Integrated Road Infrastructure Interventions on Implementation of Pedestrian Safety Rules in the City of Kisumu, Kenya

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Abstract

The study investigates combined road infrastructure interventions namely Education, Engineering, Enforcement and pedestrian demographic factors on implementation of pedestrian safety rules in the City of Kisumu. From a target population of 409,928 residents, 384 road users were sampled for both quantitative and qualitative data. Mixed method approach and pragmatism enabled the use of Ex post facto design and descriptive survey designs to obtain, analyze and report the findings of the study. The findings reveal that from the combined road infrastructure interventions ($R^2 = .254$; $p < .001$), enforcement of traffic laws ($p < 0.001$) and pedestrian demographic factors ($p < 0.001$) individually, statistically significant to influence implementation of pedestrian safety rules. On the contrary, road engineering design ($p = 0.102$) and public education on road safety ($p = 0.313$) did not have a statistically significant influence. The study concludes that integrating road infrastructure interventions improves implementation of pedestrian safety rules.

Key words: *Enforcement, Implementation of pedestrian safety rules, Integrated, Pedestrian demographic factors, Public education, Road engineering design,*

1. INTRODUCTION

Road infrastructure interventions for pedestrians include Education, Engineering, Enforcement and pedestrian demographic factors which exist globally but prove ineffective when used in isolation. Previous studies on engineering, enforcement, education, pedestrian demographic factors and attitude of pedestrians have been carried out in isolation with little focus on pedestrians, thus implementation of pedestrian safety rules (Federal Highway Authority (FHWA), 2012; WHO, 2013) is still not adequately addressed. Globally, the National Highway Transport Safety Authority (NHTSA), 2006 recommends the development and implementation of an integrated road safety program, definitive of the state's demographic characteristics, so as to ensure considerable reduction in traffic crashes and injuries on the roads. It further recommends a pedestrian safety program that promotes safe pedestrian practices, educates drivers to share roads safely with other road users, and also provides safe facilities for pedestrians through a integrated policy involving communication, education, engineering strategies and enforcement. Given the multidisciplinary nature of the road safety problem, a comprehensive implementation of pedestrian safety rules requires coordination among several state agencies (FHWA, 2012).

Thomas et al. (2012) in New Zealand and the Highway Safety Programs Guideline (2006) cited this combined approach as effective solutions in reducing road crashes. Institutions and people working towards implementation of pedestrian safety rules tend to favour either engineering measures or behaviour-change measures depending on their training and experience, but significant and sustainable improvement to pedestrian safety rules require a balanced approach that includes both perspectives (Loreno, Clinton and Sleet 2006, Pedestrian Safety Manual 2013) essential to a balanced Safe System Approach.

Despite the existence of road infrastructure interventions, pedestrian fatalities and injuries remain high. In view of this, Zegeer (2006) advocated for a universal design that would involve designing for all road users, the able bodied and the physically impaired that would address implementation of pedestrian safety rules. Road engineering designs should ideally cater for all road users whether motorists or non-motorists. The road transport system has historically focused on increasing mobility of motor vehicles on the road and has therefore designed roads for motorists. Less attention has however been paid to pedestrians and their safety (Campbell *et al.,* 2004) hence its historical neglect as well (Massoud et al., 2011). Universal design is therefore ideal in addressing implementation of pedestrian safety rules.

Acknowledging road infrastructure interventions as the road transport pillar and core foundation on which road safety is founded, Massoud et al., (2011) adds that engineering interventions are critical factor in determining the quality of the road transport system. However, engineering interventions alone are inadequate without the influence of education, enforcement and pedestrian demographic factors. This study adopted a proactive approach where integration of education, engineering, enforcement and pedestrian demographic factors was expected to prevent or reduce fatalities and injuries of pedestrian road users.

Road safety depends on man, vehicle and highway conditions that influence it (Fluery, 2006; Tingrall and Haworth, 2006 and Zheng *et al.,* 2010) where man represents all road users including pedestrians and drivers, vehicle includes all instruments on the road causing injury or death while highway conditions represent road infrastructure in line with the safe systems approach theory which advocates for safer roads, safer vehicles, safer speeds and safer road users for a sustainable urban road transport. Implementation of pedestrian safety rules needs to be tackled from the safe systems approach theory. Harry (2010) attributes road engineering designs such as sidewalks, zebra crossings and pavements as having the potential to minimize accidents or, in case of accidents, prevent road users from severe injury or death. Despite putting these pedestrian facilities in place, implementation of pedestrian safety rules is still a problem.

Statistical evidence reveal that pedestrians are the leading category of road users killed in road traffic crashes at 46% in Kenya (Ogendi and Odero, 2012).The City of Kisumu follows at 45% (Opiyo, 2005) which is above the regional and global figures at 38% and 22% respectively. However, often lost in these road safety statistics is the fact that a large number of auto related deaths and injuries every year were not drivers and passengers but pedestrians (iRAP, 2009 Kenya results) yet in the City of Kisumu alone pedestrian accidents caused one fifth of injury related hospital admissions (Ogendi *et al.*, 2013). Compared to other cities in Kenya such as Nairobi and Mombasa, pedestrians in the City of Kisumu are highly vulnerable in the road safety situation and constitute 80% victims of the fatalities. Pedestrians are over represented in the road traffic injuries and deaths yet often ignored in the road infrastructure intervention planning process. Pedestrians account for 45% of road traffic fatalities but receive very little of the road safety funding. The funding allocated for road infrastructure interventions development exists but few projects are pedestrian-oriented. The national and county government has not only failed to allocate adequate funding to address the implementation of pedestrian safety rules but are beginning to remove the road infrastructure interventions due to the belief that they provide pedestrians with a false sense of safety (Wasike, 2007).

The City of Kisumu is reported as having a high population of 409,938 residents and densely populated areas in excess of 350 persons per kilometer square (RoK Census, 2009) with 48% of the urban population living below the absolute poverty bracket yet, the city's population continue to grow, at the rate of 2.8% per annum (UN-HABITAT City of Kisumu Development Strategies (CDS), 2004 - 2009). The high pedestrian activity and traffic mix that result leads to 55% of pedestrian collisions that occurred within the City of Kisumu. It is based on the foregoing background and literature that this study investigates the integration of road infrastructure interventions and implementation of pedestrian safety rules in the City of Kisumu.

2. RESEARCH METHODOLOGY

2.1 Purpose

The purpose of this study was to establish integration of road infrastructure interventions, attitude of pedestrians on implementation of pedestrian safety rules on selected roads in the city of Kisumu, Kenya.

2.1.1 Hypothesis

Hypothesis: There is a significant relationship between the combined road infrastructure interventions and implementation of pedestrian safety rules in the City of Kisumu.

2.2 Study Population

This study targeted road users from a universe population of 409,928 residents of the City of Kisumu, including pedestrians assumed to have walked along or across and drivers who have driven on the sampled roads.

2.3 Study design

This study adopted both *Ex post facto* design and descriptive survey designs. *Ex post facto* exploratory design involved pilot testing, content analysis on previous research findings or documents, theory formulation, one's own observation, open ended questions, and test alternative hypotheses using inferential statistics from samples drawn from the target population to account for the results obtained. Descriptive survey research design was also used where information was obtained from a sample rather than the entire population in line with the cross-sectional sub-type of descriptive survey study design. From data collected using questionnaires, descriptive survey provided numeric descriptions of a sample as they were, as they would be and did not involve manipulation of the independent variable. The choice of these two research designs was informed by the fact that both descriptive and inferential data analysis was adopted in this thesis. *Ex post facto* design and descriptive survey design blended and complemented the strengths in a study that hoped to get the best of the difference.

2.4 Sample Size and Sampling Method

The study used Krejcie and Morgan (1970) formula applied at 95 % confidence level to select 384 road users from a universe population of 409,928 residents of Kisumu. The road users were conveniently classified and proportionately distributed to include 284 pedestrians out of which 200 responded to the questionnaires, 50 to the observation checklist, 34 interview guide as well as 100 drivers who responded to the driver questionnaires. Consequently, primary respondents were pedestrians with the other categories of road users, such as drivers providing supporting information.

This study applied both probability and non-probability sampling procedures to obtain a sample of roads and respondents. Probability sampling procedures included Stratified random sampling to control for gender and quota sampling for type of urban road on the ten sampled roads and cluster random sampling to divide the urban roads into clusters rather than use individual roads due to lack of sampling frame. Non-probability sampling procedure included purposive sampling procedure to sample the ten urban roads while convenience sampling to get the respondents.

2.5 Data Collection

This study applied four instruments namely questionnaire, interview schedule, observation walkability checklist and document analysis to collect quantitative and qualitative data. The self administered questionnaire adopted the iRAP star rating for pedestrians and drivers. The questionnaires were designed on the basis of LIKERT summated scales for road infrastructure interventions and implementation of pedestrian safety rules. To test reliability of the questionnaires, Cronbach's alpha coefficient was used. A research letter of transmittal was drafted by the student to the University of Nairobi and forwarded by the University to enable the researcher approach the Ministry of roads officials concerned with the sampled roads. The national research permit was obtained from the National Commission for Science, Technology and Innovation (NACOSTI) as a research approval. For the interview schedules, the researcher conducted face-to-face interviews from engineers, town planners, Kenya Urban Roads Authority (KURA) officials, educators, law enforcement officers, parents and pedestrians who gave relevant information.

2.6 Data Analysis

The quantitative data collected was processed and entered into SPSS version 22.0 for descriptive and inferential analysis. For descriptive statistics, data was described and summarized into distribution of scores using frequency, means and standard deviation. Qualitative data obtained from interviews with key informants was analyzed thematically based on the emerging themes. In order to make inferences on the study population and the research variables, inferential statistic, in this study multiple linear regression was used. Multiple Linear Regression Analysis was used to explain the relationship between road infrastructure interventions (public education, road engineering design, enforcement of traffic laws and pedestrian demographic factors) and implementation of pedestrian safety rules. The variables were hypothesized to be related by the following equation:

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where: $\hat{Y}$ is implementation of pedestrian safety rules

β_0 is the constant term

β_1, β_2, β_3 and β_4 are coefficients of the road infrastructure interventions (X_1, X_2, X_3 & X_4)

X_1, X_2, X_3 & X_4 are the road infrastructure interventions (public education, road engineering design, enforcement of traffic laws and pedestrian demographic factors)

During hypothesis testing, the final model only included variables whose coefficients were statistically significant for 95% confidence level ($p < .05$).

3. FINDINGS

3.1 Reliability of the instruments

A reliability analysis was carried out using Cronbach alpha for each of the instruments. In cases where the reliability values were low, items were deleted in order to maximize the reliability coefficient for the instruments. The reliability co-efficient for various scales in each instrument is presented in Table 1.

Questionnaire for pedestrians returned an alpha coefficient $\alpha = 0.702$ while the instrument for drivers had $\alpha = 0.72$. For social sciences, an alpha co-efficient of 0.7 and above is considered reliable in social sciences research (Oso & Onen, 2009).

3.2 Socio-Demographic Characteristics of the road users

The socio-demographic characteristics for the participants were analyzed using frequencies and percentages and presented in table 2.

From the analysis, 56% of the respondent pedestrians were male and 44% female while for drivers, 77.0% were males and 23.0% females. Majority of the pedestrians who participated in the study were aged between 30 to 40 years accounting for 30% with another 27.5% aged between 40 – 50 years. On the other hand, the majority of drivers were aged between 30 and 40 years (38%), 26% were aged between 20-30years. In terms of place of residence majority of pedestrians (59.5%) and 46% of drivers lived in peri-urban areas.

3.3 Road Infrastructure Interventions

Descriptive analysis of the road infrastructure interventions is presented in table 3

On public education on road safety, pedestrians generally agree that publicity and advertising should be increased (Mean = 4.52; SD = 0.778) and that there should be increased knowledge of the traffic act (Mean = 4.47; SD = 0.821). However, both pedestrians and drivers view on public education was neutral (Mean = 3.118; SD = 0.818) which indicates that majority of the pedestrians and drivers could neither approve of object the existing state of public education on road safety. The study found that the pedestrians were not impressed with the status of road engineering design scoring from neutral to disagree. Quality of design of zebra crossing had a mean of 3.14 and SD = 1.343 while width of sidewalk (Mean = 2.94; SD = 1.450) and pavement quality (Mean = 2.67; SD = 1.401) indicated disagreement. The study also found that pedestrians were generally positive with enforcement of traffic laws scoring a mean of 4.215 and SD of 0.844 on being law abiding. Pedestrians strongly agreed that drivers should be fined for displaying risky behavior on the road (Mean = 4.425; SD = 0.874). However, drivers were very negative regarding enforcement of traffic laws (Mean = 1.828; SD = 0.534) indicating that they disagreed.

3.4 Integrated road infrastructure interventions and implementation of pedestrian safety rules

In order to test the hypothesis, scores on the individual scales of road infrastructure interventions were obtained as well as that on implementation of pedestrian safety rules. Multiple linear regression was conducted and the output presented in Table 4.

R^2 =0.254, R^2 adjusted=0.238, Se= 0.50717, F-stat: 16.558 on 4 and 195 df, p = 0.000

The model shows that the independent variables (the predictors) accounts for 25.4% of the variance in the dependent variable (Implementation of Pedestrian safety rules). The ANOVA shows the regression is a good fit for our data with F (4,195) =16.558 which is statistically significant ($p<0.05$). Using the multiple regression model equation: $\mathbf{Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon}$ and taking only statistically significant coefficients, implementation of pedestrian safety rules and road infrastructure interventions were related by the equation:

$\mathbf{Y=1.933+0.267\ X_3 + 0.289\ X_4}$ where y is the implementation of pedestrian safety rules and X_3 and X_4 are the enforcement of traffic laws and pedestrian demographic factors respectively. The null hypothesis was therefore rejected and the study concluded there was a significant relationship between road infrastructure interventions and implementation of pedestrian safety rules.

4. DISCUSSION

The aim of the study was to investigate the relationship between the combined road infrastructure interventions and implementation of pedestrian safety rules. In terms gender composition of the study sample, the study found that majority of the pedestrians were males and the same applied for driver and pedestrians. Further, the study found that majority of the pedestrians was of the middle youthful age between 30 – 40 years. This supports the findings of Scot, (2010) Salmon (2005) Shah (2003) who all found that age and sex were important determinants of pedestrian accidents among the middle aged.

In terms of the road infrastructure interventions, public education on road safety was found to score highly with road users indicating that it should be increased to enhance implementation of pedestrian safety rules. However, the study found a contradicting opinion among pedestrians and drivers regarding enforcement of traffic laws with the pedestrians favoring strict enforcement and fines on reckless driving. Similarly, Vaa et al., (2009) and Wundersitz et al., (2010) also suggested that for road safety communications and advertising needed to be close to the point of impulse such as with radio, outdoor advertising, variable and message signs and bus boards to be effective. On the other hand, drivers scored low on enforcement of traffic laws giving the opinion that they do not approve of the strict fines for reckless driving. The study found that the road engineering design, as an intervention, was inadequate with rating being below average for all the indicators of road engineering design. As for the pedestrian demographic factors, the study found that they influence, when quantified, was neutral with scores falling on the average range for the various indicators. This showed that the pedestrian demographic factors influence implementation of pedestrian safety rules to an average extent. These findings concur with those of Kim et al., (2008); Knezek (2007); NJDOT, (2005) who also stressed that on motorists fault as a pedestrian crash factor, driver education should be encouraged and more emphasis be put on pedestrian safety through road crossing laws to ensure driver responsibility and liability while also educating road users on hazardous pedestrian behaviors.

The study found that the combined integrated road infrastructure interventions statistically significantly explained 25.4% of variance in implementation of pedestrian safety rules. Individually, only enforcement of traffic laws ($p < .001$) and pedestrian demographic factors ($p < 0.001$) were found to statistically significantly influence implementation of pedestrian safety rules. The findings are consistent with that of Campbell *et al.*, (2004) who concluded that pedestrian characteristics and safety rules be integrated with other interventions. Both behavioural and engineering interventions would ensure reduction in road accidents in general and specifically pedestrian safety.

5. CONCLUSION

This study investigated the integrated combined road infrastructure interventions and implementation of pedestrian safety rules. The study found that applying the road infrastructure interventions as simultaneously improves implementation. The study therefore concludes that road infrastructure interventions, especially pedestrian demographic factors and enforcement of traffics to realize a balanced and sustainable approach to implementation of pedestrian safety rules as an outcome variable.

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Pedestrians' questionnaire	**Items deleted to maximize reliability**	**Cronbach's alpha after deletion**
Public education on road safety.	3.2, 3.4, 3.5 & 3.6	0.67
Quality of Road engineering design	4.4, 4.5, 4.6 & 4.7	0.62
Enforcement of traffic laws	5.3, 5.4 & 5.5	0.81
Pedestrian Demographic factors	6.1, 6.2, 6.4 & 6.5	0.69
Implementation of pedestrian safety rules	8.1, 8.2 & 8.6	0.72
Instrument reliability		**0.702**
Drivers questionnaire		
Public education	None	0.80
Road engineering design	3.2 & 3.5	0.67
Enforcement of traffic laws	None	0.62
Implementation of pedestrian safety rules	9.1	0.80
Instrument reliability		**0.72**

Table 1: Reliability

Characteristic	Response	Pedestrians		Drivers	
		Frequency	Percent	Frequency	Percent
Gender	Female	88	44	23	23
	Male	112	6	77	77
	Total	**200**	**0**	**100**	**100**
Age(years)	Below 20	10	5	4	4
	Between 20 & 30	51	25.5	26	26
	Between 30 & 40	60	30	38	38
	Between 40 & 50	55	27.5	21	21
	Between 50 & 60	21	10.5	10	10
	Between 60 & 70	3	1.5	1	1
	Total	**200**	**100**	**100**	**100**
Place of Residence	Rural	33	16.5	12	12
	Peri-urban	119	59.5	46	46
	Core urban	48	24	42	42
	Total	**200**	**100**	**100**	**100**
Educational level	Primary	13	6.5	13	13
	Secondary	49	24.5	26	26
	Tertiary	49	24.5	16	16
	University	89	44.5	45	45
	Total	**200**	**100**	**100**	**100**

Table 2: Socio-demographic characteristics

Pedestrians (N= 200) **Public Education statements**	**SA**	**A**	**N**	**D**	**SD**	**Mean**	**Std. Dev**
Publicity and advertising should be increased	131(65.5%)	57(28.5%)	3(1.5%)	3(1.5%)	6(3.0%)	4.52	0.778
Increasing knowledge of the Traffic Act	135(67.5%)	45(22.5%)	4(2.0%)	4(2.0%)	10(5.0%)	4.47	0.821
Road Engineering Design	**VG**	**Good**	**Average**	**Poor**	**VP**	**Mean**	**Std. Dev**
Quality of design of zebra crossing is good	34(17.0%)	55(27.5%)	51(25.5%)	22(11.0%)	37(18.5%)	3.14	1.343
	SA	**A**	**N**	**D**	**SD**	**Mean**	**Std. Dev**
Width of side walk is suitable for pedestrians	18(9.0%)	91(45.5%)	10(5.0%)	22(11.0%)	58(29.0%)	2.94	1.450
Pavement quality is good	6(3.0%)	85(42.5%)	15(7.5%)	24(12.0%)	70(35.0%)	2.67	1.401
Enforcement of traffic laws	**SA**	**A**	**N**	**D**	**SD**	**Mean**	**Std. Dev**
I am law abiding	84(42.0%)	86(43.0%)	21(10.5%)	(3.5%)	(1.0%)	4.215	0.844
Drivers should be fined for displaying risky behavior on the road	119(59.5%)	64(32.0%)	6(3.0%)	5(2.5%)	5(2.5%)	4.425	0.874
Pedestrian Demographic Factors	**SA**	**A**	**N**	**D**	**SD**	**Mean**	**Std. Dev**
You just need your feet to walk not education	35 (17.5%)	27(13.5%)	18(9.0%)	63(31.5%)	57(28.5%)	3.40	1.463
Level of education determines decisions made while using the roads	57(28.5%)	66(33.0%)	25(12.5%)	27(13.5%)	25(12.5%)	3.52	1.360

Female pedestrians are keen when using pedestrian crossing	54(27.0%)	51(25.5%)	32(16.0%)	39(19.5%)	24(12.0%)	3.36	1.375
My age makes it easy to use pedestrian crossing	42(21.0%)	87(43.5%)	25(12.5%)	27(13.5%)	19(9.5%)	3.53	1.232

Drivers views (N=100)	**Mean**	**Std. Dev**
View on public education on road safety	3.1180	0.8183
View on enforcement of traffic laws	1.8275	0.5344
View on implementation of pedestrian safety rules	3.5398	0.6142

Table 3: Descriptive statistics

Model Summary	R	R Square		Adjusted R Square	Std. Error of the Estimate	
	.504	0.254		0.238	0.50717	
Model ANOVA		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	17.036	4	4.259	16.558	.000
	Residual	50.159	195	0.257		
	Total	67.195	199			
Model coefficients		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	1.933	0.367		5.271	0.000
	Public Education on road safety	0.049	0.048	0.065	1.012	0.313
	Road Engineering Designs	-0.057	0.035	-0.103	-1.642	0.102
	Enforcement of Traffic Laws	0.267	0.74	0.229	3.594	0.000
	Pedestrian demographic factors	0.289	0.045	0.404	6.406	0.000

Table 4: Regression output for integrated road infrastructure interventions