Recommended Walking Speed Based on Pedestrians' Behavior at Mid-Block Cross in Kathmandu

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Abstract: The design of road geometry and traffic control devices provide segregation of pedestrian traffic from the vehicular flow, thereby increasing perceived safety. Walking speed is fundamental to design traffic control devices. Unfortunately no any research is conducted in Kathmandu to recommend pedestrians' walking speed. It is, as a study in Kathmandu, crossing speed of the pedestrian is recommended for designers and policy makers, at mid-block crossings. Data were collected adopting observational and interview method at mid-block un-controlled crossings from eight locations in Kathmandu. Randomly selected 400 pedestrians were observed for their crossing time and he/she was asked with a set of questions including their age, gender, marital status, have children at home, crossing frequency, in group or individual during crossing, access to private vehicle, destination, involve or witness to pedestrian accidents, education level. The walking speed is then determined by dividing the width of road by the crossing time.

The simple means were determined to compare the speed for different variants. The results thus obtained are validated statistically adopting ANOVA test. The research concludes that the road geometrical, societal and location parameters greatly affect the walking speed. However the speed at peak time and off time is nearly same. Divider is recommended to construct in two-way roads. Male and unmarried pedestrians going to office for work are walking faster. Pedestrian having vehicles and involve/witness of road accidents seem same speed as those do not have vehicle and not involved/witness to accidents.

The recommend speed for mid block cross in Kathmandu is 1.22 m/s, however at business area the speed may be taken as 1.27 m/s and for the locations out-side the ring road the speed more than 1.10 m/s is seems to be unsafe.

Keywords: Pedestrians; Safety; Crossing Speed; ANOVA; Policy Implications

Introduction

Background

Journey itself is not a primary need of society. In order to fulfill the need of society, travel demand is generated and people start journey to get their destination. They can use public vehicles, private vehicles or both combinely to make their journeys successful. Walking is such a simple and essential mode, which either involved for journeys with transport media or comes separately. In Kathmandu valley, about 40% journeys are made on foot (JICA Report 2012). However, the trend of planning and designing the road system are based on automobile oriented one, resulting the large number of accidents. Many of the road accident in Kathmandu was found occuring at pedestrian crossings (Metropolitan Traffic Police Division, Kathmandu). So there is a need of providing facilities oriented to pedestrians' safety. Tanaboriboon and Jing (1994) found that pedestrian in Beijing, preferred signalized crossings to other types, such as under or over pass crossing. It is important to provide sufficient time to the pedestrians for crossing the road safely. Different timings for vehicles and pedestrians from various directions are provided automatically by traffic signals or manually by traffic police. In order to install traffic signal, or operate manually by traffic police, the crossing speed of the pedestrian is needed. So there is a need of research to carry out in order to determine the walking speed of pedestrian at road crossings.

WHO predicts that the road traffic injuries will rise to become the fifth leading cause of death by 2030, while it was under 9th position in 2004. Over 1.2 million people die each year in the world's roads and between 20 and 50 million people suffer non-fatal injuries (Global Status Report on Road Safety – 2009 by WHO). In 068/069 among 5096 road accidents in Kathmandu Valley, 148 were fatalities, 396 serious injuries and 3317 were minor injuries (Metropolitan Traffic Police Division, Kathmandu). In most regions of the world, this epidemic of road traffic injuries is still increasing. The data shows that over 90% of the world's fatalities on the roads occur in low income and middle income countries, which have only 48% of the world's vehicle. In the same report, Nepal is one of the low-income countries. Almost half of those who die in road traffic crashes are pedestrians, cyclists or users of motorized two-wheelers – collectively known as "vulnerable road users" and this proportion is higher in low economic countries of the world. This research is

thus focused on vulnerable road users in low economic country, i.e. for pedestrian in Kathmandu, Nepal.

Research Objectives

The main objective of this research is to determine the walking speeds of pedestrians' based on a variety of behaviors and thus recommend appropriate crossing speed at mid-block cross in Kathmandu.

Specifically this research has the following objectives:

- To quantify the significance level of pedestrians' individual behavior that would influence the pedestrian walking speed at mid-block road crossing
- To determine the education level and social parameters of pedestrian as a significant variable
- To determine whether the following parameters plays significance role for assigning walking speed of pedestrians during mid-block road crossings:
  - Road surface condition
  - Road geometrical parameters
  - Time of day
- To recommend a best walking speed for pedestrians at various locations in Kathmandu

Literature Review

First of all, pedestrians' personal features play an important role in pedestrian safety crossing (McMahon et al., 1999). Some studies point to a link between age-related declines in driving and road-crossing skill and increased crash risk (Carthy et al., 1995; Helmers et al., 2004; Mathey, 1983; Oxley et al., 1997; Oxley 2000). Male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risk situation (Rosenbloom et al., 2004; Diaz, 2002).

Besides the personal features, the external environmental factors also affect the street-crossing behavior. Sisiopiku and Alking, (2003) presented findings from an observational study of pedestrian behavior at various tyes of urban crosswalks and questionnaire survey which sought pedestrian perceptions towards various crossing facilities near university campus. For example, pedestrian waiting countdown timer can influence pedestrian behavior at signalized pedestrian crossing (Keegan and Mahony, O., 2003)

Tanaboriboon and Jing (1994) found that pedestrian in Beijing, preferred signalized crossings to other types, such as under or over pass crossing. However, crashes involving pedestrians often occur in signalized intersections (Tiwari et al., 1998). The road crossing behavior of pedestrians is also influenced by the social factor. The road waiting time at pedestrian crossings decreases as pedestrian flow increases, (Hamed, M. M., 2001), suggesting that pedestrians are more inclined to cross the road along with others.

Goh B. H. et al. (2012) recommended separate speed at signalized and un-signalized crosswalk in Malasiya. The report has concluded with current design on traffic signal using 1.22 m/s does not provide sufficient time for pedestrian to cross safely. The report recommended to use sufficient time for road crossing to the pedestrian and also recommended to investigate other contributing factors of individual behavior.

Tim J. G. et al. (2006) were analyzed to determine the effect of age, disability, intersection traffic control condition, group size and gender on walking speed. They found that the groups of two or more pedestrians crossed 0.122 to 0.183 m/s slower than individual crossers. The report identifies that the current speed of 1.22 m/s is insufficient for elder pedestrians have age 60 or more, children assisted by adults, physically disabled persons, and large group of pedestrians. Based on finding the researchers suggest to use 1.158 m/s as walking speed for timing pedestrian clearance interval (Flashing Don't Walk Indication) at locations with normal pedestrian demographics (i.e. downtown areas, shopping areas, most neighborhoods, schools areas) or locations where the age or physically disability of pedestrian population is unknown.

Methodology

Data Collection

For the development of the proposed model, pedestrians attempting to cross the street were observed at eight midblock pedestrians crossing located in Kathmandu valley. These locations have similar road geometry and traffic characteristics. The one set of pedestrian's crossings consists of five crossing located on undivided streets and another set have three locations with a divided street

The data was collected in August, 2012 (Shrawan-Bhadra, 2069). The successful observation and questionnaire survey was made for total 400 pedestrians including all eight locations. The information was gathered at different time of the day including both am and pm with peak hour and off hour. The data was tried to make as randomness and possible.

The data collection part includes two phases: firstly the pedestrians were observed for waiting time and

secondly they were interviewed for some questions. Each pedestrian was monitored from the time he/she came to curbside with the intension of crossing the road until he/she starts to walk for successful crossings. The time lapsed for crossing the road by pedestrians was also noted. For the divided lane, the second waiting time and second walking time are also recorded separately. The number of attempts made by the pedestrians is also noted. Once the pedestrians have successfully crossed from opposite location of observers, they were asked a set of questions related with this research.

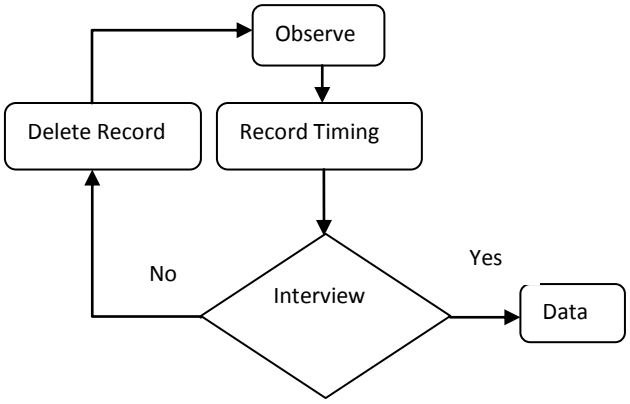

Figure 1, Flow Chart of Data Collection Process

Data includes the following parameters and are collected manually.

- Survey location
- Sample size
- Time of the day
- Behavioral and Societal parameters
- Road geometrical parameters

Survey Location

The first work for this research work is to specify the locations, which are under high-risk zone for pedestrian, during crossing of the road. In order to specify these spots, the data were taken from Metropolitan Traffic Police Office, Ramshahapath, Kathmandu, regarding road accidents. The data are available since 2067/68. The spots chosen based on these two-year accident data that includes the frequency of occurring accidents at various locations. Among all accident spots, eight most vulnerable locations were selected for taking survey work.

Sample Size Determination:

There is no data in the selected locations regarding the exact number of pedestrians crossing the road per day. The collection of data is another huge work besides the research. Therefore, the survey in the field for every 15th pedestrian as sample pedestrian. Taking observation and questionnaire is continued until the required number of sample is surveyed.

The size of sample is determined based on 95% confidence level of the population 60 thousands with 45% marginal errors. It is seen that for such type of survey; the maximum size of sample will be 384 whatever the size of sample up to 3 millions.

$$n = \frac{\chi^2 * N * P * (1-P)}{\{ME^2 * (N-1)\} + \{\chi^2 * P * (1-P)\}}$$

……..…1

Where,

n= sample size

χ^2= Chi-square for the specified confidence level at 1-degree of freedom

N= Population size

P= Population proportion (50 in this table)

ME= desired Margin of Error (expressed as a proportion)

This formula is one used by Krejcie and Morgan in their 1970 article "Determining Sample Size for Research Activities" (Educational and Psychological Measurement, #30, pp. 607-610).

Time of Taking Survey:

- Peak hour (9:00 to 11:00 am and 4:30 to 6:30 pm) and off-peak hours
- Both am and pm
- Day time as well as night time

Individual and Societal Parameters of Pedestrians

- Age
- Gender (Male/Female)
- Marital status? (Married/Unmarried)
- Have children in the house? (Yes/No)
- Have private vehicle?(Yes/No)
- Have involved or witness of any road accidents? (Yes/No)
- Is the destination to work? (Yes/No)
- Pedestrian's flow in group? (Yes/No)
- Number of road cross per day
- Education level of pedestrian

- Waiting time
- Number of attempts before successful crossing
- Crossing Time

Road Geometrical Parameters

- Width of road
- Number of lane
- Type of lane (Divided/Undivided)

Summary of Data

The summaries of data are presented herewith.

Case Processing Summary						
Cases	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Crossing speed * Age of sample?	398	99.5%	2	.5%	400	100.0%
Crossing speed * Gender?	398	99.5%	2	.5%	400	100.0%
Crossing speed * Marital Status?	399	99.8%	1	.2%	400	100.0%
Crossing speed * Have children?	398	99.5%	2	.5%	400	100.0%
Crossing speed * Have own vehicle?	397	99.2%	3	.8%	400	100.0%
Crossing speed * Have involved/witness to road accident?	394	98.5%	6	1.5%	400	100.0%
Crossing speed * Destination to Work?	393	98.2%	7	1.8%	400	100.0%
Crossing speed * No of road crossing per day?	393	98.2%	7	1.8%	400	100.0%
Crossing speed * Education level?	394	98.5%	6	1.5%	400	100.0%
Crossing speed * Carrying something during crossing?	389	97.2%	11	2.8%	400	100.0%
Crossing speed * Crossing in group?	389	97.2%	11	2.8%	400	100.0%
Crossing speed * Waiting time at curbside	400	100.0%	0	.0%	400	100.0%
Crossing speed * No of attempts before successful cross?	340	85.0%	60	15.0%	400	100.0%
Crossing speed * location?	400	100.0%	0	.0%	400	100.0%
Crossing speed * Surface condition (SDI)?	400	100.0%	0	.0%	400	100.0%
Crossing speed * Does lane Divided?	400	100.0%	0	.0%	400	100.0%
Crossing speed * Time of observation?	400	100.0%	0	.0%	400	100.0%

Statistical Analysis

Randomly selected data thus collected were checked for multi-colinearity. The data were tabulated, organized and coded into a single data file for detailed analysis of walking speed ass a function of various factors. The time taken by pedestrians to cross the road was recorded first. The walking speed of pedestrians was then determined dividing the section of road width by the time taken to cross the road. The walking speed data were analyzed using *Univariate General Linear Model command in* SPSS-16.

One-Way ANOVA

We can use the One-Way ANOVA procedure to test the hypothesis that the means of two or more groups are not significantly different. One-Way ANOVA also offers:

- Group-level statistics for the dependent variable
- A test of variance equality
- A plot of group means
- Range tests, pair wise multiple comparisons, and contrasts, to describe the nature of the group differences

Pair wise multiple comparisons

An important first step in the analysis of variance is establishing the validity of assumptions. One assumption of ANOVA is that the variances of the groups are equivalent. In general, F statistics establish that there is or is not a difference between group means, and means plots suggest where the difference may lie. We can use the One-Way ANOVA procedure to specify exactly how the means differ and test those specifications

Contrasts are an efficient, powerful method for comparing exactly the groups that we want to compare, using whatever contrast weights that we required. However, there are times when we do not have, or do not need, such specific comparisons. The One-Way ANOVA procedure allows us to compare every group

mean against every other, a method known as pairwise multiple comparisons

Post hoc

Post hoc results are valid to the extent that the standard F statistic is robust to violations of assumptions. As mentioned before, the F statistic is robust to unequal variances when sample sizes are equal or nearly equal. However, when both the variances and the sample sizes differ, the standard F statistic lacks power and is prone to give incorrect results. This section discusses two analysis of variance methods available in the One-Way ANOVA procedure that provide an alternative in these circumstances.

With the One-Way ANOVA procedure, you are able to:

- Validate the assumption of variance equality
- Obtain the ANOVA table and results
- Visually inspect the group means
- Perform custom contrasts, tailored to your specific hypotheses
- Compare each mean to every other mean, assuming variance equality or not
- Perform two types of robust analysis of variance

GLM Univariate

The GLM Univariate procedure allows us to model the value of a dependent scale variable based on its relationship to categorical and scale predictors. The GLM Univariate procedure is based on the General Linear Model procedure, in which factors and covariates are assumed to have a linear relationship to the dependent variable. Factors Categorical predictors should be selected as factors in the model. Each level of a factor can have a different linear effect on the value of the dependent variable.

Fixed-effects factors

These are the factors which generally thought of as variables whose values of interest are all represented in the data file.

Random-effects factors

These are the factors whose values in the data file can be considered a random sample from a larger population of values. They are useful for explaining excess variability in the dependent variable.

Covariates Scale predictors

Covariates Scale predictors should be selected as covariates in the model. Within combinations of factor levels (or cells), values of covariates are assumed to be linearly correlated with values of the dependent variables.

Interactions

By default, the GLM Univariate procedure produces a model with all factorial interactions, which means that each combination of factor levels can have a different linear effect on the dependent variable. Additionally, we may specify factor-covariate interactions, if we believe that the linear relationship between a covariate and the dependent variable changes for different levels of a factor.

For the purposes of testing hypotheses concerning parameter estimates, GLM Univariate assumes:

- The values of errors are independent of each other and the variables in the model. Good study design generally avoids violation of this assumption.
- The variability of errors is constant across cells. This can be particularly important when there are unequal cell sizes; that is, different numbers of observations across factor-level combinations.
- The errors have a normal distribution with a mean of 0.

Using GLM Univariate to perform an Analysis of Covariance:

By specifying an interaction between the covariate and factor, we are able to test the homogeneity of the covariate parameter estimates across levels of the factor. Since the interaction term was not significant, indicating the covariate parameter estimates are homogenous, we proceeded with an analysis of covariance. If the interaction term was significant, we could use the model with the interaction term, with the understanding that assessing the effect of program participation is complicated by the presence of the interaction. Random effects are often factors that are not of direct interest to the problem at hand. It requires a little forethought to consider that store-to-store variation might be a useful model term and consequently include it in the data collection process.

Finally, the GLM Univariate procedure is useful for modeling the linear relationship between a dependent scale variable and one or more categorical and scale predictors.

- If we have only one factor, we can alternatively use the One-Way ANOVA procedure.
- If we only have covariates, we use the Linear Regression procedure for more model-building, residual-checking, and output options.

Results and Discussions

Introduction

For the comparison of various means, ANOVA test was conducted with the null hypothesis that the various categories do not have the statistically different mean. From the test it is seen that the some results accept null hypothesis and some reject it.

Distribution of pedestrian speed based on Age

Figure 2 shows that the crossing speed distribution based on the pedestrians' age. It is clear that the speed declines with older pedestrians than younger pedestrians. However this result is not statistically significant. So the result may be due to the chance.

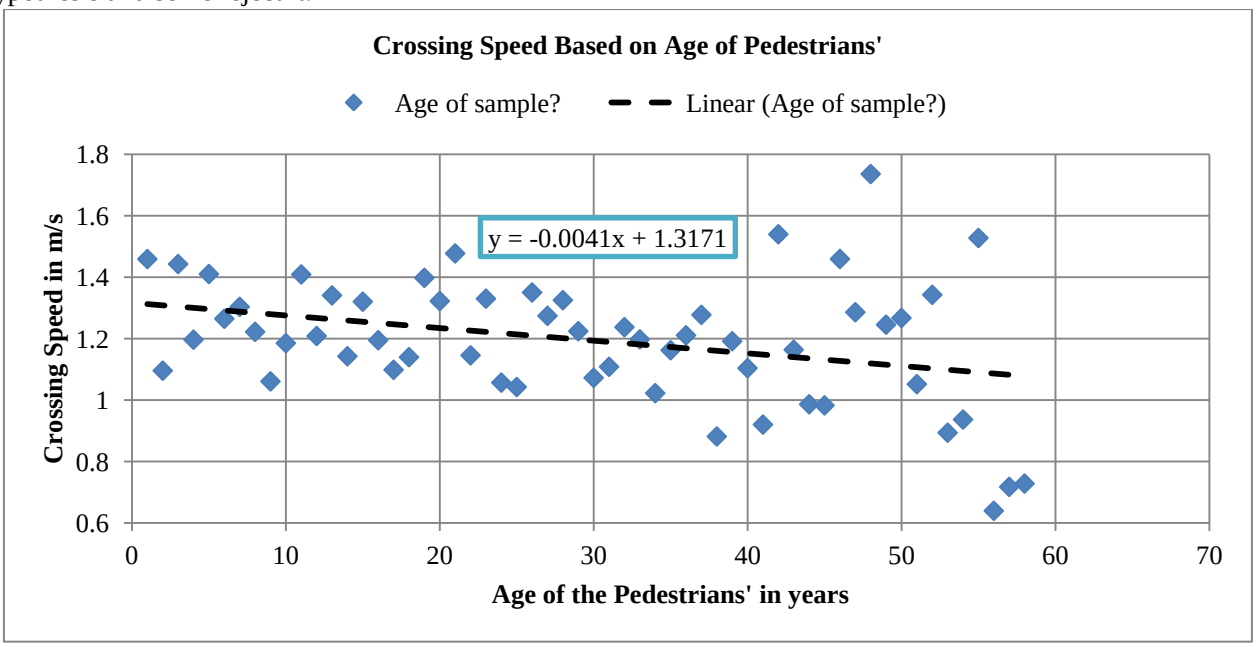

Figure 2: Distribution of pedestrian speed based on Age

Distribution of pedestrian speed based on Gender

Table 1: Distribution of pedestrian speed based on Gender shows that the speed of road crossings at mid-block cross for male is 1.186 m/s, while for female is 1.115 m/s. It shows that the male pedestrian crosses road 0.071 m/s faster than female pedestrians

Table 1: Distribution of pedestrian speed based on Gender

Gender?	Mean	N	Std. Deviation	Sig.
Female	1.17678	145	0.299682	0.131
Male	1.23504	253	0.40365	
Total	1.21381	398	0.369848	

Distribution of pedestrian speed based on Marital Status

Table 2: Distribution of pedestrian speed based on Marital Status shows that the unmarried pedestrians walk much faster than married pedestrians. However the result may be due to randomness.

Table 2: Distribution of pedestrian speed based on Marital Status

Marital Status?	Mean	N	Std. Deviation	Sig.
Unmarried	1.24707	154	0.406806	0.189
Married	1.19685	245	0.347087	
Total	1.21624	399	0.371582	

Distribution of pedestrian speed based on Have Children at home?

Table 3: Distribution of pedestrian speed based on Have Children at home?Shows that the pedestrians having children at their home, walk much slower than those who don't have. The result is not verified statistically.

Table 3: Distribution of pedestrian speed based on Have Children at home?

Have children?	Mean	N	Std. Deviation	Sig.
No	1.2546	176	0.396899	0.072
Yes	1.18702	222	0.348665	
Total	1.21691	398	0.37181	

Distribution of pedestrian speed based on Have Own Vehicle?

Table 4: Distribution of pedestrian speed based on Have Own Vehicle? Shows that the pedestrian walk faster if they have their own vehicles, however the mean of two categories doesn't seem different.

Table 4: Distribution of pedestrian speed based on Have Own Vehicle?

Have own vehicle?	Mean	N	Std. Deviation	Sig.
No	1.22041	300	0.379576	0.762
Yes	1.20724	97	0.350261	
Total	1.21719	397	0.372236	

Distribution of pedestrian speed based on Have Involved/Witness to Road Accident?

Table 5: Distribution of pedestrian speed based on Have Involved/Witness to Road Accident Shows that the pedestrians who are involved or witness of road accidents, walk much slower than those who are not. However the two means are not significantly different.

Table 5: Distribution of pedestrian speed based on Have Involved/Witness to Road Accident

Have involved/witness to road accident?	Mean	N	Std. Deviation	Sig.
No	1.21258	230	0.384938	0.822
Yes	1.22116	164	0.353649	
Total	1.21615	394	0.371797	

Distribution of pedestrian speed based on Average Number of Road Cross per Day

Figure 3: Distribution of pedestrian speed based on Average Number of Road Cross per Day shows that the speed doesn't seem much changing based on average number of road cross per day.

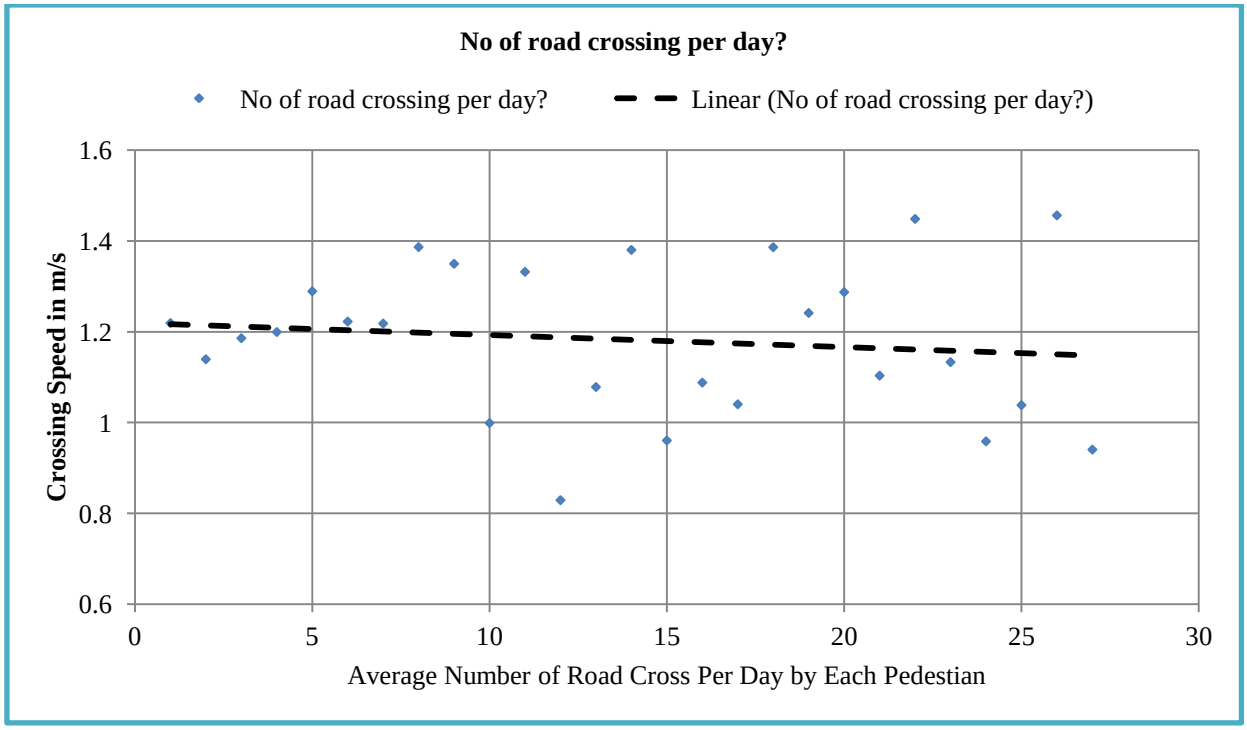

Figure 3: Distribution of pedestrian speed based on Average Number of Road Cross per Day

Distribution of pedestrian speed based on Destination to Work?

Table 6: Distribution of pedestrian speed based on Destination to Work? Shows that the pedestrians going to work in their office seems much hurry than other pedestrians.

Table 6: Distribution of pedestrian speed based on Destination to Work?

Destination to Work?	Mean	N	Std. Deviation	Sig.
other than work or office	1.20706	329	0.320998	0.213
to the work	1.26976	64	0.552068	
Total	1.21727	393	0.368424	

Distribution of pedestrian speed based on carrying something During Crossing the Road?

Table 7 shows that the pedestrian who is carrying something in their hand walk slower than that those don't carrying anything in their hand.

Table 7: Distribution of pedestrian speed based on Carrying Something During Crossing the Road?

Carrying something during crossing?	Mean	N	Std. Deviation	Sig.
nothing	1.21619	216	0.335527	0.934
something	1.21305	173	0.414799	
Total	1.21479	389	0.372368	

Distribution of pedestrian speed based on pedestrians' Crossing Road in Group?

Table 8: Distribution of pedestrian speed based on pedestrians' **Crossing Road in** Group? Shows that the pedestrian in group cross the road comfortably and slowly. Each pedestrian crossing the road alone walk about 0.032 m/s faster as compare to the pedestrians crossing with others.

Table 8: Distribution of pedestrian speed based on pedestrians' Crossing Road in Group?

Crossing in group?	Mean	N	Std. Deviation	Sig.
not in group	1.24117	226	0.320666	0.067
in group	1.17118	163	0.432243	
Total	1.21184	389	0.372603	

Distribution of pedestrian speed based on Education Level

Figure 4: Distribution of pedestrian speed based on Education Level shows that the more educated persons walk faster than less educated.

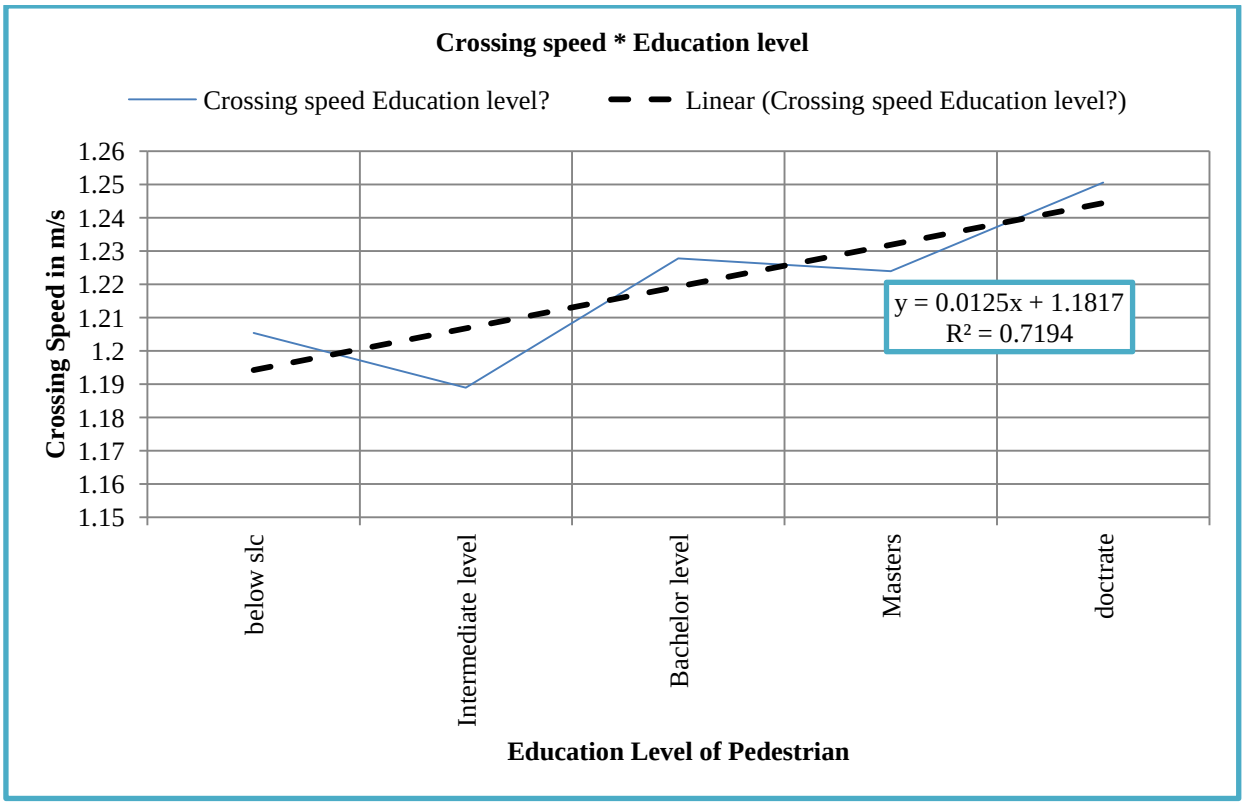

Figure 4: Distribution of pedestrian speed based on Education Level

Distribution of pedestrian speed based on Waiting Time at Curbside

Figure 5: Distribution of pedestrian speed based on Waiting Time at Curbside shows that the waiting time at the curbside not greatly influences to change the crossing speed.

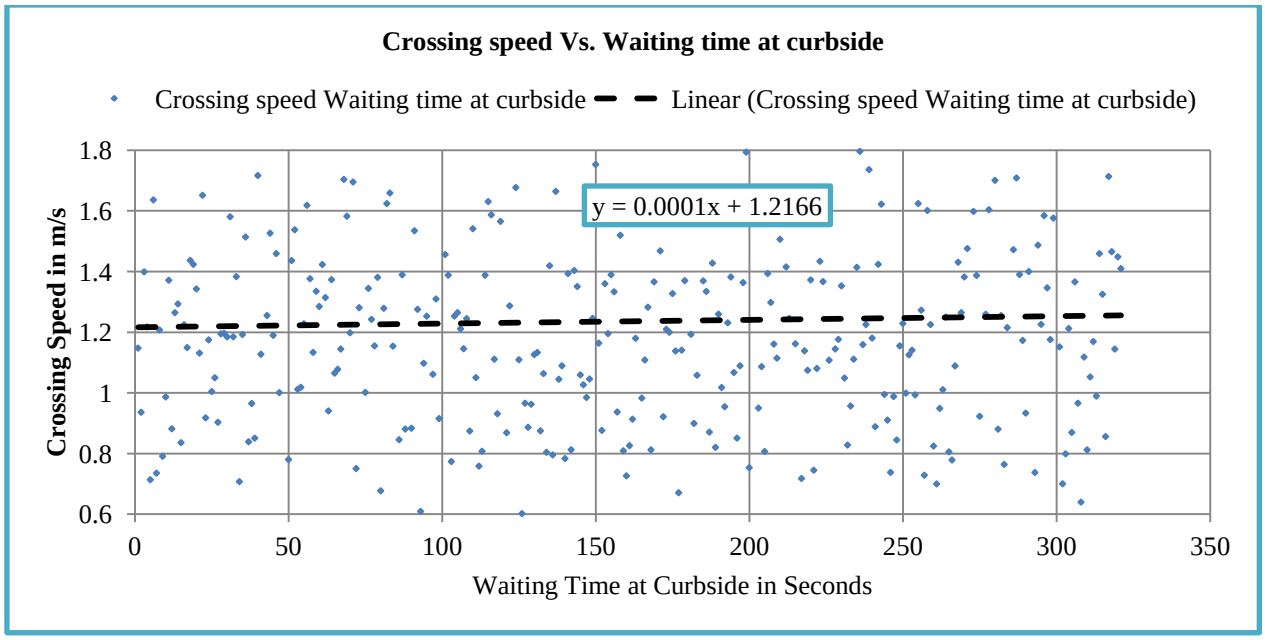

Figure 5: Distribution of pedestrian speed based on Waiting Time at Curbside

Distribution of pedestrian speed based on Average Number of Attempts Before Successful Cross

Figure 6: Distribution of pedestrian speed based on Average Number of Attempts Before Successful Cross shows that the as number of unsuccessful attempts increases, the crossing speed of pedestrian also increases.

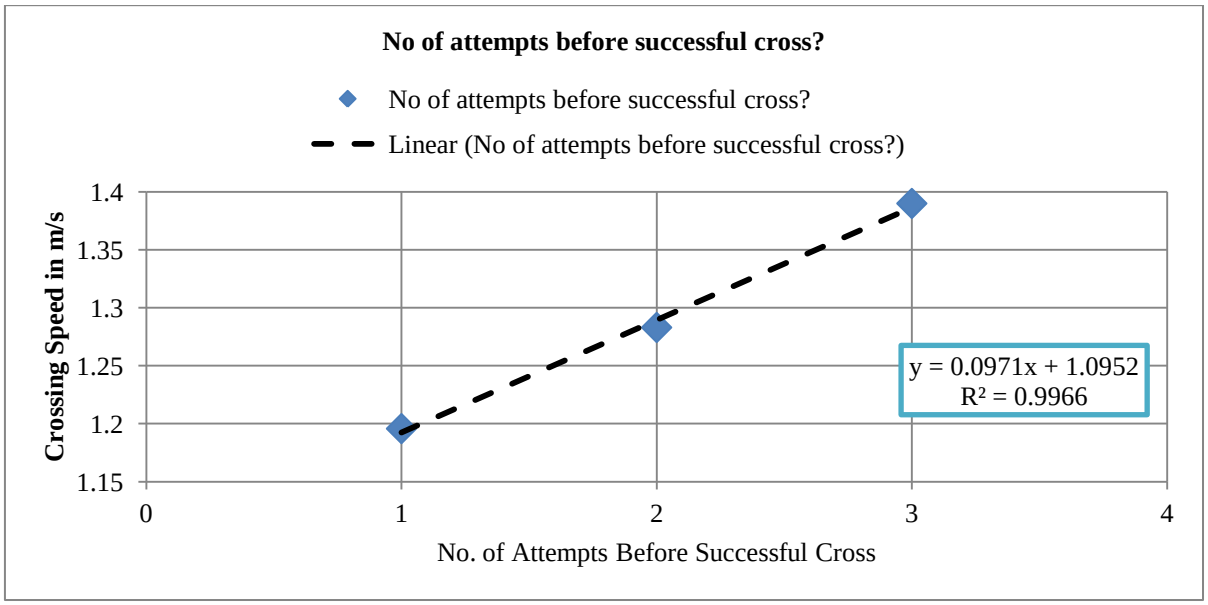

Figure 6: Distribution of pedestrian speed based on Average Number of Attempts Before Successful Cross

Distribution of pedestrian speed based on Location

Table 9, shows the result for road crossing by pedestrians at various locations. The result is statistically significant as significance level = 0.000.

Table 9: Distribution of pedestrian speed based on Location

location?	Mean	N	Std. Deviation	Sig.
Gaushala	1.12506	55	0.51891	0.000
Bauddha	1.08473	50	0.314578	
Jaulakhel	1.28633	50	0.35692	
Thapathali	1.08259	45	0.352446	
Durbarmarga	1.28738	51	0.293961	
Koteshor	1.27413	49	0.275391	
Soltimod	1.12902	50	0.267071	
Kalanki	1.45541	50	0.360476	
Total	1.21615	400	0.371121	

Distribution of pedestrian speed based on Road Surface Condition

As the road surface condition goes on poorer, the speed of crossing road by the pedestrian decreases. The result is presented in Table 10 and also in Figure 7.

Table 10: Distribution of pedestrian speed based on Road Surface Condition

Surface condition (SDI)?	Mean	N	Std. Deviation	Sig.
1	1.28089	100	0.283652	0.04
2	1.21017	245	0.35967	
3	1.12506	55	0.51891	
Total	1.21615	400	0.371121	

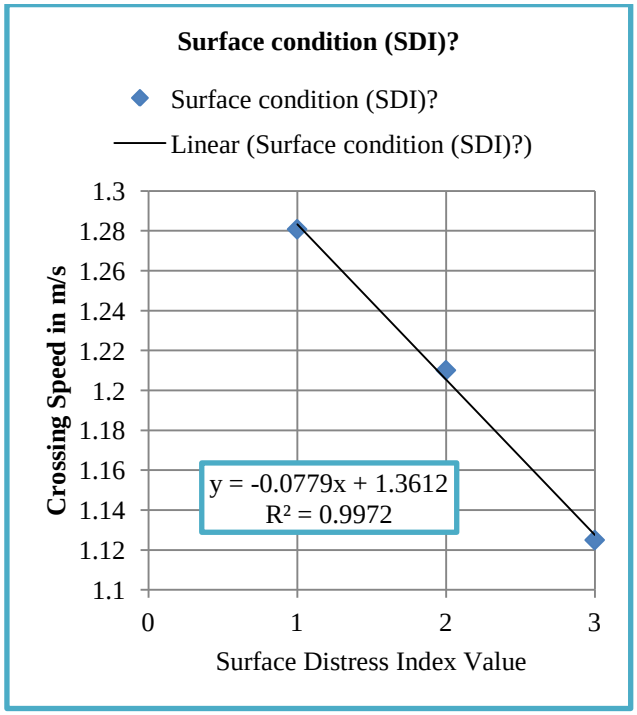

Figure 7: Crossing Speed of Pedestrian based on Surface Distress Index Value

Distribution of pedestrian speed based on Existence of Median

Table 11 tells us that the people in divided road feel easy for crossing the road. Based on speed if there exist a divider, people walk 0.0771 m/s slower than that location where the median exist. The result was validated based on statistical approach as significance level < 0.05.

Table 11: Distribution of pedestrian speed based on Existence of Median

Does lane Divided?	Mean	N	Std. Deviation	Sig.
Undivided	1.24507	250	0.340832	0.044
Divided	1.16794	150	0.41346	
Total	1.21615	400	0.371121	

Distribution of pedestrian speed based on Time of Observation

Table 12 shows that the people seem hurry at peak time than off-time. People travel 0.015 m/s faster in peak time than that of off-time. However the result may be due to chance.

Table 12: Distribution of pedestrian speed based on Time of Observation

Time of observation ?	Mean	N	Std. Deviation	Sig.
Off time	1.22225	237	0.330195	0.692
Peak Time	1.20727	163	0.424571	
Total	1.21615	400	0.371121	

Summary of Results

- The mean speed 1.216 m/s,
- Nearly equal to 1.220 m/s
- Individual Behaviors
    - Speed declines with older pedestrians
    - Male 0.0536 m/s faster than Female
    - Unmarried 0.0502 m/s faster than married
    - who do not have the children 0.0676 m/s faster than who have children at their home
    - Going to Work are hurry as they walk 0.0627 m/s faster than others
    - More educated walk faster
- Individual Behaviors
    - Crossing speed doesn't seem different for
        - Who have own private vehicle
        - Who are involved in road accidents
        - carrying hand bag or something
        - Time of day (peak time and off time)
- Societal parameters
    - Pedestrian feel comfort to cross roads along with others in group rather than single, 0.0700 m/s slower
    - This result is at the range of significance level.
- Road Geometrical Parameters:
    - Pedestrians in un-divided roads are crossing much faster and about 0.0771

m/s. This result is validated statistically as significance level lies below 0.05.

- As the road surface condition goes on poorer, the speed of crossing road by the pedestrian decreases

- Location and Environmental parameters
  - Pedestrian at business area are walking much faster
    - At Durbarmarga and Koteshor (in front of Bhatbhateni Super Market) the walking speed is 1.28 m/s.
    - However the crossing speed at Bauddha (in front of hospital) the walking speed is only 1.08 m/s.
    - 0.2 m/s is the difference
  - The result is Kalanki seems quite different because of jaw-crossings.
  - Soltimode shows the the speed of pedestrian is 1.13 m/s.

Conclusions and Recommendations

Conclusions

In this research, the walking speed of pedestrians at mid-block road cross in Kathmandu is determined based on the road geometrical parameters, pedestrians' individual behavior and societal parameters. The simple means are determined to compare the speed for different variants and the results are validated statistically adopting ANOVA test. Separate analysis of each 17-variable were carried out. Among them some models are validated statistically and some requires further study. Categorical variables are presented in tables and ordinal and continuous variables are presented graphically.

- **We conclude that the individual behaviors of pedestrians affect the speed during crossing the road.**

- The mean speed obtained from this research is 1.216 m/s. Male pedestrians walk 0.0536 m/s faster as compared with Female pedestrians. Similarly unmarried pedestrians walk 0.0502 m/s faster as compared with married pedestrians. Those pedestrians who do not have the children at their home are crossing the 0.0676 m/s faster as compared with the pedestrians who have children at their home. Hence it is concluded that the behavior of pedestrians affect the speed during crossing the road. Crossing speed doesn't seem different for pedestrians who have own private vehicle with who do not have and those who are involved in road accidents with those who are not. Pedestrians who are going to their office for the work seem quite hurry as they walk 0.0627 m/s faster with respect to those who are not going for the office work. Pedestrians carrying hand bag or something other than hand bag are walking nearly same speed as those who are not carrying anything.

- **We also conclude that the societal parameters significantly affect the speed of pedestrians.**

  The results show that the pedestrian feel comfort to cross roads along with others rather than single, as they walk 0.0700 m/s slower as compared with pedestrians crossing road individually. This result is at the range of significance level. Hence we conclude that the societal parameters also affect the speed of pedestrians at mid-block road crossings.

- **Road geometrical parameters greatly affect the speed of walking at mid block crossings. However the speed at peak and off time is nearly same.**

  Same result is obtained for divided and undivided roads. Pedestrians in un-divided roads are crossing much faster and about 0.0771 m/s. This result is validated statistically as significance level lies below 0.05. Road surface condition is also significantly affecting the speed of pedestrians at mid block crossings. Hence we can say that road geometrical parameters also affect the speed during crossing the road.

- **The nature of surrounding area or location is one parameter that affect the speed during crossing the road**

  Pedestrian at business area are walking much faster as compared with hospital areas and other intermediate crossings. At Durbarmarga and Koteshor (in front of Bhatbhateni Super Market) the walking speed is 1.28 m/s. However the crossing speed at Bauddha (in front of hospital) the walking speed is only 1.08 m/s. The result is Kalanki seems quite different because of jaw-crossings. Soltimode shows the the speed of pedestrian is 1.13 m/s. hence it can be concluded that the nature of surrounding area or location is one parameter that affect the speed during crossing the road.

Recommendations

This research recommended to use 1.22 m/s is the walking speed for pedestrians at mid block cross in Kathmandu. However the speed provided may vary based on the characteristics of the locations.

The research finally recommend the followings:

- Road geometrical parameters greatly affect the speed of walking at mid block crossings. However the speed at peak time and off time are nearly same. Based on pedestrian oriented design point of view, divider is recommend to construct in two-way roads for comfort and safety during crossings.
- Good surface condition is recommended to maintain in good condition for higher crossing speed of pedestrians and enhance road capacity.
- The speed in mid block cross in Kathmandu significantly depends up on the nature of location and the recommended speed is 1.22 m/s. However at business area the speed may be taken as 1.27 m/s (Durbarmarga, Jaulakhel, Koteshor etc) and for the locations out-side the ring road the speed more than 1.10 m/s (Bauddha) is seems to be unsafe.
- A detail comprehensive study is recommended including intersections both signalized and un-signalized along with the mid block crossings.
- Disabled people are recommended to take under considerations during conducting similar research.

It is hoped that this piece of research work will increase the sophistication of measurement in this area to better understand pedestrians' behavior at pedestrian crossings.

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