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Investigation of helmet use behavior of motorcyclists and effectiveness of enforcement campaign using CART approach

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ABSTRACT

Use of the helmet is beneficial in reducing the severity of injuries and avoiding fatalities for motorcyclists, therefore, legislation exists in almost all countries. In practice, the situation is different regarding the helmet use, especially in the developing countries. This paper investigates the helmet use behavior of motorcyclists in Karachi, Pakistan. It determines the significant factors affecting the helmet use in Karachi (Pakistan) and recommending effective campaign measures to promote helmet use. It is vital in relation to the exponential growth of motorcycle users and poor enforcement of traffic rules. Repeated cross-sectional data collected before (n = 226) and after (n = 277) the helmet use enforcement campaign is analyzed using univariate and non-parametric classification and regression tree (CART) techniques. A significant number of motorcyclists do not hold a driving license and CART analysis highlighted the significance of this variable along with exposure to the road environment (measured as daily usage of motorcycle) to explain helmet use. Campaign effects are found temporary, therefore, serious efforts are required to design coherent and structured awareness and enforcement programs.

1. Introduction

More than a million fatalities are recorded each year worldwide due to road accidents and the number of injuries exceeds twenty to fifty times the value of fatalities. Majority of these accidents are associated with middle to lower income countries [1]. Motorcycle drivers have been reported to have highest disabilities' rates due to road accidents among all other road users [2–5].

Pakistan is no exception to the global trends in road traffic accidents [6]. Karachi, being the economic hub of the country, has experienced consistent growth in population [7]. During the last decade, the public transport system of the city has almost collapsed due to the negligence and inappropriate policies of authorities [8,9]. The situation resulted in the exponential growth in motorcycle registration which has been doubled since year 2010 [10] and share of motorcycles vary in between 30 and 40% in all major road streams of Karachi [11,12]. This causes an increase in the rate of accidents, with the annual number of accidents exceeding 26,000, having vehicle involvement of >35,000 [13]. The situation is quite worse in relation to the enforcement of traffic laws and regulations [14]. Despite the revisions made in traffic law violation fines in the year 2015, penalty amounts are still significantly lower. Additionally, corrupt practices of enforcement officers have resulted in low levels of traffic rules compliance which has causes increase in traffic ticket fixing and consequently road crashes [15,16].

Studies done in two major cities of Pakistan (Lahore and Karachi) show that >50% of motorcycle accident related injuries are severe/fatal. These studies also showed that severe head injuries can be reduced by at least 4% by wearing helmets [17,18].

Despite proven benefits and existence of necessary legislation, lack of helmet use is a common phenomenon in developing economies [19]. Moreover, a brief review of the literature shows that use of the helmet in Karachi, i.e. approximately 7%, is way behind other neighboring countries [18]. Use of helmet has been reported approximately 70% in the major cities of India [20,21] and approximately 90% in China [22]. Possible reasons for not wearing helmets could be; lack of understanding related to the behavior of riders for helmet use and inefficiency of awareness/enforcement campaigns. This study addresses these issues by utilizing CART analysis to investigate the riders' behavior and proposing effective campaign strategies. Latter objective has been fulfilled by understanding the local riders' perception about the campaigns and study of successful international campaigns. The main focus of the proposed campaign strategies has been towards developing countries.

This study presents employs statistical tests and model to determine the factors affecting helmet use in Karachi including the effect of an enforcement campaign. The findings of the study are combined with the results from other studies, done in other developed as well as

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developing countries, to recommend effective campaign measures. A detailed analysis of the datasets collected before and after helmet use enforcement campaign conducted in Karachi has been carried out and a detailed account of the efficacy of such campaign is provided. The paper is structured as follows; Section 2 provides the detailed account of literature in relation with helmet use behavior in developing countries, Section 3 describes the awareness campaign conducted in Karachi, along with the methodological aspects of repeated cross-sectional survey, Section 4 analyses the data by using univariate and CART techniques and also discuss effectiveness of enforcement campaign, which is then followed by the concluding remarks.

2. Helmet use behavior: lessons from literature

Studies in relation to developing countries used a variety of methods such as observing motorcyclists, questionnaire-based survey and mixed methods. Majority of these studies are cross-sectional and only a handful of studies exist that compare helmet use behavior in the longer time frame or determine the efficacy of different interventions by analyzing before-and-after situations. This section provides a brief account of findings of these studies.

2.1. Cross-sectional studies

Observational studies (data collected by observing or extracting from video recordings from various locations) can only capture a few variables to correlate with helmet use behavior. However, they are *accurate* in estimating statistics regarding helmet use compared to the self-reported questionnaire-based survey studies [23]. Ackaah and Afukaar [24], Akaateba et al. [25] and Zephaniah et al. [26] observed the low use of the helmet for passengers (pillion riders) compared to drivers in African cities. Additionally, they also observed that helmet use was low among young riders and in areas outside the city compared to the core city areas (potentially, due to the higher surveillance). Ledesma and Peltzer [27] in the city of Mar del Plata (Argentina), found that gender (more likely females), weather (more likely during rain) and the spatial location (more likely in the core city area) are explaining the choice of wearing a helmet. They also noted that the type of motorcycle (in terms of power and engine capacity) is also a strong determinant of helmet use.

Questionnaire-based interview studies were mainly conducted at the road-side. They can provide a rich set of variables to correlate with helmet-use behavior, however, due to the self-reported response for helmet use the results can be biased. Sreedharan et al. [28], for Kerala (India) concluded that helmet use is governed by gender (males are more likely to wear helmets), marital status (married persons are more likely to wear helmets), alcohol use (drunk drivers are less likely to wear helmet) and positive opinion of individuals towards laws. In contrast to this, Khan et al. [29], Oginni et al. [30] and Roehler et al. [31] reported that age, marital status, knowledge of helmet laws, education and alcohol use did not differ between users and non-users of helmet, however, non-users listed *physical discomfort* and *limited vision* as major barriers for non-compliance. Female pillion riders in developing countries also cited physical discomfort for not wearing a helmet [32,33]. Faryabi et al. [34] reported *physical discomfort* that contains the heavy weight of the helmet, feeling of heat, neck pain, suffocation, movement of head and neck as the main barriers of helmet use among Iranian motorcyclists.

Some authors adopted a mixed method approach (combining two or more methods together). Siviroj et al. [35] and Hung et al. [36] in their study for Thailand and Vietnam respectively, concluded that young age individuals and teenagers are less likely to wear helmets. Further, lack of enforcement during night times and at local streets are major reasons for not using a helmet. Karuppanagounder and Vijayan [37] for an Indian city Calicut, noted a significantly high use of the helmet for drivers (i.e. around 80%), however, drivers cited their main reason to wear a helmet is the fear of being stopped by the police.

Aghamolaei et al. [38] and Ghasemzadeh et al. [39] collected data for male riders in Iran within the framework of Theory of Planned Behavior (TPB) and correlated individual perception, attitude and values with their helmet use behavior. Their study revealed that perceived behavior control (i.e. individual perception to use helmet from easy to difficult) was found significant in explaining their intention to use it. Their study also mentioned that motivational and nudging factors were positively correlated with helmet use, which suggests that social, health and education campaigns may improve helmet use among riders.

All studies reported in this subsection are based on the cross-sectional data and reported analysis in univariate or multivariate forms to identify key factors. Findings from some studies are supporting each other, however, variation exists in terms of the significance of a particular variable in explaining the helmet use. Therefore; policies, enforcement and awareness campaigns should be made in correspondence with the local norms and behavior.

2.2. Longitudinal and before-and-after intervention studies

Longitudinal and before-and-after intervention studies are scarce in developing countries for helmet use behavior. However, these are vital for understanding the efficacy of different laws, measures and long-term training programs. Bao et al. [40] analyzed the trend of helmet use in two provinces of Vietnam for four consecutive years (i.e. 2011 to 2014). They found mixed results and not able to distinguish the exact causes of the changes in the helmet use. In contrast to this, an earlier study from Nguyen et al. [41] found that helmet use was increased from 40% to 92% at various locations due to the introduction of mandatory helmet use law. Kim and Klaric [42] reported helmet use rate for the year 2014 (when a helmet use law was revised in Cambodia), 2015 (pre-enforcement) and 2016 (post-enforcement). In January 2016, a strict enforcement campaign was launched, and the post-enforcement data suggested an increase of 17.2 percentage points in helmet use. The paper does not provide any details of the enforcement program. Ratanavaraha and Jomnonkwao [43], investigated the effects of a community participation program to encourage helmet use for the three districts of Amphur province in Thailand. They observed an increase of 13% helmet use after the intervention. It is not indicated in the paper that whether such programs have long-lasting effects. A review study [44] for Southeast Asian Nations indicated that helmet use legislation was effective, however, strict enforcement measures are also necessary to create a significant impact. This study presents the experience observed in Karachi city (Pakistan) for a strict official enforcement campaign of helmet use that lasted for two weeks.

3. Study methodology

3.1. Enforcement campaign for motorcycle helmet use

Helmet use law exists in Pakistan since 1965. In 2015, due to the significant increase in traffic accidents and rise in motorcycle use in urban areas, authorities made significant revisions in traffic rules and fines. Wearing of a helmet was made mandatory from 8th June 2015 for drivers as well as pillion riders of the motorcycle. It was done under the umbrella of Motorcycle Safety Ordinance and imposed with an increased fine of PKR 150 for riders not wearing helmets (http://www.thenews.com.pk/May 26, 2015). To complement this law, an enforcement campaign was launched from 9th June 2015. During this campaign, motorcycle riders were stopped and warned by the traffic police officials for not wearing a helmet for one week and made them aware of modified regulations. In addition to that, the news was widely spread from electronic and print media regarding the legislation. After that week, strict enforcement was made for another one week at various points of the city. The campaign was designed in a way that

enforcement officers were forced to issue a specific number of tickets per day by intercepting motorcyclists who do not wear a helmet. However, pillion riders either male/female was not given any attention. After two years, in 2017 similar enforcement campaign was arranged in the second and third week of September. During the enforcement weeks' helmet wearing compliance was observed high according to the police. The later period of the campaign is analyzed in this study, as authorities perceived this method as effective.

3.2. Data collection methodology and analysis methods

Data for this study were collected using a mixed methodology within a repeated cross-sectional survey framework. Due to limited monetary resources available to conduct this study, we did not opt for more detailed survey methodology that may use longitudinal approach (i.e. same participants before and after the helmet reinforcement campaign). It is not easy to get commitment from all participants that were interviewed at before campaign stage, for the follow-up survey (i.e. after campaign) as it may require more time to complete the study. Furthermore, it is also not an option to handover the second stage questionnaire to the participants at the time of first interview, so that they can provide responses at some time period in future by mailing back to us. This is partly because the enforcement campaign itself was not clear at the time of first interview (many details were not known about enforcement methods), which require necessary adaptation of the questionnaire at second stage of interview. Additionally, the response rate from the participants in mail-based survey methodology is also noted to be very poor. However, attempt has been made to develop a detailed survey questionnaire considering the factors mentioned in the previous studies for a road-side interview method. These are related to determining respondents socio-demographic/economic attributes such as age, income, marital status, holding of license, etc. Additionally, the questionnaire also included questions in relation to determining travel habits and driving experience of respondents e.g. the daily number of trips, trips lengths, fuel consumption, helmet stolen and accident experience in the past. Refer to Table 1 for more details. The survey conducted at six major parking locations near shopping malls, restaurants and hospitals in the city before and after the enforcement campaign at the similar time of day (i.e. morning/afternoon and night periods). All respondents were male drivers of the motorcycle, as pillion riders (either male/female) do not wear helmets at all in Karachi [26]. Respondents were selected using systematic random sampling at each parking location i.e. every 5th motorcycle driver is selected for the interview. Wearing of a helmet is determined for respondents based on the observation during the interview process. However, respondents were also asked to state the frequency at which they wear a helmet. The analysis reported in this study is based on the *regular usage* of the helmet. The after-enforcement survey questionnaire had some added questions on opinions for encouraging helmet use and how to make enforcement campaign more effective (see Tables 5 and 6). Relevant motorcycle conditions such as the existence of side mirrors and arrangement to secure helmet with the vehicle in parking condition were also observed. The after-enforcement campaign survey was conducted in the second week of October 2017, almost three weeks later to get a clear picture on long-lasting effects of the campaign. Before enforcement survey was conducted in the last week of June 2017. In total, 246 respondents were interviewed in the before enforcement campaign, out of which 226 were found appropriate for analysis. After the enforcement campaign, 288 respondents were interviewed, within which 277 were found appropriate for analysis. In overall, a repeated cross-sectional sample included 503 respondents. Orsi et al. [45] considered an even smaller sample size in their study to represent the rider behaviour. Moreover, in a study related to CART analysis [46], a sample size of around 400 respondents was considered sufficient to estimate a model with >10 variables.

Univariate analysis and CART approaches were used to analyze collected data. Univariate analysis was applied by employing a *t*-test for different variables collected in this study between the two groups (*helmet wearing* and *non-helmet wearing* helmets in this case). The t-statistic for the continuous variable was calculated as per Eqs. (1) and (2) and for categorical variables Eqs. (3) and (4) were used as indicated in [52].

$$t = (\overline{x_1} - \overline{x_2})/S_y \tag{1}$$

$$S_y = \sqrt{\frac{S_1}{N_1} + \frac{S_2}{N_2}} \tag{2}$$

$$t = (p_1 - p_2)/\sqrt{p(1-p)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)} \tag{3}$$

$$p = \frac{y_1 + y_2}{N_1 + N_2} \tag{4}$$

where; $\overline{x_1}$ and $\overline{x_2}$ were the means of group 1 and 2, S_1 and S_2 are the standard deviations of the two groups and N_1 and N_2 are the number of respondents in each group. p_1 and p_2 are the proportions in two groups, for example, a proportion of singles (marital status) wearing and not wearing helmets. y_1 and y_2 represent the count in the respective categories.

In previous literature, mainly logit regression analysis has been used, which is a parametric method and require assumption regarding the underlying distribution of the data. The CART is a nonparametric technique, and the model can use the same variable more than once at different stages of the tree that helps uncover complex interdependencies between considered variables [47]. In comparison with regression analysis, the CART can handle multi-collinearity problems in the data more appropriately. The CART has been used extensively for understanding and predicting consumer behavior and also in road safety research (i.e. car seat belt use) [46], however, to the best of our knowledge, it is not used for understanding helmet use behavior. A binary classification tree model is developed, and in order to measure differences in helmet use behavior before and after the campaign, a discrete variable representing a response collected before or after the campaign was used among other variables. Raffalovich & Chung [48] also suggested interacting *response collection moment* variable with other key variables while building an empirical model, to see if other variables get more or less important as predictors of helmet use with

Table 1
Variables collected during the survey.

Variable	Type
Age	Continuous
Education	Discrete (0 for below matric; 1 for matric; 2 for intermediate; 3 for graduation and 4 for masters)
Single – married	Discrete (0 or 1)
Monthly income	Continuous
Driving license holder	Discrete (0 or 1)
Number of years since driving license is obtained	Continuous
Daily number of trips	Continuous
Trip length < 5 km	Discrete (0 or 1)
Trip length 5–10 km	Discrete (0 or 1)
Trip length 10–15 km	Discrete (0 or 1)
Trip length > 15 km	Discrete (0 or 1)
Fuel consumption	Continuous (PKR)
Experienced minor accident	Discrete (0 or 1)
Experienced severe accident	Discrete (0 or 1)
Helmet stolen	Discrete (0 or 1)
Interview time-of-day	Morning 1; afternoon 2; night 3
Response collection moment	Discrete (0 for the response collected before Campaign; 1 for the response collected after Campaign)

respect to response collection moment. In this regard as well, CART is more appropriate as the algorithm which is able to detect these inherent relationships and dependencies within the data to place a particular variable in the tree to make a classification. The CART analysis uses the recursive partitioning to create a tree from the data space and fitting a simple prediction model within each partition. The splitting of the nodes is based on the Gini index node impurity criterion, where each split maximizes the decrease in impurity [47]. For more explanation on this, readers can refer to [47,50,51].

4. Results

4.1. Univariate analysis

Univariate analysis between the two groups *(helmet wearing* and *non-helmet wearing)* collected before and after the enforcement campaign is performed separately. *t-tests* were performed to compare the means and proportions for the before and after campaign data. Table 2 presents the results of this analysis.

Almost similar % of regular helmet users are found in before (48%) and after campaign (46%) data. During the campaign, authorities reported around 80–90% compliance but soon after two weeks, the effect seems to be diminished. The Same observation has been shown in Vietnam for a similar enforcement campaign [40]. *Holding a driver license*, *years passed after obtaining a driving license*, *Helmet stolen* and *involvement in a severe accident* are found significant in both data sets. It is clearly evident that there exist drivers of a motorcycle in the city who even do not hold a valid license. This situation is resulted due to the poor public transport system which forced commuters to use the motorcycle. Furthermore, riders who have valid a driving license are also law-abiding, as they have more tendency to wear a helmet. Additionally, those who have more experience of driving a motorcycle after obtaining a driving license are more inclined to wear a helmet. This signifies that helmet use is more related with the law-abiding nature of an individual along with the character building opportunities an individual got with the passage of time. Some individuals have been a victim of helmet stealing events, however, interestingly victims of such events are persistent with the use of a helmet. Involvement in severe accidents (i.e. admitted in the hospital for at least three days) in relation with a motorcycle is also important to explain helmet use, however, the insignificance of this in the before campaign data may be attributed to low representation of such individuals.

The average number of daily trips has been found significant in after campaign data. It should be noted that in before campaign data, helmet wearing group and non-helmet wearing group have an average daily number of trips >3, however, in after campaign data the difference between the two groups is larger, and those performing a lesser number of trips tend to wear a helmet regularly. The daily number of trips is found as an important variable in the CART analysis presented in Section 4.2, where more details are discussed in relation with this variable. *Age*, *marital status* and *monthly income* have been found significant in the before campaign data, however, these variable are insignificant in the after campaign data. A closer look at the statistics of age and monthly income indicates that differences in the mean values are higher between the two groups of the before campaign data in comparison with the after campaign data. Respondents with higher *monthly income* and *age* have a tendency to wear a helmet more regularly. This is in line with the findings of previous studies. *Single* individuals have lesser responsibility and pressure from immediate family members, therefore, may have a tendency to not wear a helmet as indicated from the before campaign data. In terms of proportion, the trend is similar in the after campaign data as well, and the insignificance of this variable may be

Table 2
Univariate analysis for data collected before and after Helmet enforcement campaign.

Variable	Statistic	Before campaign			After campaign		
		helmet wearing	Non-helmet wearing	Significance	helmet wearing	Non-helmet wearing	Significance
Total respondent	Count	110	116	N/A	129	148	N/A
Age	Average	27.35	23.46	S[a]	26.66	25.78	N/S[b]
	Std. deviation	9.40	7.62		7.49	6.89	
	Range	18–53	16–60		15–52	16–55	
Education: less than matric	Count	5	4	N/S	1	1	N/S
Education: matric	Count	10	16	N/S	31	33	N/S
Education: intermediate	Count	50	34	S	58	74	N/S
Education: graduation	Count	36	51	N/S	26	34	N/S
Education: masters	Count	8	6	N/S	10	6	N/S
Single	Count	64	89	S	93	117	N/S
Monthly income	Average	22,953.30	17,567.31	S	19,518.03	22,693.33	N/S
	Std. deviation	13,491.62	11,207.07		18,978.08	13,585.54	
	Range	5000–90,000	0–50,000		0–80,000	0–70,000	
Driving license holder	Count	76	49	S	67	42	S
Not holding a driving license	Count	34	67	S	62	106	S
No. of years since driving license is obtained	Average	7.45	5.81	S	7.26	5.71	S
	Std. deviation	5.98	5.67		6.57	4.56	
	Range	1–8	0.5–40		0–35	1–25	
Daily number of trips	Average	3.58	3.35	N/S	2.16	3.32	S
	Std. deviation	5.06	2.53		1.43	3.99	
	Range	1–35	0–18		0–6	1–30	
Daily Trips length < 5 km	Count	23	32	N/S	35	40	N/S
Daily Trips length 5–10 km	Count	31	30	N/S	41	44	N/S
Daily Trips length 10–15 km	Count	21	24	N/S	18	28	N/S
Daily Trips length > 15 km	Count	28	25	N/S	33	36	N/S
Fuel consumption	Average	136.18	113.94	N/S	124.75	145.38	N/S
	Std. deviation	95.28	79.45		99.12	90.15	
	Range	30–200	20–500		37–500	50–500	
Helmet stolen	Count	34	18	S	23	13	S
Severe accident	Count	6	21	S	59	48	S
Interview time-of-day (Morning/afternoon)	Count	75	85	N/S	90	102	N/S
Interview time-of-day (night)	Count	30	36	N/S	45	42	N/S

[a] Significant at alpha = 0.05.
[b] Non-significant at alpha = 0.05.

due to slightly over-representation of *single* individuals in the after campaign data.

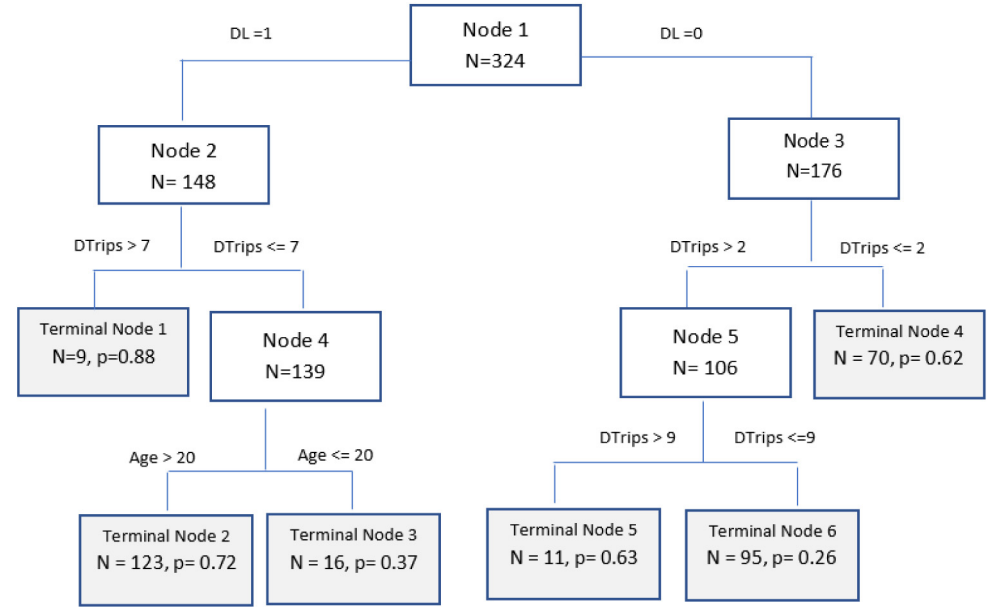
4.2. CART analysis

In order to develop a CART model, both data sets (before and after the campaign) are pooled together, with an additional dichotomous variable that represents the data collection moment. All variables in Table 1 are used to construct an optimal CART tree shown in Fig. 1. The model was developed to predict the choice of motorcycle driver/rider to wear helmet. Each terminal node of the tree is depicting the probability (p) of wearing a helmet. It also shows the number of observation contained within the leaf. The tree is generated with 2/3rd randomly drawn dataset and the remaining data set is used for testing. The overall model prediction accuracy is around 75% which is under acceptable range (see Table 3 for more details). Coincidently, test dataset shows a slightly better accuracy than learning which could be attributed to the randomness of selecting samples for learning and testing datasets.

Driving license, the daily number of trips and age are key splitters in the classification tree. Holding a driving license is the single best variable to classify helmet wearing behavior, as the initial split of the tree at node 1 is based on this variable. This depicts that individuals who have a law-abiding nature have different behavior towards wearing a helmet. This is also found true in studies from India [26] and the US [53]. Dummy variable representing the data collection moment has no role in the tree which indicates that the enforcement campaign was not able to bring any significant change in the helmet use. Those who have a driving license and perform 7 or fewer trips in a day are more inclined to wear a helmet (see Terminal node 1, where $p = .88$). Furthermore, those who have driving license tend to perform the higher number of trips in a day. After the *daily number of trips*, *age* becomes the key splitter among the license holders. Among those, younger than 20 years' individuals have only 37% chances of wearing a helmet which is significantly lower compared to their counterparts (age > 20 years) where chances of helmet use were 72% (see terminal node 2 and 3). This shows that with the increase in age, motorcycle drivers become more sensible and start wearing a helmet. The same observation is also made in the study by Ackaah and Afukaar [24] for Ghana and Bao et al. [40] for Vietnam. Therefore, it is required to target youth more significantly in the awareness and enforcement campaigns.

The situation is worse on the other hand of the CART tree as there is a significant number of motorcyclists who even do not hold a driving license. This is reflecting a seriously deteriorating condition of enforcement from traffic police as mentioned in Section 1. As per legal practice, if these individuals get caught by the traffic police, their motorcycles should be seized and the drivers should be arrested. However, drivers can get away with such situation easily on the spot after paying some amount to the officer. Due to this reason acquiring a driving license is not considered by many motorcyclists as an utmost requirement. The daily number of trips again here is found as the second best splitter in the tree. Those who are performing lesser trips (i.e. <2) tend to wear a helmet more compared to their counterparts (see terminal node 4, $p = .62$). On further investigation, it is found that these are individuals whose daily trips length is >10 km (i.e. higher exposure to the road environment). This observation is found concurrent with the previous literature [36]. The next split is also based on the same variable indicating a complex interaction of this variable. Those who are performing a significantly large number of trips in a day (>9) are more inclined to wear a helmet (see terminal node 5, $p = .63$). Regular use of helmet from these individuals may be attributed to disguise the traffic police (i.e. to have one less reason for the enforcement officers to intercept them). Among riders who do not have the driving license and their daily number of trips are in between 2 and 9, there are only 26% chances of them being regular helmet users (see terminal node 6, $p = .26$). The examination of their daily trip length indicates that most of their trips are short distance trips. Lower exposure to road environment could be the main motivation for them to avoid helmet, as carrying of a helmet for small distance trips could be burdensome.

Further exploration of the characteristics of motorcyclists who are not holding a driver license indicated that 68% have education level till intermediate (Grade 12) or lower and 77% of them are single. Furthermore, their average age is around 25 years with a high standard deviation, which indicates the representation of all age groups. Lower



Label	Variable definition
DL	Driving License (1 = Yes, 0= No)
DTrips	Daily number of trips
Age	Age in years

Fig. 1. The output of CART tree.

Table 3
Prediction results of the CART analysis.

	Learning data (N = 324)			Testing data (N = 179)		
	Observed	Predicted	Correctly predicted	Observed	Predicted	Correctly predicted
Helmet users	162	155	127(78.3%)	77	82	62(80.5%)
Non-helmet users	162	169	120(74.1%)	102	95	75(73.5%)

The overall accuracy for learning data is 75.2% and for testing data is 76.4%.

education level and low sense of responsibility towards their families may have a pivotal role in shaping their prejudiced attitude towards traffic laws.

While comparing the results of the study with the previous literature, it was found that the previous studies have mainly depended upon the univariate analysis in which interdependencies of the variables cannot be detected. Furthermore, studies investigating the effects of socio-cultural factors and enforcement/awareness campaign, simultaneously, on helmet usage have not been found. This study addresses these gaps, to some extent, in the aforementioned analysis. Therefore, some of the above-mentioned observations seem unique to this study such as the effect of age and number of daily trips. In order to further validate and analyzed the robustness of the obtained CART tree, we adopted a methodology by developing CART tree multiple times (10 times) with different sample of learning dataset (selected randomly). We also measured the accuracy of predictions using the remaining test dataset. However, the proportion of learning and testing datasets was kept same as used to develop CART tree presented in Fig. 1 (this is to ascertain that the minimum sample requirement to develop CART model is intact). The results observed are mentioned in the following points:

- The variable driving license has been found a major factor in determining the helmet wearing behavior every time the CART tree has been developed with a different random sample of the learning dataset.
- *Number of daily trips* and *age* have been found other important factors in splitting up the tree further. There are no other factors emerged in the alternative trees that may explain helmet wearing behavior. Therefore, it is quite evident that any combination of the collected data will render three factors (driving license, number of daily trips and age) to explain the helmet wearing behavior of riders.
- Slight variations have been noted in the shape of the alternative CART trees (i.e. their branching) in relation to the number of terminal nodes and non-terminal nodes. However, it is found that the reported tree in Fig. 1 is optimal as it contains the minimum number of nodes (11) compared to other alternatives. The highest and lowest number of nodes are found as 19 and 11 respectively. More variation is noted at the lowest levels of CART trees. This is due to the small variation in the training dataset that may result in different splits of nodes.
- Table 4 provides these results for all 10 CART trees along with their prediction accuracies for learning and test datasets. All trees have accuracies similar to each other for their respective learning datasets. Lowest accuracies for test dataset are found in trees that contains a large number of nodes. It can be noted that the tree reported in Fig. 1, is tree number 5 reported in Table 4.

Table 4
CART Tree development with different learning samples.[a]

CART tree no.	Number of nodes	Overall accuracy (Learning)	Overall accuracy (Testing)
1	13	73.1%	72.3%
2	15	71.1%	69.3%
3	13	73.9%	73.6%
4	15	72.1%	69.9%
5[a]	11	75.2%	76.4%
6	19	70.2%	66.3%
7	17	72.4%	67.1%
8	14	74.3%	68.3%
9	15	73.6%	68.2%
10	13	75.8%	69.2%

[a] CART tree presented in Fig. 1.

The sensitivity analysis presented here indicates that the CART approach can be slightly sensitive with the different sample of learning dataset in relation with branching and number of nodes, however, the approach is able to determine significant relevant factors quite well to describe certain behavior, as found in our case. Similar findings are also reported in other studies [49,57].

4.3. Campaign effectiveness

In relation to the enforcement campaign, it is quite evident that the effects are temporary and there are no significant changes in the way drivers are behaving. A few contextual notions of such campaigns are mentioned below:

1) There exists a lack of trust between the citizens and authorities. Citizens perceived the enforcement campaign as an act that helps authorities to make more money from the citizens by issuing a significant number of challans/ticket on traffic violations [15,16].
2) Enforcement campaigns are one-off events, which lasts for two to three weeks. There is a significant lack of consistency in the continuity of such campaigns.
3) Penalty on traffic violations is significantly low, despite the recent raise it can still be considered too little in comparison with the traffic violation penalties in developed countries.
4) Little or almost no involvements from various key stakeholders in the safety campaigns. For example; involvement of corporate sector, business developments, key society persons and celebrities.
5) Awareness campaign often adopted in developed countries such as the UK, which is focusing on educating the riders have been found to have a more sustained effect than the enforcement campaigns applied in developing countries such as Pakistan and Vietnam [40,54]. Moreover, campaigns with positive interventions, such as providing free safety equipment (vests, helmets) have also been found to have effects sustained over a longer period [55,56].

Tables 5 and 6 present the compiled results of the added questions asked during the data collected after the enforcement campaigns. Respondents are asked to provide a response on a Likert scale (1–5) about each question. Table 5 provides the distribution of individual's responses for various reasons that may contribute to their non-compliance towards helmet use. % >25 on a particular scale is shaded to highlight the importance of a particular reason among motorcycle riders. Non-regular helmet users have awareness regarding the advantages of the helmet as 96% reported strong agreement on that. Hot weather, vision and hearing problem while wearing a helmet are cited by >50% of individuals. In support of this, >50% of individuals have agreement on the issue that helmet design needs to be improved. According to our observations, 95% of the motorcycles are not equipped with the side mirrors. Interestingly, the burden of taking care of helmet has been cited by almost 70% of respondents. Respondents also

Table 5
Reasons for non-compliance towards helmet wearing – Responses distribution in %.

Reasons for non-compliance towards helmet wearing	Likert scale				
	Strongly agree	Agree	Mixed	Disagree	Strongly disagree
Helmet can save life and serious brain injury	96.0	3.0	1.0	0.0	0.0
Helmet is costly	5.3	9.3	20.5	42.5	22.4
Vision problem	24.5	30.5	32.6	8.3	4.1
Hearing problem	15.3	34.6	40.2	14.1	5.8
Problem in breathing	4.2	23.6	20.4	30.3	21.5
Due to hot weather	19.5	32.6	31.5	14.6	1.8
Physical appearance disturbed (hairs etc.)	7.8	19.3	20.5	42.5	22.4
Feels headache	1.6	10.6	16.8	45.4	25.6
Helmet is heavy	3.5	14.5	25.2	32.8	24.0
Overall design of helmet is improper	10.6	39.7	23.6	15.9	10.2
Problem in carrying helmet and its security	36.5	33.3	19.5	8.3	2.4
Traffic ticket/challans fixing and no strict enforcement	26.4	36.4	16.4	12.3	8.5

indicated that negligible enforcement and fixing of traffic tickets/challans on the violation is also one of the reasons for not wearing a helmet.

Table 6 provides the distribution of individual responses on their opinions to make enforcement and awareness campaigns more effective. Some of the opinions are already listed in the questionnaire, and users are also asked to give any other opinions they think might be necessary. For each opinion, users have responded on a Likert scale of 1–5. Similar opinions from the users are grouped together and finally, a list of 13 items is prepared. Majority of the opinions can be categorised under hard interventions such as higher penalty, periodic enforcement (every 3 or 6 months), legislation for improved design of motorcycle (i.e. containing helmet box, side mirrors, alerting sensors) and helmet (i.e. usable in hot weather). However, at the same time, respondents also highlighted the importance of structured informational campaigns. These opinions indicate that strategies comprising only the enforcement campaigns will not be effective.

5. Discussion

The univariate analysis does not indicate any significant change in helmet use that can be considered as the effect of the campaign. Some noted differences in significance or insignificance of few variables in collected data before and after the campaign can be easily attributed to the minor differences in representation of specific groups of the population. This is true in case of variables such as age, monthly income, marital status and daily travel habits. However, it is noticed that variables representing drivers' responsible nature and his experiences such as holding a driving license, years passed holding a driving license, helmet stolen and accident experience are more vital in explaining helmet use. CART analysis further strengthened this argument where the major factor distinguishing the helmet use was found as holding a driving license. This is a distinct finding in comparison with earlier studies in which researchers emphasized the importance of socio-demographic, economic and travel habits related variables. This finding is not in conflict with earlier studies, however, it emphasized the fact that driver's sense of responsibility, his attitude towards traffic law are more directly related to helmet use, and other variables have the secondary role i.e. these variables have more importance in determining the appropriate attitude. For instance, in studies where individuals belong to classes representing higher age [23–26], higher income and education [25,27,28], married [28] and higher exposure to road environment and spatial location [27,35,36,37] showed a significantly higher use of a helmet. Individuals from such classes may have greater opportunities to appropriately shape their attitude towards abiding traffic laws and therefore higher sense of responsibility towards their own safety and others.

It is quite unfortunate that many motorcycle drivers are driving without holding a valid license and some of them wear a helmet with an intention to avoid getting caught by the police officials. In relation to campaign effectiveness, the effect was found temporary. Neither univariate analysis nor CART show any evidence regarding campaign effect for the helmet use. This gives clear indication that one-off type events/campaign in such a situation where there is a significant lack of control on driving and safety conditions are not fruitful and therefore more sustained approaches and measures are required to improve the overall situation. A study in India, where a helmet is used by around 80% of the motorcyclist is also due to the strict enforcement [21]. Some of the required measures to improve the overall situation are highlighted below.

1) Traffic police attitudes and their image need to be improved i.e. more sense of professionalism need to be shown from them. Fixing of traffic tickets/challans culture need to be stopped at once. Hard measures need to be taken in this regard immediately such as severe punishment and dismissal of enforcement officers involved in such acts.

2) Other strategies such as involvement of corporate sector and large business developments in shaping programs and incentives for their employees to encourage helmet use and any violation in this regard should be considered as misconduct in the work environment. For instance; assuring that workers entering the premises and parking lots using their motorcycles should have their helmets on.

Table 6
Opinions for making Campaigns more effective – Responses distribution%.

Opinion for making campaign more effective and promoting helmet use	Likert scale				
	Strongly agree	Agree	Mixed	Disagree	Strongly disagree
Distribution of free helmet	6.5	12.6	23.4	45.6	11.9
Higher penalty charges for non-compliance	26.5	35.6	23.6	10.8	3.5
Periodic enforcement campaign (every 3 or 6 months)	35.4	23.5	15.6	12.3	6.2
Periodic awareness programs/advertisements using digital media including messages from accidents victims/doctors	40.5	35.6	14.6	7.8	1.5
Legislation for design of motorcycle with helmet box	45.6	33.2	13.6	5.3	2.3
Employer-based incentive programs for regular users of helmet	16.8	31.5	30.6	15.6	5.5
Inclusion of key society persons/celebrities in Awareness campaign	12.3	38.2	26.5	13.6	9.4
Steps for improving traffic police attitudes/behaviour towards general road users	26.5	28.3	23.5	18.9	2.8
Use of new technologies for strengthening enforcement	13.5	32.6	23.5	18.2	12.2
Youth awareness programs in high schools/colleges and universities	12.5	39.4	32.6	12.5	3.0
Steps towards improving helmet designs, making them more efficient and affordable	18.5	32.6	23.5	16.4	9
Mandatory legislation and enforcement for side mirrors provision in motorcycle	19.1	26.4	25.4	18.2	10.9
Use of advance sensors in motorcycle to integrate helmet wearing alert system, which reminds riders to wear helmet when engine starts (like seat belt alert system in Cars)	23.4	29.5	27.6	14.7	4.8

3) Efforts need to be made to make digital media based awareness campaigns more effective, such as showing a realistic data, interviewing victims of incidents in the past and messages from doctors and celebrities. It is very important that these programs are telecast periodically every 3–4 weeks at prime times to keep the subject live in the minds of people.

6. Conclusions

Based on the analysis and discussion presented in Sections 4 and 5, both univariate and CART analysis revealed that campaign effects were only temporary and the behaviour of riders regarding wearing a helmet is found similar in the repeated cross-sectional data. Holding a driving license is found a key variable that explained helmet wearing behaviour in both analyses, which indicate that it is the law-abiding nature of motorcycle riders that influence them to use helmet regularly. It also reflects on the inefficiency of the enforcement agencies that drivers of motorcycle do not hold a valid license. The analysis indicated that education, marital status and income, which are found in some previous studies as main determinants of helmet wearing behaviour, are not found directly significant in explaining helmet wearing behaviour of Karachi's motorcycle riders. The number of trips in a day which can explain the exposure of motorcycle riders to the road environment was found as another key variable. Motorcycle riders tend to wear a helmet when they are more exposed to the road environment. However, non-holders of driving license may use the helmet to disguise police authorities to avoid unpleasant circumstances/conflict with them. CART analysis has been found an appropriate methodology and the results are providing more insights to analyze helmet wearing behaviour compared to the univariate analysis. Despite the advantages offered by CART analysis such as; handling of multicollinearity, no requirement on the model functional form and easiness in understanding the variable interactions, the results may be subjected to instability if the context is changed slightly. Therefore, further exploration is required to investigate the helmet behaviour from other non-parametric data mining techniques e.g. neural networks.

It is noted that non-compliance towards helmet wearing is due to the corrupt and non-strict enforcement from the authorities. Non-periodic and unstructured enforcement campaigns as analyzed in this study are not able to render fruitful results. Additionally, the burden of carrying a helmet, vision and hearing problem and hot weather are major reasons because of which helmet is not worn regularly by the riders. Majority of the respondents have an opinion that strict enforcement along with high penalties and improved motorcycle design (side mirrors and helmet box) will increase helmet usage. Additionally, strict enforcement needs to be coupled with awareness campaigns and these programs should follow a coherent structure that allows continuity over a longer period of time to achieve the road safety goals.

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References

[1] WHO, Global Status Report on Road Safety 2013: Supporting a Decade of Action, World Health Organization, 2013.
[2] S. Dhondt, C. Macharis, N. Terryn, F. Van Malderen, K. Putman, Health burden of road traffic accidents, an analysis of clinical data on disability and mortality exposure rates in Flanders and Brussels, Accid. Anal. Prev. 50 (2013) 659–666.
[3] A. Mehmood, I.Q. Khan, M.U. Mir, A. Moin, R. Jooma, Vulnerable road users are at greater risk during Ramadan–results from road traffic surveillance data, J. Pak. Med. Assoc. 65 (2015) 287–291.
[4] G. Rubin, K. Peleg, A. Givon, N. Rozen, I.T. Group, Upper extremity fractures among hospitalized road traffic accident adults, Am. J. Emerg. Med. 33 (2) (2015) 250–253.
[5] S.S. Vahdati, A. GhafarZad, F. Rahmani, F. Panahi, A.O. Rad, Patterns of road traffic accidents in north west of Iran during 2013 new year holidays: complications and casualties, Bull. Emerg. Trauma 2 (2) (2014) 82.
[6] P. Raina, N. Sohel, M. Oremus, H. Shannon, P. Mony, R. Kumar, et al., Assessing global risk factors for non-fatal injuries from road traffic accidents and falls in adults aged 35–70 years in 17 countries: a cross-sectional analysis of the Prospective Urban Rural Epidemiological (PURE) study, Inj. Prev. 22 (2) (2016) 92–98, https://doi.org/10.1136/injuryprev-2014-041476.
[7] I. Alam, Political Economy of Demographics, The News, 2017 (1st September 2017).
[8] M. Adnan, Qing-Qi as a Mode for Public Transport: A study of its Potentials and Deficiencies in the Context of Karachi Metropolitan, Paper presented at the Pakistan Urban Forum III, Lahore, Pakistan, 2015 (December, 2015).
[9] M.S. Ali, U. Gazder, Urban Transportation Policy Framework for Karachi, Paper Presented at the First International Conference on Sustainable Transportation & Traffic Management, Karachi, Pakistan, 2010.
[10] PSYB, Pakistan Statistical Year Book, Retrieved from http://www.pbs.gov.pk/content/pakistan-statistical-year-book-2014 2014 Last accessed on 5th December, 2016.
[11] M. Adnan, Passenger car equivalent factors in heterogenous traffic environment-are we using the right numbers? Procedia Eng. 77 (2014) 106–113.
[12] M.S. Ali, M. Adnan, S.M. Noman, S.F.A. Baqueri, Estimation of traffic congestion cost-a case study of a major arterial in Karachi, Procedia Eng. 77 (2014) 37–44.
[13] RTIR&PC, Road casualities report-2015, Retrieved from Road Traffic Injury Research and Prevention Center, Karachi, Pakistan, 2015http://roadsafety.pk/.
[14] M. Muzzammil, M.S. Minhas, J. Effendi, S. Jahanzeb, A. Mughal, A. Qadir, Qing-qi rickshaw: a boon or bane for public transportation? A study of road traffic injury patterns involving qing-qi rickshaws in Karachi Pakistan, J. Ayub. Med. Coll. Abbottabad 29 (2) (2017) 289–292.
[15] M. Durrani, H. Waseem, J.A. Bhatti, J.A. Razzak, R. Naseer, Associations of traffic safety attitudes and ticket fixing behaviours with the crash history of Pakistani drivers, Int. J. Inj. Control Saf. Promot. 19 (4) (2012) 351–356, https://doi.org/10.1080/17457300.2011.635207.
[16] J. Jackson, M. Asif, B. Bradford, M. Zakria Zakar, Corruption and police legitimacy in Lahore, Pakistan, Br. J. Criminol. 54 (6) (2014) 1067–1088, https://doi.org/10.1093/bjc/azu069.
[17] I. Ahmed, T. Islam, G. Ali, M.M. Nawaz, Pillion riders' cloth related injuries and helmet wearing patterns: a study of Lahore, Pakistan, Int. J. Inj. Control Saf. Promot. 23 (4) (2016) 388–394.
[18] J.A. Bhatti, J.A. Razzak, U.R. Khan, R. Jooma, Helmets and traffic injury outcomes: findings from a setting lacking legislation on proper wearing and quality assessment, Cogent Med. 5 (1) (2018) 1434031.
[19] B.T. Stewart, I.K. Yankson, F. Afukaar, M.C.H. Medina, P.V. Cuong, C. Mock, Road traffic and other unintentional injuries among travelers to developing countries, Med. Clin. 100 (2) (2016) 331–343.
[20] R. Mirkazemi, A. Kar, Socio-economic determinants of helmet-wearing behaviour in Pune city, India, Int. J. Inj. Control Saf. Promot. 21 (4) (2014) 376–381.
[21] K. Karuppanagounder, A.V. Vijayan, Motorcycle helmet use in Calicut, India: user behaviors, attitudes, and perceptions, Traffic Inj. Prev. 17 (3) (2016) 292–296.
[22] S.T. Chiou, T.H. Lu, C.H. Lai, T.L. Chiang, I. Kawachi, Social inequality in motorcycle helmet use: when a reduction in inequality is not necessarily good news, J. Epidemiol. Community Health 68 (7) (2014) 630–634.
[23] S. Wadhwaniya, S. Gupta, S. Tetali, L.K. Josyula, G. Gururaj, A.A. Hyder, The validity of self-reported helmet use among motorcyclists in India, WHO South-East Asia J. Public Health 4 (1/2) (2015) 38–44.
[24] W. Ackaah, F.K. Afukaar, Prevalence of helmet use among motorcycle users in tamale Metropolis, Ghana: an observational study, Traffic Inj. Prev. 11 (5) (2010) 522–525.
[25] M.A. Akaateba, R. Amoh-Gyimah, I. Yakubu, A cross-sectional observational study of helmet use among motorcyclists in Wa, Ghana, Accid. Anal. Prev. 64 (2014) 18–22, https://doi.org/10.1016/j.aap.2013.11.008.
[26] S.O. Zephaniah, A.M. Hainen, S.L. Jones, Mixed binary logit analysis of motorcycle helmet usage observations in Nairobi, Kenya, Paper Presented at the Transportation Research Board 95th Annual Meeting, 2016.
[27] R.D. Ledesma, R.I. Peltzer, Helmet use among motorcyclists: observational study in the city of Mar del Plata, Argentina, Rev. Saude Publica 42 (1) (2008) 143–145.
[28] J. Sreedharan, J. Muttappillymyalil, B. Divakaran, J.C. Haran, Determinants of safety helmet use among motorcyclists in Kerala, India, J. Inj. Violence Res. 2 (1) (2010) 49.
[29] I. Khan, A. Khan, F. Aziz, M. Islam, S. Shafqat, Factors associated with helmet use among motorcycle users in Karachi, Pakistan, Acad. Emerg. Med. 15 (4) (2008) 384–387.
[30] F.O. Oginni, V.I. Ugboko, R.A. Adewole, Knowledge, attitude, and practice of Nigerian commercial motorcyclists in the use of crash helmet and other safety measures, Traffic Inj. Prev. 8 (2) (2007) 137–141.
[31] D.R. Roehler, S. Sann, P. Kim, A.M. Bachani, S. Campostrini, M. Florian, ... A.A. Hyder, Motorcycle helmet attitudes, behaviours and beliefs among Cambodians, Int. J. Inj. Control Saf. Promot. 20 (2) (2013) 179–183.
[32] M. Saeed, S.M. Siddiqui, U.R. Khan, M. Swaroop, Perceptions regarding helmet use: a cross-sectional survey of female pillions in Karachi, Pakistan, J. Surg. Res. 211 (2017) 261–265, https://doi.org/10.1016/j.jss.2016.11.063.
[33] S. Siddiqui, S. Arora, J. Peipert, S. Sagar, M. Crandall, M. Swaroop, Survey of helmet influences of female pillions in New Delhi, J. Surg. Res. 184 (1) (2013) 404–410, https://doi.org/10.1016/j.jss.2013.05.103.
[34] J. Faryabi, M. Rajabi, S. Alirezaee, Evaluation of the use and reasons for not using a helmet by motorcyclists admitted to the emergency Ward of Shahid Bahonar Hospital in Kerman, Arch. Trauma Res. 3 (3) (2014), e19122. https://doi.org/10.5812/atr.19122.

[35] P. Siviroj, K. Peltzer, S. Pengpid, S. Morarit, Helmet use and associated factors among Thai motorcyclists during Songkran festival, Int. J. Environ. Res. Public Health 9 (9) (2012) 3286–3297.
[36] D.V. Hung, M.R. Stevenson, R.Q. Ivers, Barriers to, and factors associated, with observed motorcycle helmet use in Vietnam, Accid. Anal. Prev. 40 (4) (2008) 1627–1633.
[37] S.T. Heydari, K.B. Lankarani, M. Vossoughi, K. Javanmardi, Y. Sarikhani, K. Mahjoor, M. Mahmoodi, M.K. Shirazi, M. Akbari, The prevalence and effective factors of crash helmet usage among motorcyclists in Iran, J. Inj. Violence Res. 8 (1) (2016) 1.
[38] T. Aghamolaei, S.S. Tavafian, A. Madani, Prediction of helmet use among Iranian motorcycle drivers: an application of the health belief model and the theory of planned behavior, Traffic Inj. Prev. 12 (3) (2011) 239–243.
[39] S. Ghasemzadeh, T. Babazadeh, H. Allahverdipour, H. Sadeghi-Bazargani, K. Kouzekanani, Cognitive-behavioral determinants of using helmet by motorcyclists in a rural community, J. Transp. Health (2017)https://doi.org/10.1016/j.jth.2017.04.007.
[40] J. Bao, A.M. Bachani, C.P. Viet, L.N. Quang, N. Nguyen, A.A. Hyder, Trends in motorcycle helmet use in Vietnam: results from a four-year study, Public Health 144 (Supplement) (2017) S39–S44, https://doi.org/10.1016/j.puhe.2017.01.010.
[41] H.T. Nguyen, J. Passmore, P.V. Cuong, N.P. Nguyen, Measuring compliance with Viet Nam's mandatory motorcycle helmet legislation, Int. J. Inj. Control Saf. Promot. 20 (2) (2013) 192–196, https://doi.org/10.1080/17457300.2012.706617.
[42] P. Kim, K. Klaric, Motorcycle passenger helmet use in Cambodia: a turning point? Paper Presented at the Australasian Road Safety Conference, 2016, Canberra, ACT, Australia, 2016.
[43] V. Ratanavaraha, S. Jomnonkwao, Community participation and behavioral changes of helmet use in Thailand, Transp. Policy 25 (2013) 111–118, https://doi.org/10.1016/j.tranpol.2012.11.002.
[44] K. Peltzer, S. Pengpid, Helmet use and associated factors among motorcyclists in the Association of Southeast Asian Nations: prevalence and effect of interventions, Afr. Saf. Promot. 12 (1) (2014) 72–86.
[45] C. Orsi, A. Stendardo, A. Marinoni, M.D. Gilchrist, D. Otte, J. Chliaoutakis, ... A. Morandi, Motorcycle riders' perception of helmet use: complaints and dissatisfaction, Accid. Anal. Prev. 44 (1) (2012) 111–117.
[46] K. Shaaban, A. Pande, Classification tree analysis of factors affecting parking choices in Qatar, Case Stud. Trans. Pol. 4 (2) (2016) 88–95.
[47] D. Steinberg, P. Colla, CART: classification and regression trees, Top Ten Algorithm. Data Min. 9 (2009) 179.
[48] L.E. Raffalovich, R. Chung, Models for pooled time-series cross-section data, Int. J. Confl. Violence 8 (2) (2014) 210.
[49] L. Breiman, J.H. Friedman, R.A. Olshen, C.J. Stone, Classification and regression trees: Wadsworth, Belmont, CA, 1984, Since 1993 this Book Has Been Published, Chapman & Hall, New York, 1984.
[50] G. De'ath, K.E. Fabricius, Classification and regression trees: a powerful yet simple technique for ecological data analysis, Ecology 81 (11) (2000) 3178–3192.
[51] M.A. Razi, K. Athappilly, A comparative predictive analysis of neural networks (NNs), nonlinear regression and classification and regression tree (CART) models, Expert Syst. Appl. 29 (1) (2005) 65–74, https://doi.org/10.1016/j.eswa.2005.01.006.
[52] J.L. Devore, Probability and Statistics for Engineering and the Sciences: Cengage Learning, 2011.
[53] M.L. Ranney, M.J. Mello, J.B. Baird, P.R. Chai, M.A. Clark, Correlates of motorcycle helmet use among recent graduates of a motorcycle training course, Accid. Anal. Prev. 42 (6) (2010) 2057–2062.
[54] A.J. Lee, N.P. Mann, R. Takriti, A hospital led promotion campaign aimed to increase bicycle helmet wearing among children aged 11–15 living in West Berkshire 1992–98, Inj. Prev. 6 (2) (2000) 151–153.
[55] P.C. Parkin, X. Hu, L.J. Spence, K.E. Kranz, L.G. Shortt, D.E. Wesson, Evaluation of a subsidy program to increase bicycle helmet use by children of low-income families, Pediatrics 96 (2) (1995) 283–287.
[56] S.A. Sumner, A.J. Pallangyo, E.A. Reddy, V. Maro, B.W. Pence, C. Lynch, ... N.M. Thielman, Effect of free distribution of safety equipment on usage among motorcycle–taxi drivers in Tanzania—a cluster randomised controlled trial, Injury 45 (11) (2014) 1681–1686.
[57] J. Morgan, Classification and Regression Tree Analysis, Boston University, 2014 , (Technical Report No.1), Avaialabe at https://www.bu.edu/sph/files/2014/05/MorganCART.pdf.