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A TREE MODEL TO SPOT THE PRINCIPAL RISK FACTORS FOR MINOR AUTOMOBILE PENAL DAMAGES

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ABSTRACT

Minor penal damages can reduce car fairness and attract some costs to have them repaired. This study measured the types of car panel dents (cpd), possible risk factors and developed a tree model to recognize the most important factors. The study included 70 automobile panel repair workstations in Abeokuta, Southwest Nigeria, where variables were measured from 70 car panel technicians (cpt), 140 private car drivers (pcd) and 140 commercials car drivers (ccd). Variables with no significant association ($p \leq 0.05$) to cpd-risk ratings were eliminated. The tree model was developed and implemented on SPSS package. The prediction strength was ascertained from the risk estimate and classification information generated. Creased dent was the highest (60%) type reported by cpt. Car users identified influences of bicycles/motorbike (61%) and minor auto collisions (mac) (52%) as the highest risk factors among others. The model recognized five 'mac', 'bicycles/motorbikes', children manhandling', 'inexperience driving' and 'rough driving' as the most important. With the risk estimate of 0.168 (Std. Error = 0.024), the risks predicted could only be wrong for 16.8%. Car users' safety trainings, right packing locations and control of motorbikes/bicycles on public roads were recommended, among others, as measures to minimize cpd risks.

1. INTRODUCTION

Car body panel is the exterior surface of an automobile between a rear door and the boot and typically wraps around the wheel well. The body panel serves as a covering and a protection against the elements that may

damage car's frame. Repairs of minor or major car dents require the services of an experienced technician, popularly known as panel beaters. A car panel technician (*cpt*) is a person who specializes in vehicle body repairs when a car sustains a major or minor accident. The job of a *cpt* include: removing, repairing and replacing damaged panels on any vehicle, making or forming panels to replaced damaged ones, filing, grinding and sanding the body of a vehicle to restore a smooth vehicle surface, re-fitting body hardware such as door locks, realigning chassis and body frames, removing and replacing a vehicle's auto-electric components if damaged and repair dents on a damaged vehicle (Sheen Group, 2016).

Dent or gouge (minor body damage) can happen to a car and may occur all the time. Car dents may include: cracked windshield, dented bumper, deep paint scratches, suspension damage, rear end damage (Gina, 2016). They are common and are frequent as result of a variety of accidental bumps from foreign objects, other vehicles, and the elements. Peterborough (2015) mentioned the following as leading causes of car dents- car doors (crowded parking lots or parking garages), shopping trollies (misplaced shopping trollies may bump into the sides of vehicles), hail (unpredictable natural elements), recreational sports (neighbourhood games e.g. football), car wash (accidental bumps while on the conveyer), low speed fender bender (minor collision at a slow speed). Dent may cause door dings, bumper scrapes and scratches to panel among others which may require the service of *cpt* and will attract some costs (Matthew, 2017). According to Autos.com (2013), depending upon the specialist's skill and reputation, repairs of car dent may cost from $50 to $120 for a 1-inch dent. The price will increase with the size of the repair of about $10 to $30 for every additional half-inch.

Increased awareness of the principal causes of car dents and the risk factor, most especially in the study domain is the most effective method of prevention. Many techniques were used by different researchers to identify and estimate risks/hazards. Decision tree is one of such techniques which has been widely used to model and assess one risk or another ranging from transportation, physical work activities, health, business and many more (Baumont et al., 2000; Kingman and Field, 2005; Khakzad et al., 2011; Paul, 2012).

A decision tree is a nonlinear discrimination method, which can split a sample into progressively smaller subgroups. The technique of decision tree is simple and a powerful method of representing human knowledge (Milovic and Miloviv, 2012). Decision tree methodology is a commonly used data mining method for establishing classification systems based on multiple covariates or for developing prediction algorithms for a target variable. The procedure selects the independent variable that has the strongest association with the dependent variable. It classifies a population into branch-like segments that construct an inverted tree with a root node, internal nodes, and leaf nodes (Ture et al., 2007; Song and Lu, 2015). A root node (a decision node) represents a choice that will result in the subdivision of all records into two or more mutually exclusive subsets. Internal nodes (chance nodes) represent one of the possible choices available at that point in the tree structure; the top edge of the node is connected to its parent node and the bottom edge is connected to its child nodes or leaf nodes. Leaf nodes (end nodes) represent the final result of a combination of decisions or events (Kingman and Field, 2005; Baumont, 2000; Khakzad, 2011).

In this study, decision tree was considered for prioritization of various risk factors in assessing the risks level associated with the focal problem, car dents risk. The objectives were to assess various types of automobile panel dents (cpd), prevalence of cpd in the study domain, possible risk factors and developed a tree model to recognize the most important out of all the potential factors.

2. MATERIALS AND METHODS

2.1. Data Collection

Seventy automobile panel repair work stations involving 70 cpt were interviewed on the various categories of dents repaired. This was done with the use of a set of questionnaires. Information about different car dents descriptions and types were made available for the subjects to identify.

Two hundred and eighty (280) car users (140 private and 140 commercials) were interviewed while their cars were observed for dent type. The category of dents on the car were noted by the assessor using observation method while the car handlers were interviewed. Information related to frequency of car dents and their causes were contained in the questionnaire. The contents include, among others: the general information about the subjects' years of car ownership/driving/panel repair, frequency of car dent, causes of the reported dent, areas of the vehicle affected, level of damages, cost of repairs among others. Respondents were asked to respond to the car dent related causal factors/questions variables on a five scale points (5 = very high contributor, 4= high contributor, 3= contributor, 2=low contributor, 1= very low contributor). Car dent risk on a five scale points (5=very high risk, 4=high risk, 3= medium risk, 2= low risk and 1= very low risk. The interviews were conducted at the panel repair shops, gas filling stations and car parks. An average of 10 minutes was spent with the car owners/drivers while 15 minutes was spent with the panel technicians.

2.2. Development of Tree Model

2.2.1. Determination of causal variables

Primary variables were collected among the subjects and collated by three ergonomics professionals drawn from academic environment. These were used to build a decision tree model that could divide the risk factors into "high risk" and "very high risk" groups. Because the main application of the decision tree model was designed to screen 'high' and 'very high' risk subjects, we relatively reduced the screening number in low-risk and very low risk subjects. The suspected variables were filtered and those variables that had no association significantly ($p \leq 0.05$) to 'car-dent' risk ratings (dependent variable) were removed using Chi-Squared analysis.

2.2.2. Growing decision tree

The details of the subjects' responses (dependent and the independent variables) were inputted into Statistical Package for the Social Sciences (SPSS) software (SPSS, 2009) where the decision tree model was implemented. The vertices of a decision tree denote branch points. It sorts instances according to the attribute values, each attribute in an instance to be classified represents a node, and each branch represents a value that the node can predict. Instances are classified starting from the root node and following the argument down based on their attribute values until it reaches the final node (Olivas, 2007; Milovic and Miloviv, 2012). A classification decision trees type with Chi-squared Automatic Inter-action Detector (CHAID) method was used in this study. CHAID software, available through SPSS was engaged to assess the statistical significance of the bivariate association between each of the collated risk factors and the outcome measure – 'car dent' risk until the most statistically significant value was identified. At the selection of a risk factor, the sample was divided according to the values of the risk factor. This selection procedure was then repeated for each of the sample partitions to further partition the sample. The result of the partitioning process was to identify subgroups of cases sharing risk factor attributes that also exhibited high and/or very high levels of homogeneity with regard to the outcome measure, car dent risk. A number of decisions was made in other to execute the CHAID algorithm. These include;

the setting of end-node splitting criteria, tree depth and level of significance required for a partitioning variable to be selected.

2.2.3. Model estimation

The prediction strength of the model was ascertained (from the risk estimate and classification information generated) by the percentages of cases predicted correctly and the level of risk estimate.

2.3. Data Analysis

Descriptive statistics was used to present frequencies of the processed data. One-way analysis of variance (ANOVA) was used to determine whether there were statistically significant differences between the means of subjects' responses to car-dent risk factors. The Tukey Honest Significance Difference (HSD) test generally described as the preferred method for conducting post hoc tests on a one-way ANOVA was used to ascertain the specific groups that differed.

3. RESULTS AND DISCUSSION

3.1. Responses on Car Dents

3.1.1. Types and prevalence of car dents

Among the various types of dents common to car as shown in Figure 1, 60% of the 140 subjects assessed were affected with cross/creased dent. This was followed by sharp dents (54%). Others include multipoint dents (32.8%) and extreme dent (30%), rust (17.2%) and round dent (16%).

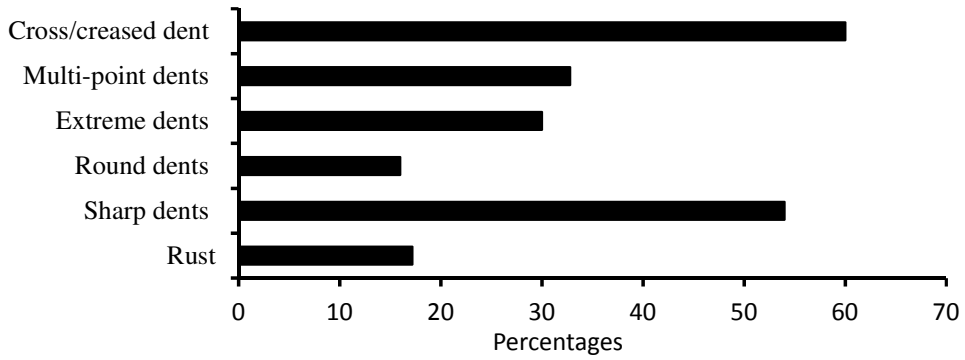

Figure 1: Types of dents and prevalence common to vehicles

3.1.2. Causes of car dents

As shown in Figure 2, car owners/drivers reported 12 factors that usually caused car dents. These included bicycles/motor bike (61%), minor auto collision (52%), in experienced drivers (50%), rough driving (41.2%), parking under dangerous objects (25.6%). Others were children manhandling (25.2%), bumping into car doors (20.4%), riot or public disorder (12.8%) and playing recreational sports near vehicles (11.2%).

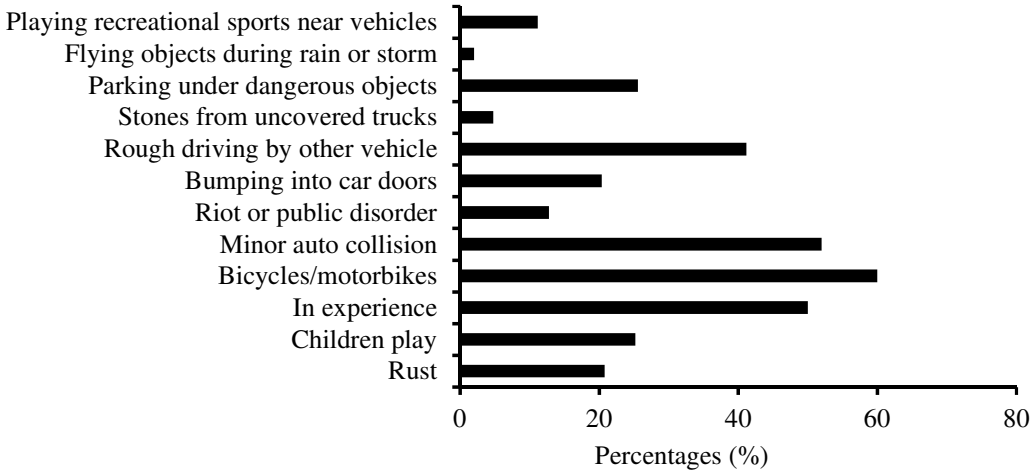

Figure 2: Reported causes of various types of car dents

3.1.3. Frequencies of car dents' repairs

From Figure 3, 54% of all private vehicles assessed had visited technician for dent repairs in more than 2 times in the last one year, 32% fixed their car panel between 2 to 5 times. Only 5% however reported not to have repaired dents in the past one year. About 50% of commercial vehicles mentioned to have repaired dents between 2 to 5 times, 26% visited panel technicians in less than 2 times, 20% between 6 to 10 times.

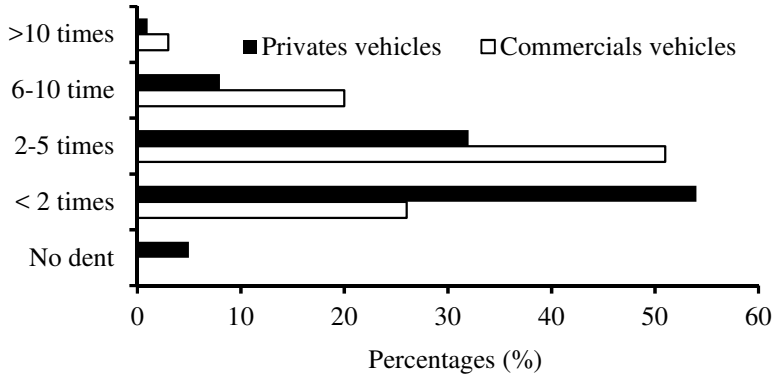

Figure 3: Reported frequency of car dents that required some repairs

3.2. Model for Recognizing Important Risk Factors

3.2.1. Identified attributes factors

Table 1 shows the attributes identified by assessors and the ones reported by *cpt*, car private owners and commercial drivers, as contributed to dents suffered by their cars. These attributes were sub divided into six factors: road conditions, road users, unforeseen situations, packing related, drivers' errors and miscellaneous. Twenty-one (21) attributes were reported as shown in Table 1.

Table 1: Mean ratings of identified attributes capable of influencing car panel dent risk

Codes	Car Dents' Risk Factors (cdrf)	Mean Scores
	A. Road Conditions	
Cdrf-1	Road garbage	1.748±0.55
Cdrf-2	Bad road	3.300±0.73
	Road users	
Cdrf-3	Motorcyclist	4.68±0.23
Cdrf-4	Trucks	1.45±0.50
Cdrf-5	Riot or public disorder	2.12±0.74
	B. Unforeseen factors	
Cdrf-6	Minor auto collision at low speed	4.74±0.67
Cdrf-7	Natural elements like sleet	1.85±0.63
Cdrf-8	Car theft	2.54±0.67
Cdrf-9	Flying objects during rain or storm	1.95±0.60
Cdrf-10	Rust	1.48±0.50
	C. Packing factors	
Cdrf-11	Playing recreational sports near vehicles	3.27±0.68
Cdrf-12	Busy parking lots	3.31±0.70
Cdrf-13	Bumping into car doors	2.60±0.55
Cdrf-14	Children car manhandlings	4.67±0.68
Cdrf-15	Parking under dangerous objects	3.2±0.68
Cdrf-16	Animals rub against car panel	1.79±0.50
	D. Drivers' errors	
Cdrf-17	Rough driving	4.64±0.69
Cdrf-18	In experience motorists	4.736±0.60
Cdrf-19	Opening doors into poles (e.g at gas stations)	1.93±0.56
	Miscellaneous	
Cdrf-20	Manhandling at repair workshops	1.66±0.66
Cdrf-21	Stickers or decals	1.64±0.58

3.2.2. Decision tree model

Figure 4 is a decision tree model implemented on SPSS platform for recognition of factors' contributing to car dent risk. The tree is displayed top down with the root node at the top. Because the model contained categorical dependent variables, the tree tables display frequency counts and percentages. Node definitions display the value(s) of the independent variable used at each node split. The tree diagram shows that using CHAID method, '*minor auto collision'* was the highest contributor to car dent risk. The next best attribute was the influence of 'm*otorcyclist'* with about 83% in the very high category. The model also included more contributors like, *children manhandling, 'inexperience driving'* and '*rough driving'*. The tree model may not be a complete simple one since it has 12 nodes and 7 terminal nodes. This is good for a reliable model that can function in a practical procedure where many independent (predictor) variables may be desired than a simple model where less numbers of predictors are appreciated for easy descriptions. This model does not pose any problem since five independent variables, 'minor auto collision', 'children manhandling', 'm*otorcyclist*', 'in experience driving', 'rough driving' are included in the final model. It was reported that accidents due to motorcycles riding increased every year and in most of the accidents that occur, motorcyclist took the lion cause. One of the reasons identified was that motorcyclists do not follow lay down traffic rules (FRSC, 2007; Oluwadiyaa et al., 2009). A minor accident that results into car dent may lead motorcyclist come off worse than the car driver. This might be one of the reasons why the model developed in this study identified motorist as the second highest contributor to car dent risk, forming one of the chanced nodes of the model. A bicycle rider may smash into a car and get it dented. Bumper can be damaged, deep scratches of body panel may also result. One of the ways to weaken the risk factors is to control the activities of motorist. Using motorbike as means of transportation should be restricted to some

selected routes if it cannot be completely eliminated. Car owners/drivers should also be fully aware of how to relate with the risk factor (motorcyclist) to prevent their influence on their cars. Competing with the motorcyclist on road should be avoided.

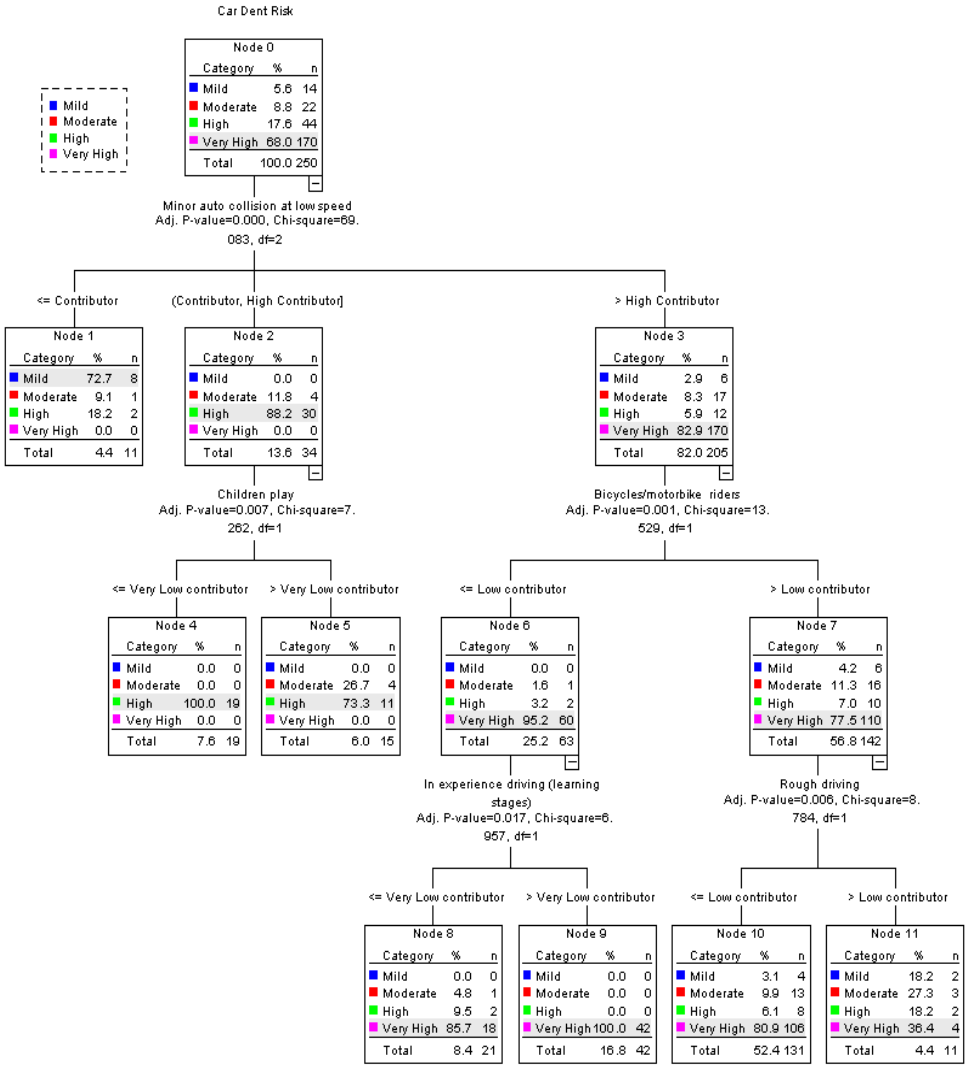

Figure 4: The tree model for recognizing important risk factors leading to car's panel dents

The model also identified children manhandling of car body panel among the principal risk factors. Children are fond of playing with any object available. When cars are packed around a house, it should be at a secured place. Children may be playing tennis, football or throwing objects. A shot of any of these, the handlebars or pedal of children bicycles, may cause dent to the car parked at unsecured place. It is also common among children to scratch car body with sharp or pointed objects. The car paintwork may be battered resulting into dents. Such dent may be hard to ignore. Packing in a garage where children cannot access is one way to secure a car from children. However, where there is no provision for such facility, use of car cover may be helpful. Children can also be well informed of the reasons to keep off the asset.

Agbonkhese et al. (2013) reported that the majority of Nigerian drivers do not possess the right authorization to drive and many are unqualified before driving cars on road pavements. Their decision-making ability and reaction speed to traffic is bad. Inexperience motorist or those popularly called learner, are seen as big risk for car dents. It is one factor identified by the model among the principal. Private car owners that newly acquire a vehicle should acquire full driving skills before getting on public roads. While this is ongoing, minimum possible driving speed should be adhered to. However, skilful motorist should be careful when learners compete with them. Adequate distance should be ensured when this group of road users are followed. Relevant road control agencies should equally ensure adequate driving training for all road users before they are fully authorized to drive on roads.

Recklessness, spotted among the strongest risk factors by the model, may move a motorist to drive his vehicle in a way that disregards the driving rules on public roads. This includes among others, speeding, careless overtaking, unsafe lane changes, failure to signal, lack of yielding to road signs, driving too fast for personal reasons. Drunk driving may be a common cause for reckless driving as deaths from recklessness are the third leading cause of death in Nigeria roads. There is every possibility to incur or cause one level of accident or another to other motorist causing car dents. In many cases reckless driving resulted into either minor or major accidents. Enhanced traffic regulations should be considered at making road users follow traffic rules.

3.3. Evaluation of the Model Quality

3.3.1. Risk and the classification of the model

'High' and 'Very high' were the selected categories of primary interest in the development of the model. The model identified those factors most likely to pose 'high' and/or 'very high' risk of car dents, hence were decided as the target category. The model risk and the model classification shown in Tables 2 and 3 provided a quick evaluation of how well the model works. With the risk estimate of 0.168 (Std. Error = 0.024) obtained from the quality test conducted for the model the 'high' or 'very high' risks predicted by the model could only be wrong for 16.8% of all the cases. So, the "risk" of misclassifying a factor was approximately 17%. The results in Table 3 are noted consistent with the risk estimate. Table 3 shows that the model classified approximately 14% correctly as 'high' risk for car dents and 82.0% as 'very high' risk. However, on the overall, it classified 83.2% of the risk correctly.

Table 2: The model risk table

Estimate	Std. Error
0.168	0.024

Growing Method: CHAID, Dependent variables: risk of car dent

Table 3: The model classification table

Observed	High	Very High	Percent Correct
High	30	12	68.2%
Very High	0	170	100.0%
Overall Percentage	13.6%	82.0%	83.2%

3.3.2. Statistical significance tests

The results shown in Table 4 provided statistically significant evidence that the means of factors for car dent are not the same for all the groups (One-way ANOVA, $F = 223.549$, $df = 7$, $P < 0.001$). The table explored where the differences between the factors groups are found with Tukey HSD post hoc tests.

Table 4: Means for groups in homogeneous subsets.

Car Dents' Risk Factors	Subset for alpha = 0.05	
	1	2
Play recreation	3.2720	
Bad roads	3.3000	
Busy parking	3.3100	
Motorcyclist		4.6266
Rough driving		4.6400
Children play		4.6718
Inexperience driver		4.7360
Auto collision		4.7400
Sig.	0.912	0.412

Table 4 compared the factors groups, two at a time. The factors groups are listed in order according to their mean value for the dependent variable. The 'Play recreation' factor is indicated first because it has the lowest mean value and the 'auto collision' group is shown last since it has the highest mean factor. The arrangement of the mean values in columns or subsets show which age groups differ/do not differ significantly in terms of their mean contributor factor to car dent. The means for two groups shown in different columns indicated that there is statistically significant evidence of a difference between their mean values.

4. CONCLUSION

This study measured the types of car panel dents (*cpd)*, possible risk factors for car dents and developed a decision tree model to recognise the most important *cpd* risk factors. From the outcome of the study, creased dent type was the highest reported by car panel technician. This was followed by sharp dents, multipoint dents and extreme dent. In descending order, car users identified influences of motorcyclist, minor auto collisions, in experienced drivers, reckless driving and wrong parking as the main risk factors among others. A decision tree model was developed from multiple collated attributes. The prediction quality of the model was verified to be robust. The model recognized; '*minor auto collision'*, '*motorcyclist', children manhandling', 'inexperience driving'* and '*reckless driving'* as the main factors. Car users' safety trainings, packing in safe locations and control of motorcyclist on public roads among others, were recommended by the authors as measures to minimize *cpd* risks.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Agbonkhese, O., Yisa, G.L., Agbonkhese, E.G., Akanbi, D.O., Aka, E.O. and Mondigha, E.B. (2013). Road Traffic Accidents in Nigeria: Causes and Preventive Measures. *Civil and Environmental Research*, 3(13), pp. 80-99

Autos.com (2013). Average cost to fix a car dent. Available from http://www.autos.com/auto-repair/average-cost-to-fix-a-car-dent

Baumont, G., Ménage, F., Schneiter, J.R., Spurgin, A. and Vogel, A. (2000). Quantifying human and organizational factors in accident management using decision trees: the HORAAM method. *Reliability Engineering and System Safety*, 70(2), pp. 113-124.

FRSC, (2007). An article on FRSC Establishment Act. www.frsc.gov.ng . Dec. 15, 2007

Gina, P. (2016). Essential car insurance for auto body repairs. Available from

https://www.insurance.com/auto-insurance/coverage/insurance-for-auto-body-repairs.html

Khakzad, N., Khan, F., and Amyotte, P. (2011). Safety analysis in process facilities: Comparison of fault tree and Bayesian network approaches. *Reliability Engineering and System Safety*, 96(8), pp. 925-932.

Kingman, D.M. and Field, W.E. (2005). Using fault tree analysis to identify contributing factors to engulfment in flowing grain in on-farm grain bins. *Journal of Agricultural Health and Safety*, 11(4), pp. 395-405.

Matthew, W. (2017). How to Repair a Dent in Your Car with Filler. Available from https://www.thoughtco.com/auto-body-dent-repair-281389

Milovic, B. and Miloviv, M. (2012). Prediction and decision making in health care using data mining. *Arabian Journal of Business and Management Review*, 1 (12), pp. 126-136

Olivas, R. (2007). Decision Trees: A primer for decision-making professionals. Available from www.lumenaut.com

Oluwadiyaa, K.K., Adegbehingbe, O.O., Olasinde, A.A. Olaide, A. G. and Godirina S.C. (2009). Motorcycle crash characteristics in Nigeria: Implication for control. *Accident Analysis & Prevention*, 41(2), pp. 294-298

Paul, P., Ellen, D., Mick, H., Xianglu, H. Marjoke, H. and Marion, J. (2012). A decision tree for assessing effects from exposures to multiple substances. *Environmental Sciences Europe*, 24(26), pp. 1-12.

Peterborough (2015). Six Frequent Causes of Car Dents Available from http://www.peterboroughbodyrepair.com/six-frequent-causes-of-car-dents.

Sheen Group, (2016). Panel Beating Training Requirement. Available from https://sheengroup.com.au/resources/information-centre/panel-beating-training-requirements

Song, Y. and Lu, Y. (2015). Decision tree methods: applications for classification and prediction. *Shanghai Arch Psychiatry*, 27(2), pp. 130–135.

SPSS (2009). Statistical Package for the Social Sciences (SPSS) Inc. Released 2009. PASW. Statistics for Windows, Version 18.0. Chicago: SPSS Inc.

Ture, M. Kurt, I. and Kurum, T. (2007). Analysis of intervariable relationships between major risk factors in the development of coronary artery disease: a classification tree approach. *The Anatolian Journal of Cardiology*, 7(2), pp. 140–145