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Effectiveness of Traffic Signal Countdown Timers on Pedestrian Crossings Behaviour: A Case Study at Tripureshwor and Narayangopal Intersection

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Abstract
The violations of traffic signal and dangerous crossing of roads at Intersection by pedestrian is common in Nepalese context. The objective of this study is to compare the pedestrian behavior while crossing the signalized intersection with and without the countdown timers. In the context of this analysis two regression models were developed. The first model is binary logistic regression which examine pedestrian compliance and second was pedestrian walking speed model. The independent variables considered to model the pedestrian behavior are gender, age, marital status, purpose of trip, time of day, education level, group size, past accident experience, frequency of use of intersection, and waiting time at kerb. Videographic and questionnaire survey was conducted to collect the data. Randomly selected 400 number of pedestrians were observed for walking speed, compliance behavior and other demographic information.

Multinomial logistic regression was performed on IBM SPSS to develop the compliance model and walking speed model. The significant variables were selected based on likelihood ratios. Gender, Age, Group size, Past accident, Use of Intersection are significant variables for compliance behavior of pedestrian before the installation of countdown timers. The result shows that countdown timers increase the compliance rate by 9.5% by installing countdown pedestrian signal. Multinomial logistic regression was performed to develop pedestrian crossing speed model. Gender, age and past accident history are statistically significant for cross walk speed. Speed comparison with and without countdown timer shows the cross walk speed is slightly increased (0.02m/s) by installing signal countdown timer.

Keywords
Pedestrians, Signal Countdown, Compliance model, Pedestrian walking speed, Logistic regression

1. Introduction

An intersection is a major section of the highway that requires active control, guidance, and accurate navigation of vehicles. Intersections can be signalized or not, depending on the existing traffic requirements at the location and the justification for the need for this specific control device. A signalized intersection is typically designed to reduce the number of crashes caused by certain conflicts, such as side-end conflicts and rear-end collisions. Beyond these, Pedestrian-vehicle conflict is one of the most serious safety concerns at signalized intersections [1]. Despite this, research in this area has primarily focused on vehicular traffic operations and safety. The interaction of various elements makes pedestrian behavior more complex than vehicular traffic operation. Many pedestrians cross the roads in many developing countries with the least pedestrian safety. As a result, the use of pedestrian signal phases is becoming more common in order to improve the safety of non-motorized road users.

Pedestrian countdown timers (PCT) are pedestrian signal heads with countdown timers that are installed at major intersections to control vehicle-pedestrian interaction. The presence of these timers near the pedestrian signal heads helps pedestrians to make decisions. They provide more information to pedestrians about the current and upcoming phases in order to encourage them to complete the crossing in the allotted time. A conventional pedestrian signal consists of three phases: a walk phase (displayed by a walking figure or green signal or the word "WALK"), a flashing don't walk phase (displayed by a flashing hand or yellow signal or the words "DON'T WALK"), and a steady don't walk phase (displayed by a solid hand or red signal or the words "DON'T WALK" displayed continuously). A pedestrian countdown signal has the same three phases as a standard pedestrian signal, but the flashing don't walk phase is displayed by a flashing hand and a countdown timer that indicates how much time is left until the flashing don't walk phase ends. When pedestrians are allowed to walk in the crosswalk, the walk phase is displayed on all pedestrian signal types. The flashing don't walk phase appears after the walk phase to give people who entered the crossing during the walk phase enough time to safely cross the intersection. The steady don't walk phase appears after the flashing don't walk phase. It indicates when pedestrians are not allowed to use the crossing because opposing traffic has a green light. The pedestrian who crosses the intersection during don't walk phase are called non-complier. The main reason behind this non-compliance behavior is individual feature and attitudes. Aside from personal characteristics, external environmental factors influence road crossing behaviour and attitude. [2] presented research results from an observational study of pedestrian behavior at various types of urban crosswalks, as well as a questionnaire survey of pedestrian perceptions of various crossing facilities shows, pedestrian waiting countdown timer can affect pedestrian behavior at signalized pedestrian crossing [3].

2. Relevant Literature

According to a research of the literature, the first countdown signal installation took place in Sacramento County, USA, in 1998. Since then, several urban centers have installed countdown signals for both pedestrians and vehicles. [4][5]. The pedestrian countdown signal's primary purpose is to assist pedestrians in getting off the street prior to being exposed to oncoming motor traffic. [6]. The 2003 Manual on Uniform Traffic Control Devices [6] provides the set of standards for traffic control device use, along with the Countdown Pedestrian Signal Display (CPSD) guidelines. The Institute of Transportation Engineers' New England section's technical committee carried out research on CPSD installed at three intersections in Boston MA [7] and concluded that countdown signals failed to result in any significant improvement in the considered variables , and in some cases actually diminished pedestrian safety. According to research conducted near a senior citizen complex, CPSD seems to to be more beneficial to vehicular traffic than to pedestrians. [8]. According to research on pedestrian signal comprehension, Pedestrian Green Flashing (PGF) is by far the most poorly understood indication in China, with comprehension rates as low as 70% at times. This low rate is commonly attributed to pedestrians' risky crossing practices and noncompliance with the PGF[9], and it has been determined that the countdown pedestrian signal enhances pedestrian awareness of the signal.

The Minnesota Department of Transportation (MN DoT) conducted a study on the effectiveness of CPSD at five intersections in the Minneapolis-Saint Paul metropolitan area and found that replacing traditional pedestrian signals with CPSD increased crossing success from 67% to 75%. Teenagers experienced the greatest increase, with rates of compliance and success increasing by 20%. Applications of countdown pedestrian signal design to only the flashing don't walk indication have also been the subject of research studies, which also found the pedestrians to be in favor of the countdown signal[10][11].

Several research have shown that countdown pedestrian signals are effective in improving traffic safety, and both pedestrians and drivers have been observed to make better decisions by using the time remains to cross the road displayed on pedestrian countdown signals at signalized intersections.[12] [13]. In contrast, the findings from the study conducted on Columbia shows neither CPSD have positive impacts on pedestrian safety nor any adverse pedestrian behavior induced by CPSD. [10].

Pedestrian behavior at signalized intersections studies have revealed a high rate of random crossings, especially in the final moments of the pedestrian red light[14]. Crossing at a red light in the final moments before the pedestrian green light turns on increases the likelihood of an accident by eight times that of crossing properly[15]. As a result, there is an urgent need to investigate the efficacy of existing devices i.e. countdown displays that should reduce the number of illegal crossings during the entire duration of the pedestrian red light, as well as the need to find reliable solutions.

More frequently, pedestrian countdown displays are used in conjunction with conventional traffic lights to enhance both the safety and behavior of pedestrians at signalized pedestrian crossings. A study conducted in Tel Aviv (Israel) to investigate the group effect [16] of pedestrians while crossing the road concluded that male pedestrians are more likely to cross the road at a red light than female pedestrians [17]. Furthermore, the majority of these pedestrians crossed at the red light if they were alone at the pedestrian crossing (individual), as opposed to pedestrians in a group (a group) who were waiting for the pedestrian green light to appear [18].

The main objective to install CPSD is to reduce the number of illegal pedestrian crossings on roads (during the pedestrian red light), thereby increasing their safety and improving traffic flow. However, there is no unified and consistent view in academic circles regarding the impact of countdown displays on pedestrian behavior, and thus the justification for installing them. From the above mentioned literature, inconsistent findings regarding the impact of countdown displays on pedestrian behavior and the justification for their installation only added to the need to investigate their effectiveness. A large number of studies have been conducted on pedestrian behavior at signalized and non-signalized pedestrian crossings, as well as the effects of pedestrian countdown displays. However, to the knowledge of authors, none of the studies has made attempts towards the examination the effectiveness of pedestrian signal countdown timer on pedestrian behavior such as compliance, crossing speed etc. in Nepalese context.

In context of Nepal, few research have been conducted on pedestrian behavior while crossing the signalized intersection. A cox proportional hazard model was developed to investigate the pedestrian behaviour to cross roads at Kathmandu valley [19]. Waiting time, pedestrian personal feature, social parameter, environmental parameter and road surface conditions are consider to develop the model. Education level and social parameters was found significant in this study. The result shows that, male pedestrians, pedestrians crossing in group, pedestrians going to work and well educated pedestrians are likely to accept higher risk and shows non-compliance behavior.

This study was carried out in Baneshwor and Narayangopal intersection to investigate the impact of countdown timer on the performance of signalized intersection. Saturation flow model and delay model shows that the capacity of road intersection can be enhanced by introducing the countdown timer [20].

3. Methodology

The methodological framework from the data collection to the model development is presented in Fig. 1. The first step is problem identification and research question design. Next is selection of predictor variables and data collection by means of questionnaire survey and videographic technique. So collected data is processed for model development. Logistic regression model is developed in SPSS. Compliance model and speed adaption model is developed to reflect the pedestrian behavior. Finally, the developed model is validated and comparision is made between the countdown timer and without countdown timer scenario.

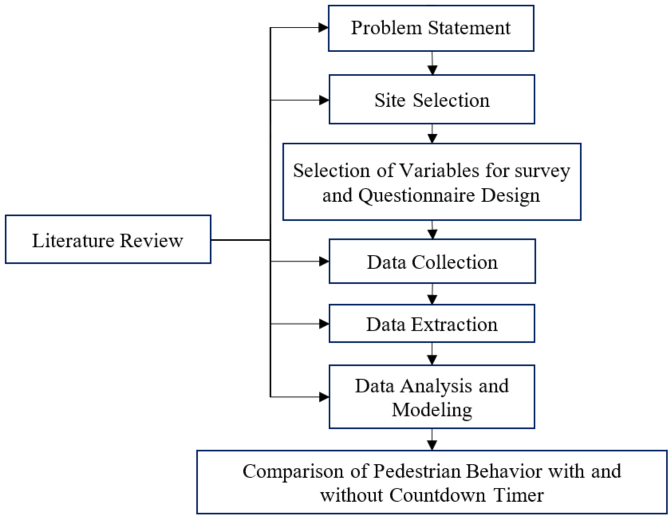

Figure 1: General framework of study

3.1 Data Collection

The data is collected through questionnaire survey and videographic technique. The different types of variables considered in this study is presented in Figure 2.

The main aim of this study is to develop pedestrian behavior (compliance and speed) model without and with signal countdown timer and ultimately investigate the effectiveness of countdown timer. For this purpose, altogether eleven number of independent variables are considered in this study. Out of them ten variables are categorical variables and wait time is continuous type variable. The dependent variables in this study is: Compliance behavior and Speed. Compliance behavior is coded as 0 and non compliance is coded as 1.

Since all the independent variables except wait time is categorical variables. So speed is also modelled as categorical variable. Speed is categories in three different classes viz low speed (speed less than 1m/s), medium speed (speed in between 1m/s to 1.4m/s) and high speed (speed greater 1.4m/s). Different variables and their types are shown in Table1.

3.2 Logistic Regression

Logistic regression is a statistical technique used to forecast binary outcomes such as "yes" or "no" based on previously observed data. The model determines the dependent variable by examining the connection between one or more independent variables.

Logistics regression compute log-odd

odd=P/(1-P)

Where,
P = probability of success and
(1-P) = probability of failure

In logistics regression, log-odd can be expressed in the liner combination and shown in the equation.

$$\log\frac{P_1}{P_2} = \alpha + \sum_{k=1}^{k} \beta_k X_k \quad (1)$$

In logistic regression, the log odd ratio can be expressed as linear combination of independent variables. In above equation 1,

Table 1: Individual and societal parameter used for study

Variable name	Description		Type
Gender	Male	0	Nominal
	Female	1	
Age	<18	0	Nominal
	19-16	1	
	>60	2	
Group Size	Single	0	Nominal
	>1	1	
Marital Status	Married	0	Nominal
	Unmarried	1	
Trip Purpose	Work	0	Nominal
	Education	1	
	Entertainment	2	
	Others	3	
Past Accident	Yes	0	Nominal
	No	1	
Use of Intersection	Frequently	0	Nominal
	Rarely	1	
Education	Un Educated	0	Nominal
	Upto 12	1	
	>12	2	
PCS search	Yes	0	Nominal
	No	1	
Time of Day	Morning	0	Nominal
	Day	1	
	Evening	2	
Wait Time	Second		Scale

P_1 and P_2 is probability of compliance and probability of non compliance. The ration of P_1 and P_2 called odds. And the result is interpreted as odd ratio. α is intercept and β is coefficient, X is independent variables.

$$P_1 = \frac{e^{\alpha + \sum_{k=1}^{k} \beta_k X_k}}{1 + e^{\alpha + \sum_{k=1}^{k} \beta_k X_k}} \quad (2)$$

Equation 2 shows the probability of begin fall in first category. α is constant term or intercept, β is coefficient for specific variables and k number of independent variables are denoted by X.

$$P_2 = \frac{1}{1 + e^{\alpha + \sum_{k=1}^{k} \beta_k X_k}} \quad (3)$$

Equation 3 shows the probability of being fall in second category or not likely to fall in first category. It is also called probability of failure. P_2 can be calculted as: P_2=1-P_1.

4. Data Analysis, Result and Discussions

The survey conducted in the month of May and June. Three days morning and evening peak data is collected with and without countdown timer. Altogether 800 valid responses are collected. Tripureshwor intersection and Narayangopal intersection is selected and both having similar road geometry and flow characteristics. Table 2 presents the socioeconomic factors and trip characteristics of pedestrian.

Table 2: Demographic Information

Variable Name	Category	Frequency	%
Gender	Male	410	51.25
	Female	390	48.75
Age	<18	219	27.38
	19-16	335	41.87
	>60	246	30.75
Group Size	Single	142	17.75
	>1	658	82.25
Marital Status	Married	497	62.13
	Unmarried	303	37.88
Trip Purpose	Work	132	16.50
	Education	254	31.75
	Entertainment	204	25.50
	Others	210	26.25
Past Accident	Yes	372	46.50
	No	428	53.50
Use of Intersection	Frequently	442	55.25
	Rarely	358	44.75
Education	Uneducated	67	8.38
	Upto 12	331	41.37
	>12	402	50.25
PCS search	Yes	552	69.00
	No	248	31.00
Time of Day	Morning	298	37.25
	Day	254	31.75
	Evening	248	31.00

Table 3: Logistic Regression model for compliance behavior

Variable Category	With Timer			Without Timer		
	B	Sig.	Exp(B)	B	Sig.	Exp(B)
I	-2.98	.05		1.32	.00	
WT	-0.11	.00	0.89	-0.04	.00	0.96
Male	-1.62	.02	0.2	-0.84	.00	0.43
Female						
<18Yrs.	-4.62	.00	0.01	-2.15	.00	0.12
19-60Yrs.	-1.67	.16	0.19	-0.85	.01	0.43
>60Yrs.						
Single	2.7	.03	14.88	-1.95	.00	0.14
Group						
Married	3.25	.00	25.84			
Unmarried						
PA yes	2.89	.00	18.05	1.1	.00	3.0
PA No						
UoI frequent	2.3	.00	9.93	0.98	.00	2.66
UoI rare						
Uneducated	-3.7	.00	0.02			
Upto 12	1.2	.12	3.32			
>12						
PCS yes	4.78	.00	118.51			
PCS no						
Morning	-0.48	.61	0.62			
Day	1.51	.15	4.5			
Evening						

4.1 Compliance Model

Compliance model is developed by using collected data. Two different model is presented in Table 3 without and with timer case. While develop the compliance model, wait time, gender, age, group size, marital status, past accident, use of intersection, education, PCS search and Time of Day are significant for with timer. Similarly, wait time, gender, age, group size, past accident, use of intersection are significant for without timer case. Compliance model is developed by using significant vaiables and shown in Table 3.

The table 3 shows that for one unit increase in wait time, the odd-log of a case compliance relative to non-compliance decrease by 0.04 unit. The odd ratio 0.96 indicate, if increase in value of wait time, the odd of compliance decreases by 0.959 times as compared to noncompliance in without timer case, but with timer case the odd of compliance is decreased by 0.89 times. Hence, higher the waiting time with countdown timers leads less compliance behavior relative to without countdown timer. As gender [0], male (b = -0.84, $p < 0.05$) was likely to decrease the compliance rate relative to non-compliance was 0.432 times than female. Under 18 age group (b = -2.146, $p < 0.05$) and age group between 19 to 60 years was likely decrease their compliance rate relative to non-compliance was 0.117 and 0.428 times respectively than those whose age is >60 years without timer case and with timer case the odds was 0.2, 0.01 and 0.19 times. The pedestrian who crosses the road singly (b = -1.948, $p < 0.05$) was likely decreases their compliance rate relative to non-compliance was 0.143 times than those who cross the road in group. Pedestrian who have past accident experience (b = 1.098, $p < 0.01$) was likely increase their compliance rate relative to non – compliance was 2.997 times as compared to who have not faced any kind of accident in past respectively. The pedestrian who uses the intersection frequently is likely increases the compliance as compared to non-compliance is 2.657 times as compared to new pedestrian for this intersection.

With timer case, Married pedestrian (b = 3.252, $p < 0.05$), pedestrian who have past accident experience (b = 2.893, $p < 0.05$) was likely increase their compliance rate relative to non – compliance was 25.83 and 18.04 times as compared to unmarried pedestrian and who have not faced any kind of accident in past respectively. The uneducated pedestrians (b = -3.69, $p < 0.05$) compliance rate as compared to non-compliance is 0.025 times and pedestrian education level upto 12 (b = 1.2, $p < 0.05$) is likely increases the compliance rate as compared to non-compliance 3.31 times relative to educated pedestrian (Education level > grade 12). Pedestrian who has search the signal is likely increases the compliance behavior relative to non-compliance 118.49 times as compared to those pedestrians who have crosses the road without searching the signal. Time of day have no significant impact on compliance behavior of pedestrian.

Hence it can be conclude that, the compliance rate of female, age greater 60 yrs, pedestrian who crosses the roads in group, married, pedestrian who faces the accident in past, and pedestrian who have search signal is increased by installing countdown pedestrian signal display and overall compliance rate of pedestrian at signalized intersection can be enhanced by 9.5% by installing countdown timer.

The classification table 4 shows the how well the model is able to predict the correct category. The percentage accuracy in prediction of compliance behavior is 97% and as that of non-compliance behavior is 94%. The model correctly classified 96% cases in overall for pedestrian signal with countdown timer case. Similarly, The percentage accuracy in prediction of compliance

Table 4: Validation of compliance model

With CPSD			
Observed	Predicted		
	0	1	Percent Correct
0	219	5	97.80
1	10	166	94.30
Overall %	57.30	42.80	96.30
Without CPSD			
	0	1	Percent Correct
0	155	31	83.30
1	41	173	80.80
Overall %	49.00	51.00	82.00

behavior is 83% and as that of non-compliance behavior is 80%. The model correctly classified 82% cases in overall for pedestrian signal without countdown timer case.

4.2 Speed model

To develop the speed model, speed is categories into three different class. Speed is categorized into different class with reference to 15th percentile speed and 85th percentile speed. The 15th percentile speed is 0.97m/s and 0.98m/s, 85th percentile speed is 1.44 and 1.5m/s without and with CPSD respectively. So to make similar range for both cases, Speed greater than 1.4 m/s is termed as high speed, speed in between 1.0m/s to 1.4m/s is termed as medium speed and speed less than 1.0m/s is termed as low speed. Firstly, speed model is developed by using all the independent variables. But only Gender, Age, Past accident and Use of intersection are found to be significant for without countdown timer. Similarly, Gender, Age, Group size, Past accident are significant for with countdown timer. So, model is developed by using significant variables only and presented in Table 6.

As gender [0], male (b = -0.444, $p > 0.05$) was likely to decrease the odd to fall in low-speed range relative to high-speed range was 0.642 times but seems to insignificant as compared to female. Under 18 age group (b = -1.337, $p < 0.05$) and age group between 19 to 60 years was likely decrease odds to fall in low-speed range relative to high-speed range was 0.263 and 0.159 times respectively than those whose age is >60 years. The pedestrian who has past accident experience (b = 0.79, $p > 0.05$) was likely increase their odds to fall in low-speed range relative to high-speed range was 2.204 but seems insignificant as compared to who have not faced any kind of accident in past respectively. The pedestrian who has frequently use the intersection (b=0.807, $p < 0.05$) was likely increases the odds of fall in low-speed range as compared to high-speed range 2.241 times as compared to new pedestrian to this intersection. Similarly, as gender [0], male (b = -0.716, $p < 0.05$) was likely to decrease the odd to fall in medium speed range relative to high-speed range 0.489 times as compared to female. Under 18 age group (b = -1.281, $p < 0.05$) and age group between 19 to 60 years was likely decrease odds to fall in medium-speed range relative to high-speed range was 0.278 and 0.336 times respectively than those whose age is >60 years. The pedestrian who has past accident experience (b = 0.873, $p < 0.05$) was likely increase their odds to fall in mediumspeed range relative to high-speed range was 2.393 times as compared to who have not faced any kind of accident in past respectively. The pedestrian who has frequently use the intersection (b=0.629, $p < 0.05$) was likely increases the odds of fall in medium speed range as compared to high-speed range 1.875 times as compared to new pedestrian to this intersection.

As gender [0], male (b = -0.905, $p > 0.05$) was likely to decrease the odd to fall in low-speed range relative to high speed range but seems to insignificant as compared to female. Under 18 age group (b = -2.029, $p < 0.05$) and age group between 19 to 60 years (b=-1.493, $p < 0.05$) was likely decrease odds to fall in low-speed range relative to high-speed range was 0.131 and 0.225 times respectively than those whose age is >60 years. The pedestrian who has past accident experience (b = 0.879, $p > 0.05$) was likely increase their odds to fall in lowspeed range relative to high-speed range was 2.409 times but seems insignificant as compared to who have not faced any kind of accident in past respectively. The pedestrian who crosses the road singly (b=1.697, $p < 0.05$) was likely increases the odds of fall in low43 speed range as compared to high-speed range 5.458 times as compared to pedestrian who crosses the road in group.

Similarly, as gender [0], male (b = -0.863, $p < 0.05$) was likely to decrease the odd to fall in medium-speed range relative to high speed was 0.422 times as compared to female. Under 18 age group (b = -1.265, $p < 0.05$) and age group between 19 to 60 years (b=-1.107, $p < 0.05$) was likely decrease odds to fall in medium-speed range relative to high-speed range was 0.282 and 0.33 times respectively than those whose age is >60 years. The pedestrian who has past accident experience (b = 1.129, $p < 0.05$) was likely increase their odds to fall in medium-speed range relative to high-speed range was 3.093 times as compared to who have not faced any kind of accident in past respectively. The pedestrian who crosses the road singly (b=1.081, $p > 0.05$) was likely increases the odds of fall in medium-speed range as compared to high-speed range 2.949 times but seems insignificant as compared to pedestrian who crosses the road in group. In overall, the pedestrian road crossing speed is increased by 0.02m/s by installing countdown pedestrian signal display.

The classification table 6 shows the how well the model is able to predict the correct category. The percentage accuracy in prediction of speed category 0 is 0% and as that of category 1 is 88% and category 2 is 33%. The model correctly classified 63% cases in overall for pedestrian signal without countdown timer case. Similarly, The percentage accuracy in prediction of

Table 5: Validation of Speed model

With CPSD				
Observed	Predicted			
	0	1	2	Percent Correct
0	0	32	0	0.00
1	0	291	0	100.00
2	0	77	0	72.80
Overall %	0.00	100.00	0.00	72.80
Without CPSD				
	0	1	2	Percent Correct
0	0	40	1	0.00
1	0	216	27	88.90
2	0	77	39	33.60
Overall %	0.00	83.30	16.80	63.7

Table 6: Logistic Regression model for pedestrian crossing speed

		With Timer				Without Timer			
Speed Category	Variable Category	B	Wald	Sig.	Exp(B)	B	Wald	Sig.	Exp(B)
0	Intercept	-0.22	0.18	0.68		0.30	0.27	0.60	
	Male	-0.44	1.27	0.26	0.64	-0.91	3.69	0.06	0.40
	Female								
	<18years	-1.34	5.65	0.02	0.26	-2.03	10.51	0.00	0.13
	19-60years	-1.84	15.29	0.00	0.16	-1.49	6.54	0.01	0.22
	>60 years								
	Past Accident [Yes]	0.79	3.72	0.05	2.20	0.88	3.29	0.07	2.41
	Past Accident [No]								
	Frequent use Int.	0.81	4.11	0.04	2.24				
	Rare use Int.								
	Group Size [Single]					1.7	6.51	0.01	5.46
	Group Size[Group]								
1	Intercept	1.42	13.9	0.00	4.12	2.22	26.22	0.00	9.23
	Male	-0.72	7.83	0.01	0.49	-0.86	8.36	0.00	0.42
	Female								
	<18years	-1.28	10.17	0.00	0.28	-1.27	9.45	0.00	0.28
	19-60years	-1.09	9.87	0.00	0.34	-1.11	6.56	0.01	0.33
	>60years								
	Past Accident[Yes]	0.87	10.66	0.00	2.39	1.13	11.64	0.00	3.09
	Past Accident[No]								
	Frequent use Int.	0.63	6.28	0.01	1.88				
	Rare use Int.								
	Group Size[Single]					1.08	3.76	0.05	2.95
	Group Size[Group]								

speed category 0 is 0% and as that of category 1 is 100% and category 2 is 0%. The model correctly classified 72% cases in overall for pedestrian signal with countdown timer case.

5. Conclusion and Recommendations

With the aim to investigating the effectiveness of pedestrian signal countdown timer installed in Kathmandu valley without considering the pedestrian crossing behavior. Both the compliance behavior and pedestrian road crossing speed model was developed based on data collection by videographic method and road side questionnaire survey. Eleven independent variables: Gender, Age, Marital Status, Group size, Past accident, Education level, Use of Intersection, Time of Day, Trip purpose are considered in this study. Test results show that:

- While developed compliance model of pedestrian without countdown timer; wait time, gender, age, group size, past accident record, use of intersection are significant variable. In addition to these variables; Marital status, Education, PCS search and Time of Day are also affect the compliance behavior of pedestrian with countdown timer.
- Compliance trend of pedestrian is increased by 9.5% by installing signal countdown timer.
- Gender, Age, Past accident, Use of Intersections are significant factors for crossing speed of pedestrian without signal countdown timer; whereas; Age, Group size, Past accident, and Time of Day are significant for speed of pedestrian with signal countdown timer.
- Speed of pedestrian is slightly increased (0.02m/s) due to installing signal coutdown timers.
- Logistic Regression analysis and the validation tests reveals that the prediction accuracy of compliance model is 83% and 96% without and with timer case respectively; and prediction accuracy of speed model is 52% and 56% respectively.

Another potential area of future research is the adoption of advanced modeling techniques, such as machine learning, to represent complicated interactions between the dependent and independent variables and improve the model's predictive capability.

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