic safety [52][53] cannot be ignored. Such characteristics include; impaired risk perception, hostility, aggressiveness, disinhibition, susceptibility to boredom and sensation seeking [54][55][56][57][58].

Fourth, distractions caused by cellular phone usage have become an apparent problem and most detrimental technological distractions to public health. In most cases, increased risk of road accidents is inevitable. This occurs because the act of talking on a cellular phone while driving is a dual-task [59][60]. Furthermore, drivers involved in such act, underestimate the level of distraction posed by such devices when they drive, thus undermining the likelihood of an accident to occur [61]. Finally, Driver inexperience has contributed to cases of road fatalities among European countries [62] [63][64][65][66][67][68][69][70]. Other studies also reveal that driver factors have been largely responsible for increase in road fatalities [71][72][73][74][75][76][48] [49][77][78][79][80][81][82][83][84][85][86][87][88][89][90].

Vehicular factors, a prominent contributory factor to road fatalities, have had negative effects on public health [91][92][93]. According to insight gained and categorization done from the works of Brodie and colleagues [14]. Vehicular factors are mostly defects or faults associated with vehicles driven by drivers. These include but are not limited to errors or defects within the engine, brakes, clutch, gear system, accelerator of the car, defects in the design of the air bag of the car, and other vehicular faults [14].

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Occupational-related fatal accidents are common occurrence over the years. Occupational factors play a prominent role in road fatality incidences [94] [95] and constitute great threat to public health. Truck driving was among the occupations with the highest risk for fatal injuries [96]. It was also observed world-wide that work related traffic crashes were the leading causes of occupational deaths. For instance, in the UK and New Zealand, work related traffic crashes were considered the single largest cause of occupational fatality [97]. Similar trend was applicable to Australia and France, with about 50% and 60% respectively [98][99]. In the USA and Canada, however, occupational traffic crashes made up 25% and 30% of work related deaths respectively [100][101]. The negative impact of environmental factors on public health and safety cannot be underestimated [102][103][104][105] [106][107][108][109][110]. An example of this is drivers' inability to see clearly oncoming vehicles at road intersections due to bad weather conditions [111][112].

Finally, research from in-depth accident investigations from the TRACE ((TRaffic Accident Causation in Europe) project depicted that factors responsible for road fatality were classified by categories and sub-categories into: Driver behavior, Driver state, Driver Experience, Road environment, Traffic condition and Vehicle [113].

3. MATERIAL AND METHODS

Data collection was obtained from and granted by permission and authorization by the International Road Federation (IRF). The first set of data, managed by the International Road Federation (IRF), came from reports of road accidents and fatalities from 1970 through 2005 from the European Road Statistics 2007 Report. The report was published at a government website (http://www.irfnet.eu/images/stat/2007/ERF_stats2007.pdf), and has been updated in a timely fashion. The author spent extended time mining and analyzing the data. The road accidents and fatalities data used, was over a 35-year period for twenty-one selected European countries for the purpose of this research. The second set of data came from survey reports reflecting the perceptions of European road users on contributory factors responsible for road fatalities.

The data was sourced from the results obtained from the face-to-face interviews conducted with fully licensed, active car drivers among 23 European countries based on representative national samples of not less than 1000 respondents for each country [10]. This was achieved by administering a questionnaire containing questions about rating 15 causes of road accidents, using a six-point ordinal scale as shown in Table 1. Permission to use the SARTRE data for our work was granted by INRETs (Institut National de recherché sur les transports et leur securite) in France. We extracted the data for 21 countries used in our study [11-12]. These data were analyzed by using the Multilayer perceptron model embedded within the dtreg neural network software.

3.1 Description of Survey Data

According to the SARTRE 3 reports, a multidimensional scaling was performed on the perception of European drivers concerning the causative factors of road accidents in all 23 European countries considered in their study [114]. Permap version 11.2a was used to assess the validity of the two-dimensional representation of the multidimensional data. Based on the results generated by the analysis performed by the SARTRE project, individual fit measure per country was generated as shown in Table 2 and the subject space for the 23 European countries was also produced as shown in Figure 1. However, for our study, only 21 European countries were considered.

Based on SARTRE 3 report, various perceived road fatality causative factors fell into different regions of the quadrants. The perceived causative factors in the SARTRE 3 report were re-classified into driver, vehicular, environmental and occupational factors in our study. The first quadrant represents region with "High perceived risk: Low perceived prevalence" of these perceived causative factors. The 2nd quadrant represents region with "High perceived risk; High perceived prevalence" of the perceived causative factors. The 3rd quadrant represents region with Low perceived risk: High perceived prevalence of the perceived causative factors. The 4th quadrant represents region with Low perceived risk: Low perceived prevalence of the perceived causative factors.

In our study, the individual space of each of the 21 European countries considered was used for analysis. A careful study was made on how dimensions 1 and dimensions 2 of the subject weight of each European country attributed either towards the risk dimension or the prevalence dimension. Based on the interpretation of the individual spaces of each country, the perceived accident cause in the individual space, with respect to risk dimension and prevalence dimension were extracted; the extracted results of the 21 European countries used for this study were rescaled for analysis. The rescaled interpretations over the years, for each country studied, were entered into the Exp Data5.csv data sheet accordingly. In summary, the process involved studying the individual spaces of each country with respect to their risk and prevalence dimensions. Comparison was then made with the perceived road fatality causative factors in their group space; then these were rescaled based on the distribution observed in the various quadrants and matched appropriately with the corresponding years for each country. The rescaled data was prepared in a format suitable for analysis.

4. DATA ANALYSIS

After extraction, the data were transformed into an Excel-format. The Excel-format file was later converted into a .csv extension file, suitable as input data into neural network software. An artificial neural network module within predictive modeling software was used for this analysis. The Multilayer perceptron architecture within the dtreg modeling software was applied on the road accident and fatalities data to classify various factors responsible for such incidents.

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The factors were obtained from relevant literatures. This was analyzed using the DTREG (version 10.0.0) Software. Dtreg software has been applied to other studies [115][116][117][118][119][120]. DTREG is an artificial neural network software. Artificial neural network have previously been applied towards road fatality, public health and safety research [121] [122][123][124][125][126][127][128]. In the experiment carried out using this neural network model, the following parameters were set as key parameters in predicting the outcome of the classification of the relevance of each accident enhancing factor. These were: environmental factors, occupational factors, vehicular factors and driver factors. The number of network layer used in building this model was three. We specified the neural network model to automatically optimize the hidden layer.

This helped to evaluate how well the selected number of neurons fit by using cross validation or a hold-out sample. Over fitting detection and prevention was also done by enabling this option. This allowed the Multilayer perceptron model to hold out a specified percentage of the training rows and used them to check for over fitting as model tuning is performed. The tuning process used the training data to search for optimal parameter values. The percentage (%) training row to hold out was 20%. Maximum steps without change was also 20. V-fold cross validation value was 10. The hidden layer activation function and output layer activation function was the Sigmoid (Logistic) activation function. Insight gained from the work of Brodie [14] was applied to regroup and categorize road fatality factors and its possible components.

5. RESULTS AND DISCUSSION

Data spanning 1970-2005, was used for this study. For the 21 European countries, it was observed that the neural network model was able to perform intelligent classification by classifying each road fatality contributory factor by relative significance values and presenting the most prominent of these factors. The results revealed driver factors had a relative significance of 100.000; vehicular factors, 86.620; occupational factors, 68.384 and environmental factors, 24.100 as shown in Figure 2. These results only reveal estimates of the contribution of each perceived road fatality causative factor to road fatality among the survey data of the 21 European countries.

Results revealed that drivers played significant role in the cause of road accidents. Driver attitudes have been largely responsible for high road fatality. Results also revealed that out of all the perceived road fatality contributory factors**,** driver factors had the highest significance value of 100.000 (See Figure 2). The implication of this is that driver factors have been the most prominent factor responsible for most road fatalities. This corroborates the fact that driver factors are the key contributory factors in road accidents and drivers themselves play a major role in the cause of road fatalities. Thus, the negative impact of driver factors on public health and safety cannot be underestimated. Unchecked driver factors can constitute potential danger to public health. Thus, uncontrolled driver factors, has the tendency of increasing casualty and mortality rate among road users.

When the result of our study was compared with the results of Treat and Taylors', [15]; [16], it was observed that they estimated that human or driver factors, either alone or in combination with other factors, have significantly contributed about 95% to road accidents and fatalities.vThe result of our study was also compared with SARTRE report [11][12]; driver factors have been attributed to be largely responsible for most road fatalities in the report. When we compared our results with the TRACE 2009 report [113], driver factors played major role in the cause of road fatalities, thus validating the results obtained in our present study.

Based on the computational analysis performed on the perception data of European drivers on road fatality contributory factors, vehicular factors had a high significance value. The implications of a high predicted value for vehicular factors, as a perceived factor responsible for road fatality on roads, cannot be underestimated. In comparison with the study earlier carried out by Treat [15]. Treat estimated that vehicular factors were responsible for some percentage of vehicular crashes and road fatalities. The reason he gave was due to poor vehicle maintenance by the drivers. Treat did not however consider in details the possible defects present in those manufactured cars, and its long-term impact on road safety and public health. Over the past thirty years, vehicular defects could have resulted in the injury or death of many drivers, car users and pedestrian alike, thus posing great danger to public health and safety.

The perceptions of European drivers as analyzed in this study showed that occupational factors have direct influence on driver behavior, thus affecting drivers' performance. Occupational factors have undisputable and undeniable negative impact on driver's health and public health at large. Occupational factors such as drivers' driving hours, stress due to employment arrangements, supervision related depression, work pressure, drivers' sleepiness and fatigue and other related occupational hazards [14] can negatively affect road safety and public health. In comparison with the study conducted by [15] Treat and Taylor, [16], they estimated that human or driver factors, either alone or in combination with other factors have significantly contributed about 95% to road accidents and fatalities.

Environmental factors constitute a menace to public health and safety. These include: bad weather conditions, bad road network, landscape problem, traffic congestion and poor road infrastructure responsible for road fatalities. From our result, environmental factor accounted for a relative importance of 24.100. In comparison with the work carried out by Treat, [15], environmental factors accounted for 33.8%. From Table 3, countries like Sweden, UK, Finland, Denmark, Germany, France, Netherlands, and Austria, where road safety targets were set and EU targets adopted, experienced a faster and sharper reduction of road fatalities over the years. However, other countries like Belgium, Ireland, Italy, Greece and Portugal experienced slow, but little reduction in cases of road fatalities because road safety targets were not set in such countries, although they have adopted the EU target. Spain, however, experienced an increase in road fatalities due to road fatalities enhancing factors.

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Between the years (2000-2005), the following countries experienced a fluctuating but decreasing trend in cases of road fatalities. They are: Estonia, Slovenia Cyprus, Hungry, Czech Republic, Slovakia and Poland. In most of these countries, road safety targets were set, thus the decreasing trend. Moreover, most of these countries have adopted the EU target -50% reduction of fatalities to 2012 [127; 128].

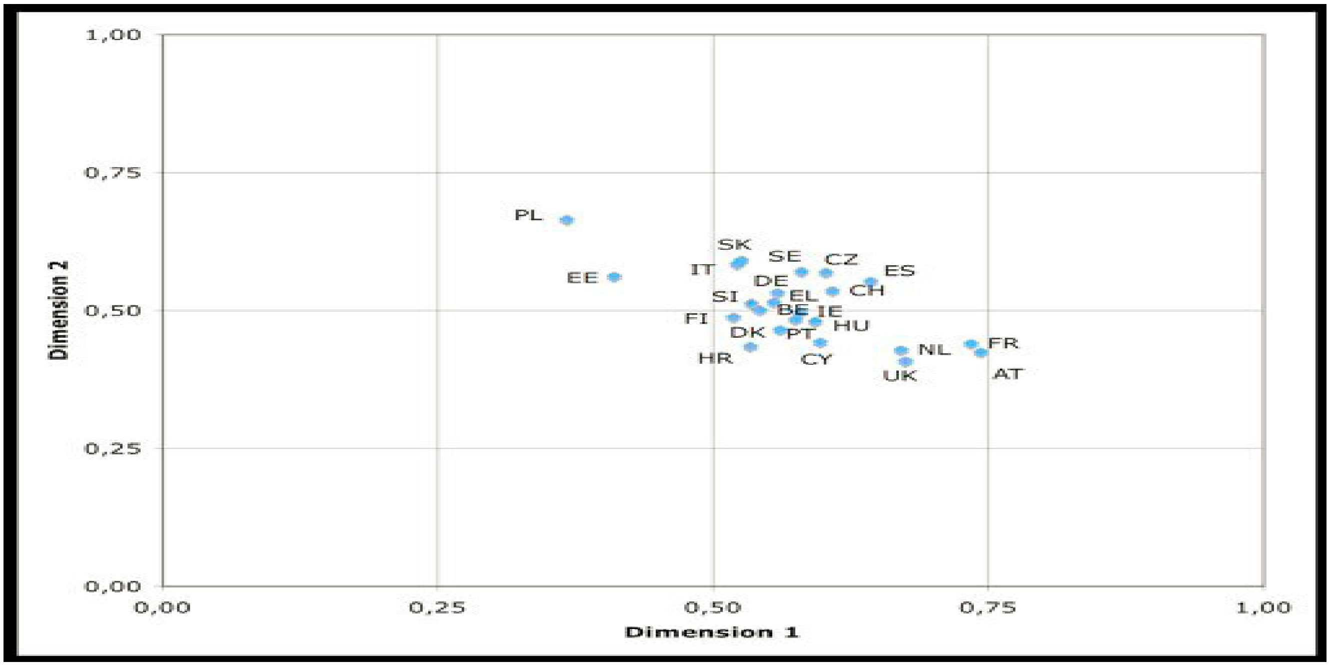

Figure 1: The subject space of the European countries.
Source: SARTRE 3 report (SARTRE, 2004) and (SARTRE, 2003)

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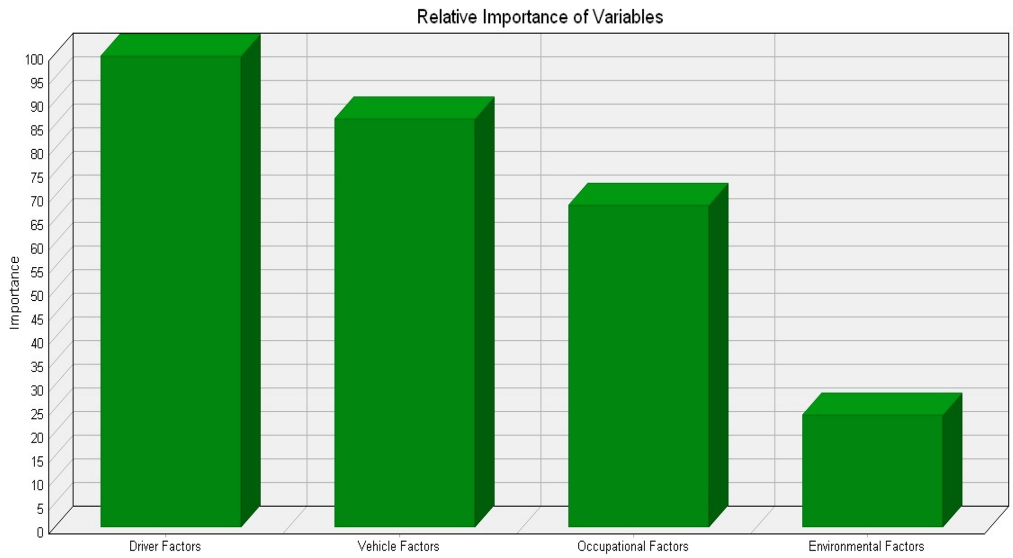

Figure 2: Results Of Predictive Modeling Software on the Classification of Different Perceived Road Fatality Contributory Factors

Table 1
The survey question, consisting of 15 items (a–o) to be rated on an ordinal six-point scale
How often do you think each of the following factors is the cause of road accidents?

(a)	Driving when tired	1	2	3	4	5	6
(b)	Drinking and driving	1	2	3	4	5	6
(c)	Following the vehicle in front too closely	1	2	3	4	5	6
(d)	Driving too fast	1	2	3	4	5	6
(e)	Taking medicines and driving	1	2	3	4	5	6
(f)	Taking drugs and driving	1	2	3	4	5	6
(g)	Poorly maintained roads	1	2	3	4	5	6
(h)	Using a mobile phone (hand-held) and driving	1	2	3	4	5	6
(i)	Using a mobile phone (hands-free) and driving	1	2	3	4	5	6
(j)	Traffic congestion	1	2	3	4	5	6
(k)	Bad weather conditions	1	2	3	4	5	6
(I)	Poor brakes	1	2	3	4	5	6
(m)	Bald tyres	1	2	3	4	5	6
(n)	Faulty lights	1	2	3	4	5	6
(o)	Defective steering	1	2	3	4	5	6

Source:(Vanlaar & Yannis, 2006; SARTRE, 2003; SARTRE, 2004)

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Table 2
Source: SARTRE 3 Report (SARTRE, 2004)

Country	Subject's weight		Explained Variance
	Dimension 1	Dimension 2	
Poland (PL)	0.36721	0.66588	0.58
Germany (DE)	0.55846	0.53328	0.60
Denmark (DK)	0.56067	0.46611	0.53
Austria	0.74331	0.42514	0.73
Belgium	0.54229	0.50164	0.55
Spain	0.64284	0.55395	0.72
Finland	0.51868	0.48877	0.51
France	0.73445	0.44067	0.73
United Kingdom	0.67478	0.40914	0.62
Greece	0.55548	0.51594	0.57
Ireland	0.57887	0.49813	0.58
Italy	0.52584	0.59196	0.63
Netherlands	0.67089	0.42925	0.63
Portugal	0.59289	0.48094	0.58
Sweden	0.57478	0.48477	0.57
Czech Rep.	0.60229	0.56993	0.69
Slovakia	0.52175	0.58496	0.61
Hungary	0.58013	0.57151	0.66
Slovenia	0.53463	0.51361	0.55
Estonia	0.40994	0.56251	0.48
Cyprus	0.59748	0.44326	0.55

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Data presentation

Table 3: Road Fatalities Statistical data from 1970-2005 for 21 European countries

Countries/Years	1970	1980	1990	2000	2001	2002	2003	2004	2005
Belgium (BE)	2950	2396	1976	1470	1486	1315	1353	1162	1089
Denmark (DK)	1208	690	634	498	431	463	432	369	331
Germany (DE)	21332	15050	11046	7503	6977	6842	6613	5842	5361
Greece (EL)	1099	1445	2050	2037	1880	1654	1605	1619	1614
Spain (ES)	5456	6522	9032	5777	5516	5347	5399	4741	4442
France (FR)	16448	13672	11215	8079	8160	7655	6058	5530	5339
Ireland (IR)	540	564	478	418	412	376	339	379	399
Italy (IT)	11004	9220	7137	6410	6682	6736	6015	5625	5426
Estonia (EE)	NA	NA	NA	204	199	224	164	170	168
Netherlands (NL)	3181	1997	1376	1082	993	987	1028	804	750
Austria (AT)	2507	2003	1558	976	958	956	931	878	768
Portugal (PT)	1842	2941	3017	1874	1671	1655	1546	1294	1247
Czech Rep. (CZ)	NA	NA	NA	1486	1334	1431	1447	1382	1286
Hungary (HU)	NA	NA	NA	1200	1239	1429	1326	1296	1278
United Kingdom (UK)	7770	6240	5402	3580	3598	3581	3658	3368	3336
Slovakia (SK)	NA	NA	NA	628	614	610	645	603	560
Poland (PL)	NA	NA	NA	6294	5534	5827	5640	5712	5444
Sweden (SE)	1307	848	772	591	583	560	529	480	440
Slovenia (SI)	NA	NA	NA	313	278	269	242	274	258
Cyprus (CY)	NA	NA	NA	111	98	94	97	117	102
Finland (FI)	1055	551	649	396	433	415	379	379	371

Source: http://www.erf.be, sourced on the 18th of February, 2008
Source: International Road Federation - Brussels Programme Centre

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6. RECOMMENDATIONS

Adoption of the EU target of -50% reduction of fatalities setting 2012 as a target [127, 128], will help promote public health and safety. Enforcement of road safety principles will help achieve a reduction of road fatalities. Thus, enforcement of road safety regulations is needed to decrease the incidences of fatal accidents, which will ultimately promote public safety.

7. CONCLUSION

The occurrence of road fatalities has been associated with perceived risk factors from four major perspectives such as driver factors, vehicular factors, occupational and environmental factors.

APPENDICES

Our study was able to justify that driver factors represents the most perceived and prominent road fatality contributory factor, among the countries surveyed. Addressing these perceived factors will help promote public health and safety. Future work can be directed towards investigating in details, the predicted impact of each perceived factor on road fatalities, validating the predicted impact of control measures on road fatalities and their corresponding effects on public health, based on insight obtained from other works [129].

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Author's Brief

Dr. Olugbenga Oluwagbemi is a lecturer and researcher in the Department of Computer and Information Sciences of Covenant University, Nigeria. He holds a PhD degree in Computer Science. He is a member of the ACM (Association of Computing Machinery) and the ISCB (International Society for Computational Biology).