THE EFFECT OF NON-INFRASTRUCTURAL VISIBILITY AIDS ON CRASHES AND INJURIES AMONG COMMERCIAL TRANSPORT PEDAL BICYCLISTS IN ELDORET

BY:

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DECLARATION

Declaration by the Candidate

This is my original work and has not been submitted for the award of a degree in any other university. No part of this work may be reproduced without prior permission from the author and or/ Moi University.

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DEDICATION

This work is dedicated to my parents, the late - Elizabeth Adongo Owiti (Ado) and Boniface Owiti Nyamiel (Tata), for their care and lifelong love.

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ABBREVIATIONS AND ACRONYMS

CBS.	Central Bureau of Statistics, Kenya.
CI	Confidence intervals
CPSC.	Consumer Product Safety Commission.
Epi_Info.	Epi_Info Version 3.5.1., August 13, 2008, CDC Atlanta ™.
IREC	Institutional Research and Ethics Committee
KNBS	Kenya National Bureau of Statistics
M	Metres
NEISS.	National Electronic Injury Surveillance System.
NHTSA	National Highway Traffic Safety Administration (in USA)
OECD	Organization for Economic Co- operation and Development
OR	Odds Ratios
RA	Research Assistants
SWOV.	Institute for Road Safety Research (Netherlands).
USA	United States of America
VEM	Visibility Enhancement Materials
WHO.	World Health Organization

DEFINITION OF ENGLISH TERMS

Bicycle or Pedal bicycle – A non-motorized vehicle with two wheels and pedals which is designed to carry persons and / or goods.

Conspicuity – Ability to be seen, recognized and identified as a particular element of the traffic system. An object must compete with others, to attract attention.

Mixed traffic- Traffic organized in such a way that movement of all categories of road users, motorized and non-motorized, are performed on the same road space.

Non infrastructural visibility aids –Equipments or treatments on road elements e.g. bicycles or bicyclists, which make them more conspicuous. They include lights, reflectors and conspicuous clothing.

Rider – a person who operates a bicycle *boda boda*

Time periods, include: **Daytime** = Time from 6.31am to 6.30pm; **Dusk =** Time from 6.31pm to 7.30pm; **Non-daytime =** Time from 6.31pm to 6.30am; **Whole day** = Period of 24 hours or daytime, dusk, night and dawn all together; **Night** = Time from 7.31pm to 5.29am and **Dawn** = Time from 5.30am to 6.30am.

Visibility – Ability to be seen. An object may be seen but not recognized, that it is a particular traffic element.

Vulnerable road user – Road user belonging to a category most at risk in traffic and generating little risk to other road users. A road user unprotected by an outside shield e.g. pedestrians, bicyclists, motorized two wheelers etc.

DEFINITION OF NON ENGLISH TERMS

Bicycle *boda boda* – A pedal powered bicycle with a rear cushioned carrier used for commercial transportation of passengers and / or goods, in Kenya and Uganda.

Motor cycle *boda boda* – A motor cycle with extended cushioned carrier used for commercial transportation of passengers and / or goods, in Kenya and Uganda.

Matatu - Low capacity, privately owned public passenger transport vehicle used in Kenya.

Tuk-tuk – Three wheeled motor cycle used for passenger or goods transportation.

ABSTRACT

Background: Effectiveness of non-infrastructural visibility aids on bicycle crash injury prevention was not well established, yet they were widely used.

Objective: To determine influence(s) of non-infrastructural visibility aids on specified riders' crashes and injuries within defined low visibility periods of the 24 hour day.

Setting: Eldoret Municipality, Kenya.

Study Design: Cross-sectional survey.

Methods: A pre tested semi structured, interviewer administered questionnaire was used on 364 riders, to determine their self reported characteristics and crash injury details for the year 2008. Non infrastructural visibility aids on riders and their bicycles were determined by an observation checklist. Data entry, cleaning and analysis employed the Computer program, Epi_Info version 3.5.1. Frequencies of variables were determined. Two by two tables and multivariate logistic regression, determined significant relations between specific non infrastructural visibility aids and riders' crashes or injuries, specified by both defined crash periods (night, non-daytime or whole day) and received management (self care, outpatient care or in-patient care). Outputs were: Odds ratios, 95% confidence intervals, coefficients and p-values. Presentations were in summary measures and tables.

Results: Riders' main characteristics: 100% (N=364) male, 70.9 % (N=258) age group 21-30 years, 80.8% (N=294) 4 years or less riding experience, 75.0% (N=273) rode at least once at night, 99.2% (N=361) spoke Swahili and 90.4% (N=329) owned the observed bicycle *boda boda*.

Proportions of bicycle *boda boda* with specific visibility aids: 62.9% (N=229) rear reflectors and 27.2% (N=99) working headlight.

Riders' proportions with reflective strips and group uniform were 55.5% (N=202) and 69.2% (N=252) respectively.

Riders' injuries were 77.7% (N=369). Self involved riders' injuries were the most common, 54.2% (N=200), followed by motor vehicle related ones, 27.9% (N=103). Among injuries managed by in-patient care, 60.0% (N=18) occurred within non-daytime hours. Bright garments were associated with 34% reduction of non-daytime crashes (OR=0.6577, 95%CI: 0.4539-0.9530).

At multivariate level, working headlight was associated with 75% reduction (OR=0.2539, 95%CI: 0.0771-0.8358) of non-daytime injuries which were managed by outpatient care. **Conclusion:** Non-infrastructural visibility aids may be useful in prevention of injuries within periods of the 24 hour day with low average natural visibility.

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CHAPTER 1:

INTRODUCTION

Background

1.1. Bicycle crash injuries

Bicycling is a risky activity. Trips, kilometers or hours may be used as exposure units in modal casualty rates to compare risks in modes of transport. Denominators may be per: 100, 100 000 population, 10 000 vehicles, billion kilometers and 100 million - trips, kilometers or hours. Hours travelled produce closer rates between different transport modes (Promising, 2001).

Police data internationally, classify vehicle crash injuries into fatal, serious and slight injuries; however definitions of these categories vary. Crash injury resulting into death within thirty days of the crash is fatal injury in all with few exceptions. Methods are available for conversion of such data into widely used 30 day period. Serious or severe injury is one leading to in-patient care, while injury for which the injured is given out-patient care is slight injury. These injury categories do not correlate very well with injury severity, due to misclassification (OECD, 1998).

Bicycle crash injuries were under reported more than injuries in other transport modes. Studies comparing police and hospital reported bicyclists' crash injuries in Great Britain found the percentages for fatal, serious and slight bicycle crash injuries in police data were 100, 33 and 21 respectively (OECD, 1998).

Regulations for prevention and control of bicycle crash injuries exist at the international, national and local levels. Examples include the 1968 Geneva

Convention on traffic, specific national traffic laws and local by-laws. Enforcement levels however vary with settings (Promising, 2001). In Kenya, both the Traffic Act and Local Government Act, have regulations that promote safe bicycling. In Eldoret, key informants among the Eldoret *boda boda* groups' leadership and Municipal Officials reported and gave documentary evidence to show that *boda boda* by-laws and articles in *boda boda* groups' constitutions' had bicycling regulations for local application (**Appendix V & VI**).

Global level

Reviews of road traffic crash literature confirmed bicyclists and other vulnerable road users were consistently more affected by traffic related injuries and deaths in all regions of the world.

In Wuhan-china, up to 45% of road fatalities in the 1993 Police and Emergency room data were bicyclists (Li, 1997). In Britain, using 1988 data, bicycling fatality rate was found to be 64 per 100 million hours or 4.6 per 100 million kilometers or 12.5 per 100 million trips, which was second only to that of the motorized two wheelers (Promising, 2001).

Regional level

Risks to bicyclists were higher in the more complex road environment of the Low and Medium Income Countries (Breen, 2004; Forjouh, 2003; Odero, 2004). African region has high road fatality rates, which was estimated in 2002 at 28.3 per 100 000 population (Breen, 2004).

Kenya

Bicyclists' fatality rate in Kenya was 9.5% in 2007. Effective road traffic injury prevention and control interventions were not accessible to cyclists in Kenya (Nantulya, 2001; Odero *et al*, 2003). Probably that could explain the rising trend in bicycle crash injury counts noted since 2002 (CBS, 2007). In Kenya, intentions to implement the construction of facilities for Non- Motorized Transport e.g. bicycle lanes, were already in place (CBS, 2002). However, wide scale implementation had not yet begun.

1.1.1. Bicycle crash injuries in Eldoret

Key informants

Commercial transport bicyclists locally known as bicycle *boda boda* riders, hereafter referred to as riders were generally blamed for the crashes. None compliance with traffic regulations, reckless riding, drugs, riding inexperience, lack of awareness of road regulations, claimed to be rampant among the riders were thought to be responsible for the crashes, according to informants drawn from bicycle transport regulators. But key informants drawn elsewhere, gave reasons which included- congestion in the town streets, recklessness among motor vehicle drivers and traffic police laxity, as the main causes of bicycle accidents in the town. However, all reported perceived decline in bicycle crash injuries. All these were in response to the question about problems brought by bicycle *boda boda* (Appendix IV).

Reviews of local crash injury data

Reviews were carried out for the period from 2005 to 2009, to document the trend and magnitude of police and hospital reported bicycle crash injuries in Eldoret.

Eldoret police station

Crash injuries were 156 in all, categorized by the police classification into fatal, serious and slight injuries, with counts of 49, 67 and 40 respectively. On correction for known underestimation of bicycle crash injuries in police records, as documented in OECD (1998), the counts would have been 49, 201 and 200, giving a total of 450.

A rising trend was noted contrary to perceptions of all the interviewed key informants. Fatalities averaged 10 per year. Limitations which made this data unsuitable for determination of relations between visibility aids and crash injuries are summarized hereafter. Known gross underestimation of actual bicycle crash injuries in police records, which was 65% in this data set. Actual age for the injured and sex were not possible to get due the secrecy revolving around police data. Numbers reported injured over a five year period were only 156, which was too few for multivariate analyses, a critical issue in such a study. Finally, the data was not disaggregated by occupation of the bicycle rider, i.e. private or bicycle *boda boda* rider.

Moi Teaching and Referral Hospital (MTRH)

All accidents took the fourth position among the top 10 causes of outpatient morbidity in 2007 and 2008, but climbed to third position in 2009, after respiratory diseases and malaria.

Patients admitted for in-patient care following pedal bicycle crash injuries within the five year period were 128. Majority injured, 53.1% (N=68) were male within the age

group 18-52 years. This was also the age range for 91.5% (N= 333) of the Eldoret bicycle *boda boda* riders, in survey results in this thesis *(Refer: Table: 4.1).*

When the data was disaggregated by time of the crash and final treatment outcome, the graph plotted showed a general decline of injuries up to year 2008, followed by increases in 2009.

Figure 1.1, shows the distribution pedal cyclists' injuries managed in MTRH.

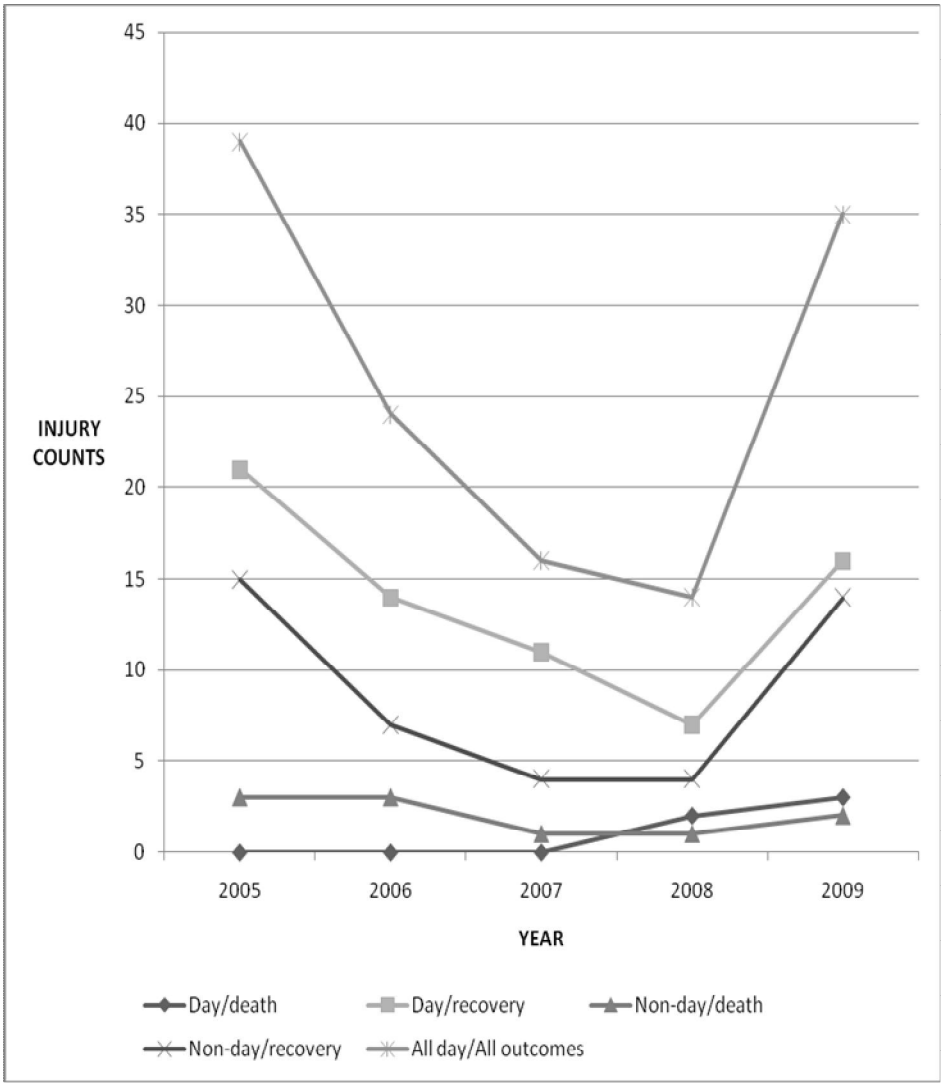

Figure 1.1: In-patient pedal cyclists' injuries, MTRH 2005-2009

There were no daytime injuries which resulted into hospital deaths from 2005 to 2007. This safer period for bicyclists coincided with the peak of bicycle *boda boda* riders' population in Eldoret, according to key informants.

Bicyclists' safety from crash injuries is inversely proportional to their modal share in traffic (Promising, 2001).

Table 1.1: In-patient treatment outcomes of pedal cyclists' injuries

Non daytime injury (6.31pm -6.30am)	**Treatment outcome**		**OR** (95% CI)
	Death	**Recovery**	
Yes	**12**	**44**	**3.6545** (1.2038-11.0942)
No	**5**	**67**	

Non-daytime period between 6.31pm and 6.30am, was associated with a 265% increase in deaths (OR=3.6545, 95% CI: 1.2038-11.0942) of injured pedal cyclists, who were managed by in-patient care *(Refer table 1.2)*.

Visibility changes between daytime and non-daytime in the course of a 24 hour day was an important severity predictor of pedal bicyclists' injuries. This concurs with previous study results. Travelling in darkness is a known risk factor for severe crash injuries (Breen, 2004).

1.1.2. Non-Infrastructural Visibility Aids

Visibility aids for night time, include retro-reflective materials, lamps and flashing lights. Bicycle reflectors, are made of retro-reflective materials. Yellow, red and orange retro-reflective materials are quite effective in improving detection and recognition. Yellow is the most effective non-fluorescent colour. Daytime visibility is improved by fluorescent materials in yellow, red and orange. Visibility aids' potential to increase conspicuity, increase drivers' ability to detect and recognize pedestrians and bicyclists thus may lead to evasive actions to prevent crashes. However, their effectiveness in prevention of bicycle crash injuries remained unknown (Kwan & Mapstone, 2006).

Visibility aids on the bicycle *boda boda* and riders

Multiple visibility aids were available for use by the bicycle *boda boda*. However, various constraints barred riders from accessing them. Cost, lack of awareness of visibility aids themselves, their effectiveness, discomfort associated with the use of garments at certain times and even lack of legislation, were cited by various key informants.

In Eldoret, certainly legislation was in place, mandating the use of visibility aids on all bicycles. These included-traffic rules' based on the traffic act, chapter 403 and *boda boda* by-laws based on the local government act, chapter 265, both of the laws of Kenya. Articles in the *boda boda* group constitutions also mandated the use of visibility aids by the members **(Appendix VI)**.

A cross sectional study in Uganda, which sought to determine the preferred visibility enhancement devices among motor cycle and bicycle *boda boda* riders, found that riders preferred aprons and reflective stickers for various reasons. The same study also found that police data and self reports, but not hospital data, were good methods for evaluating effectiveness of visibility enhancement devices (Kobusingye *et al*, 2004).

In a cross sectional study carried out in Kisumu-Kenya, 418 bicycle *boda boda* riders were asked about bicycle safety equipments. Among the visibility aids, the proportions that were aware of the use of certain equipments for bicyclists' safety, ranged from 2.2% for reflective clothing to 30.6% for headlights. Indicators and side mirrors fared between 16.3% and 15.1% respectively (Cholo, 2008).

Visibility aids among non-commercial bicyclists

Use of visibility aids among pedal bicyclists has been found to be low among several bicyclist populations, in the absence of enforcement and / or other interventions. This remained so, despite the existence of international and local regulations mandating their use. The 1968 Geneva convention on traffic, a United Nations treaty, mandates the use of bicycle headlight and a red rear reflector (Promising, 2002).

The highest visibility aids' use found on bicycles among Melbourne Australian adult commuters was 10.7%. Closer home, in Busia – Uganda, 90% of bicycle *boda boda* had no reflectors, despite their usage at night (Kwamusi, 2002). Lots of effort including ongoing awareness campaigns, legislation and consistent humane enforcement, raised the use of front bicycle lights among bicyclists in Netherlands to 74% by 2006 (Brink, 2006, cited in SWOV, 2006).

1.1.3. Self reported bicycle survey

In a 5 year period, bicycle injuries reported were 128 and 156 from MTRH and Eldoret police, respectively, which were inadequate for multivariate analyses. As for non-infrastructural visibility aids, both sources yielded nothing.

Studies have previously documented under reporting of bicyclists' crash injuries by police. Olkkonen (1993, cited in OECD, 1998) reported a 15 times under reporting of bicyclists' crash injuries in results of a study which compared data from police, hospitals and population surveys.

Various epidemiological studies have determined the ratio of road deaths: injuries requiring hospital care: minor injuries to be 1:15:70, respectively (Breen, 2004). Most bicyclist injuries never reach hospital or police records and therefore may only be accessed by self reports, despite some of its known limitations. As Schupack and Driessen (1976) concluded, information for exploration of bicycle crash injuries is better sourced directly from the bicyclists themselves.

The purpose of this study was to determine whether observed visibility aids on bicycle *boda boda* and riders could explain self reported riders' crash injuries experienced under both defined periods of low average natural visibility (whole day, non-daytime or night) and received management (self care, outpatient care or in-patient care).

1.2. Problem statement

Reviews of local pedal bicycle crash injury data in the main hospital and police station confirmed annual average deaths of 10 bicyclists and increasing injuries in the last five years. Riders, as the majority bicyclists in Eldoret at the time, with more riding exposure than private bicyclists, were likely to be disproportionately represented in the injury data. More fatalities and severer injuries occurred within non-daytime hours, according to the reviewed local injury data.

Eldoret had only two kilometers of a bicycle lane, consequently all road vehicles shared the same road space, placing pedal bicycle *boda boda* riders at great injury risk (Breen, 2004).

Enforcement of traffic regulations was sporadic and ineffective as is had always been, despite the elaborate traffic laws, chapter 403 and the local government act, chapter 265, among other regulations (Odero *et al*, 2003).

Non-infrastructural visibility aids were the main injury counter measures at the disposal of the riders. However, their effectiveness against bicycle crash injuries was unknown (Kwan & Mapstone, 2006).

1.3. Justification

Evidence for visibility aids' beneficial role in bicycle *boda boda* crash injury reduction, will be a step in filling the existing knowledge gap on their effectiveness in bicycle crash injury reduction. This knowledge would be used in promotion of non-

infrastructural visibility aids in prevention and control of bicycle crash injuries, with expectations of reversing the prevailing losses associated with the injuries.

Fear for crash injuries blocked 70% of the poor road users in Eldoret from choosing the bicycle as a mode of transport (Heyen-Perschon, 2002). Safer bicycling will allow the poor majority and the society at large to reclaim the social, economic and environmental benefits.

1.4. Research question

- What is the relation between visibility aids and bicycle crash related injuries, among the bicycle *boda boda* riders in Eldoret Municipality?

1.5. Objectives

1.5.1. Main Objective

- To establish the influence(s) of non-infrastructural visibility aids on specified riders' crashes and injuries within defined low visibility periods of the 24 hour day.

1.5.2. Specific Objectives

- To describe the bicycle *boda boda* riders' cultural, demographic, economic and social characteristics.
- To determine the counts of observed specific non infrastructural visibility aids on each bicycle *boda boda* and rider.
- To determine details of riders' self reported crashes and related injuries, including: counts, persons injured, month, time, circumstances and management, from February to December 2008.

- To determine relations between specific non infrastructural visibility aids and specified riders' crashes or injuries, defined by both crash periods (night, non-daytime or whole day) and received management (self care, outpatient care or in-patient care).

CHAPTER TWO:

LITERATURE REVIEW

2.1. Commercial Transport Bicycling

2.1.1. Evolution

Commercial pedal bicycle transport, hereafter referred to as bicycle *boda boda*, originated from the eastern Uganda town of Busia, in the late 60's and early 70's. Bicycles were used to smuggle goods across the Kenya - Uganda border at the time. Riders would shout the English word 'border' repeatedly in search for persons or goods to ferry across. Eventually the words 'border

Border' became corrupted to 'boda boda'. Soon, the riders, their bicycles and even their business acquired the name 'boda boda' (Malmberg-Calvo, 1994). Economic decline, unemployment and opportunity to fill a transport gap, eventually spread the new transport mode northwards to another border town, Malaba and thereafter to the rest of East Africa and beyond.

A bicycle *boda boda* is a man's pedal powered bicycle with padded cushioned rear carrier, where the passenger sits comfortably as the rider cycles. The support for the rear carrier is strengthened and modified to carry loads of 100kg or more. The cushions are also easily detachable to allow transport of goods of any kind.

In the early nineties, small capacity motor cycles with extended seats, hereafter called motor cycle *boda boda* also joined the *boda boda* business, again starting from Uganda (Bos et al, 2003; Howe, 2001).

Today both types of *boda boda* are used to transport goods and passengers in most of rural and urban Africa. In Kenya and Uganda bicycle *boda boda* predominate in areas with flat terrain due to cheaper fares than their motor cycle counterparts (Howe, 2001). Bicycle *boda boda* riders are drawn from the poor segment of society. In a survey done in Tororo district of Uganda, the majority were found to be young men in the age group 18-29 years, with mainly primary school education. The strenuous nature of the work and some cultures bar women from riding bicycles, probably that explains why bicycle *boda boda* remains a male preserve.

2.1.2. Benefits

Bicycle *boda boda* has contributed significantly in increasing the conduct of social and economic activities, by providing accessible short distance transport services, employment and a transport links with previously inaccessible rural areas and even within the urban centres (Malmberg-Calvo, 1994).

2.1.3. Road safety

Safety from traffic crashes is a major problem among bicycle *boda boda* riders. Reckless riding, drunkenness and non compliance with traffic regulations, contribute to the accidents (Amimo, 2001 cited in Howe, 2001). However, lack of safety from accidents also arises from other factors including aggressive motor vehicle drivers, mixed traffic system, competition for space, lack of bicycle facilities, among others (Godard, 2000 cited in Heyen-Perschon, 2002).

In most of the low and medium income countries, interventions against bicycle crash injuries are inaccessible to bicyclists. Safety concerns bar 70% of the poor urban road users in Eldoret from choosing the bicycle mode of transport (Heyen-Perschon, 2002).

2.2. Prevention and Control of Bicycle Crash Injuries

2.2.1. National road safety policy

Bicyclists are vulnerable road users. They shoulder disproportionate crash injury burden worldwide. Prevention of bicycle crash injuries is complex, but must be integrated with the crash injury prevention and control of crash injuries of other road users; in the national road safety policy. The following injury prevention guidelines will therefore apply (Breen, 2004):

(i) Formulation of a national road safety policy which incorporates road safety for bicyclists and other vulnerable road users. The Swedish 'Vision zero', is one such national road safety policy.

(ii) .Creation of a lead agency with powers and adequate budget to implement the national road safety policies relevant to bicyclists' road safety.

Examples include: Institute for Road safety Research (SWOV) in Netherlands and National Highway Traffic Safety Administration (NHTSA) in USA. In Kenya, the newly reconstituted National Road Safety Council of Kenya (NRSCK), is still in its infancy!

(iii). Sustained political will to support the lead agency in implementation of the national road safety policy sections favourable to improving bicyclists' road safety.

(iv). Multi-sectoral collaboration, both horizontal and vertical, within the government and with road safety stakeholders among international organizations, non-governmental organizations and the private sector, to

promote bicyclist road safety. Public health sector, should take its central roles, which include influencing relevant policies, injury surveillance, research, services, among others.

(v) Creation of departments within national research institutions, to coordinate and carry out research on relevant injury issues affecting bicyclists.

(vi) Adoption of the Systems Approach Model to manage bicycle crash injuries, among other injuries. This model tackles injury prevention through four laid down steps. The steps are: identification of injury problems, formulating strategies to address the identified problems, setting targets and finally monitoring implementation of evidence based injury prevention interventions.

(vii) National road traffic injury surveillance system, to include detailed injury data on bicyclists' crash injuries to enable researchers to carry out analysis leading to decisions for improvements in bicyclists' road safety.

2.2.2. Legislation

Apart from the 1968 Geneva Convention on traffic, other regulations governing bicycle transport vary by settings, e.g. countries, states or cities. However, like other traffic regulations some from different countries have similarities.

Bicycle legislation in Kenya

Bicycles were regulated by traffic laws and additional regulations (by-laws) enacted by local authorities under section 201A of Chapter 265, local government act of the laws of Kenya, to manage local bicycling issues. The by-laws specify terms and

conditions for conducting bicycle *boda boda* business and penalties for contravention of the same **(Appendix IV: Eldoret *Boda boda* by-laws 2008).**

Chapter 403(Revised 1988), the traffic act, of the laws of Kenya, section 69(a) mandates Police officers to regulate all traffic and keep order to prevent obstruction to roads, parking and public places, while section 55 (1) dictates the maintenance of all vehicle parts in good working condition, including lights and tyres, then section 87 of the same act, prohibits and specifies penalties for careless driving of vehicles other than motor vehicles (e.g. bicycles) on roads or any public places. Section 89, also of the same act, specifies how persons and goods should be carried on any bicycle. Traffic rules in the traffic act, specify mandatory requirements for functional bicycle lights [number 24 section (b), part i & ii], rear reflectors and signs [number 25 section (1), parts (a) i & ii] (The Laws of Kenya, Chapters 265 & 403).

None of the traffic rules mandated the use of bicycle riders high visibility garments or helmets!

2.2.3. Individual Prevention and Control Strategies

Measures for prevention and control of bicyclists' injuries are broadly divided into infrastructural and non-infrastructural measures. Infrastructural measures are environmental planning and modifications, while non-infrastructural measures include – education, publicity, visibility improvements, bicyclist protective devices, enforcement and regulations. Newer injury prevention methods, like intelligent transport systems, alcolocks, telematics, intelligent speed adaptation, promise further improvements in bicyclists' road safety. Evaluation of injury prevention and control

interventions using different study designs, have confirmed the superiority of multifaceted interventions in reducing crash injuries to the vulnerable road users, mostly in the developed countries (Breen *et al*, 2004; OECD, 1998).

The Haddon Matrix Model divides the crash event into three time-sequences phases (pre-crash, crash, post-crash) and relates them with the epidemiological triad (human, machine/equipment, environment). The nine resulting cells provide opportunities for solving any injury problem. Known effective injury prevention and control interventions used in developed countries, are inaccessible to local cyclists (Forjouh, 2003).

Education and publicity are effective interventions, when combined with other interventions, however on their own they produce short term behaviour changes, which are not translated into consistent injury reduction (Breen, 2004). Education, publicity, and subsidies have been combined with mandatory regulations to increase usage of bicycle helmets, with good results.

Bicyclist helmets are an effective head injury prevention method, as shown by various studies. Head injury reductions attributed to helmet use are in the range of 47% to 88%. (Breen *et al,* 2004).

Effectiveness of bicycle facilities in crash injury reduction is variable in different settings; however it is estimated to be about 10%. However, they increase traffic conflicts at road intersections. In Kenya, minimal bicycle facilities were seen in the towns of Kakamega, Webuye and Eldoret (Investigator).

Area-wide traffic calming measures are lowered speed zones, roundabout, speed humps, speed bumps and narrowed roads. In Ghana, speed bumps reduced fatal crash injuries by 55% at certain traffic crash black spots (Breen *et al*, 2004).

Effectiveness of non-infrastructural visibility aids in bicycle crash injury reduction is not well established, although they were still widely used and enforced (OECD, 1998). No randomized controlled trials have been done to confirm their effectiveness (. Kwan and Mapstone, 2006).

Bicycling injury prevention and control efforts must be evidence based and driven by a politically supported lead agency with adequate authority, responsibility and resources to plan, implement and co–ordinate actions, if any success is to be achieved (Breen *et al*, 2004).

Unfortunately, National Road Safety Council of Kenya, the agency mandated to prevent and control traffic injuries in this country, only has an advisory role (Odero *et al*, 2003).

2.3. Non-infrastructural Visibility Aids

Some bicycle *boda boda* and riders use certain non-infrastructural visibility aids.

2.3.1. Visibility Aids Used by Bicycle *boda boda* and Riders

A similar study in the Ugandan city of Kampala and its peri-urban areas was carried out on bicycle and motor cycle *boda boda* riders. The study objectives included determination of types of visibility enhancement devices (VEM), their acceptability,

distribution, as well as identification of possible study populations, sample sizes and outcome measures for evaluating the effectiveness of VEM based interventions.

Identified VEMs included: garments with reflective materials, in the form of aprons, T-shirts, arm / head bands and specialty. Others were adhesive strips/tape stuck to bikes or helmets. Aprons worn by riders and reflective tape on bikes were the most preferred. Reasons for the preferences were that aprons could be worn on any clothing, while tapes remained stuck at all times. Lack of awareness of VEMs or their effectiveness, discomfort associated with aprons in certain weather conditions and lack of legislation mandating usage. Proposals for possible distributors for VEMs, included: Stage chairmen, City council authorities and spare parts retailers. Measuring crash rates through police data or self reports was a good method of evaluating VEMs effectiveness (Kobusingye *et al,* 2004).

2.3.2. Visibility Aids Used by Non-Commercial Bicyclists

A systematic review of randomized controlled trials and controlled 'before' and 'after' studies, assessing the effect of visibility aids, on pedestrian and cyclists - motor vehicle collisions and injuries was carried out. No studies were found comparing: visibility aids versus no visibility aids or different visibility aids, on the occurrence of collisions between bicyclists or pedestrians and motor vehicles. The same review also assessed motor vehicle drivers' responses on detection and recognition distances, yielding 37 studies. The authors concluded that visibility enhancing materials or aids assist drivers in earlier recognition and detection of pedestrians and bicyclists.

In daytime, fluorescent materials in-yellow, orange and red colours, proved more effective in improving drivers visibility. Lamps, flashing lights and retro-reflective

materials in red and yellow, improved night time visibility. Retro reflective materials in bio-motion configurations enhanced recognition. It was also concluded that visibility aids have the potential to prevent collisions between motor vehicles and cyclists or pedestrians (Kwan and Mapstone, 2006).

Some local, national and international regulations recommend or enforce the use of specific visibility aids, despite the absence of firm scientific evidence of their effectiveness in bicycle crash injury prevention (Breen *et al*, 2004; Kwan and Mapstone, 2006; OECD, 1998; Promising, 2001). Detection distance is a reasonable surrogate for crash injury (Kwan and Mapstone, 2006).

A real life experiment was conducted at night in some sub-urban streets in Australia. Participants drove round a set circuit with known- visibility levels and stationery bicyclists at fixed points apart. Results showed that 85% of the tail lights were seen by the subjects at distances more than 100m. However, headlights were seen at a range between 40m and 100m only. Cairney concluded that a flashing light emitting diode was more effective (OECD, 1998).

A night time study in the UK, tested detection and recognition distances of bicycle lamps and reflectors, under two glare conditions - full light or low beam. Watts, the researcher, observed greater cyclist detection at the road centre bicycle position and low glare. A combined rear lamp and small rear reflector resulted in greater detection distance (650m) and lower recognition distance (54m). Bright reflective jacket - pedal reflectors combination; however had a greater recognition distance and delineation as a bicyclist (OECD, 1998; Kwan and Mapstone, 2006).

Actual observation of the use of active visibility aids thought to increase bicyclists' conspicuity with the potential of preventing crash injuries has been done in some settings, with variable results. An observation study done at night in towns in the United Kingdom, surveyed 2500 cyclists. No lights were noted on 9% of the bicycles, 6% missed tail lights while 6% missed head lights. 23% of the observed lights were malfunctioning and 9% were off (Watts, 1984).

In Netherlands, where the use of bicycle lights is compulsory, Blokpoel observed 1500 to 3000 cyclists in darkness at five sites. Results showed that 55% to 70% used their lights (OECD, 1998). The Vienna Convention on road traffic (1968), which is ratified by United Nations member states, recommends the use of head lamps and a rear reflector.

The presence of passive visibility aids e.g. bicycle reflectors, if in good condition signifies usage. In Australia, Morgan *et al*, asked observers to count bicyclists using visibility aids. Items looked for included- flags, reflective vests, reflective strips or anything which could aid visibility at night. The highest level they found was 10.7% among Melbourne adult commuters. Primary school sites in country centers followed with 4.8%. Bicyclists in recreational and secondary school sites had rates of 0.2 to 1.9 % (OECD, 1998).

Consequently, it may safely be concluded that different bicyclist populations use different proportions of visibility aids.

2.3.3. Conspicuity and Bicycle Crash Injuries

Blokpoel conducted an ecologic study in Netherlands to evaluate the compulsory bicycle spoke reflector (wheel circle) law. Comparisons were made between casualties four years before 1987 and two years after.

Results showed a statistically significant decline (5%) in casualties at dusk, dawn and darkness, in the 'after' period, as compared with daytime casualties in the same 'after' period. However, this study was confounded by the observation that cyclists with wheel circles used headlamps also at a rate of 70% as compared with those with no wheel circles at 36%. It was concluded that the contribution of the wheel circle in injury reduction could therefore not be determined (OECD, 1998). However, the observed decline should have been attributed to the combined effect of headlights and wheel circles.

A bicycle crash injury survey was carried out in the USA by the Consumer Product Safety Commission's (CPSC's) directorate of epidemiology, on casualties who attended hospital emergency rooms in 1991.

Results showed an overall injury rate of 8.8 per 1000 riders. Twenty one percent (21%) of the injuries occurred in non daylight conditions, giving a risk 3.64 times higher than the day time risk. Most of the fatalities (90%) involved motor vehicle-bicycle collisions and 85% of the victims were male. Visibility aids found on the bicycles in the crashes were - head lights 14.5%, tail lights 20.6% and reflectors 90%. Overall, less than 8% of the crash bicycles had lights and even those with lights were

not using them at the time of the crash. On major roads, 35% of the injuries happened under non day light conditions (Tinsworth *et al*, 1993).

This study demonstrated the higher injury risks of night time riding and some correlation with low levels of bicycle lights' use in the USA at the time. The CPSC regulations only demand reflectors on bicycles. Emergency room hospital patients' population in high income settings or anywhere else differs significantly from the general cyclists' population. Rates of injury experience or visibility aids in the proposed study and this study will therefore not be comparable.

A cross sectional survey of bicyclists was carried out by Email in New Zealand in November 2006. Self reported bicycle crashes within the preceding 12 months was the main outcome measure. Mean number of days of absence from work due to bicycle crash injuries was noted. Several bicyclist characteristics were sought and assessed as possible bicycle crash injury predictors.

It was concluded that low bicyclist conspicuity may increase the rates of bicycle crash related injuries and that 'days off work may be useful outcome for assessing risk factors for bicycle - motor vehicle crashes. Increased use of high visibility clothing by cyclists is likely to reduce bicycle crash related injuries (Thornley *et al*, 2008).

High visibility clothing may not be accessible to bicyclists in Low and Medium Income Countries. Bicyclist populations in New Zealand and those in local settings are also likely to have significantly different characteristics which are important in injury causation and prevention. Consequently, findings of this study may not be

applicable to local settings. Weaknesses of self report based studies include questionable validity of exposure and outcome measures.

2.4. Conceptual Framework

This study was guided by the author's proposed conceptual model of riders' characteristics **(1)** and non-infrastructural visibility aids **(2)** that interacted with environmental factors under conditions of cyclic changes in natural visibility to generate crashes and the non-fatal injury outcomes (self care (**4a)**, outpatient care (**4b)** or in-patient care **(4c).** Outcomes which permanently prevented post-crash pedal bicycle riding were excluded by the data collection method-self report! Figure 2.1, shows the conceptual framework.

Visibility changes result into the defined periods: non-daytime, night and whole day, each with assumed average natural visibility lower than daytime. The model is divided into 4 parts, with specific contributions to the achievement of the overall goal of this study.

Part 1, was to identify riders characteristics among the social, cultural, economic and demographic characteristics. These were to include gender, age, drug consumption, riding habits, among others. It sought to achieve the objective number one.

Part 2, was to identify treatments and devices which improved conspicuity for the bicycles and riders. They included: paint, flags, reflectors, lights and high visibility garments. Its main aim was to achieve objective number two.

Parts 3 & 4: Determined details of the crashes and injuries, including persons injured, month, time, circumstances and received management, each under specified conditions. It sought to achieve objective number three.

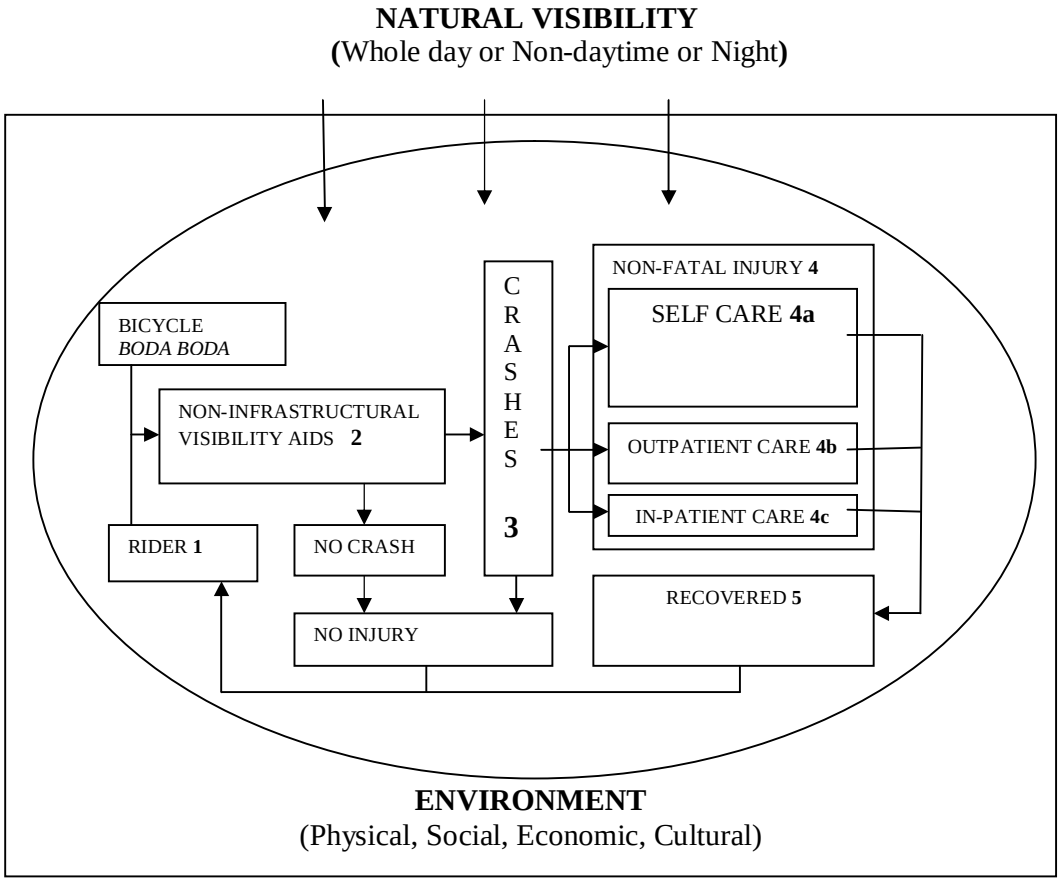

Figure 2.1: Conceptual Framework.

Parts 2, 3, 4a, 4b & 4c: Sought to determine relations of each visibility aid with specified crashes and injury outcomes, each specified by variable combinations of defined periods, circumstances and injured persons, which made up objective number 4. Examples of injury outcomes could be: non-daytime, in-patient managed injuries or

night time *boda boda* –motor vehicle collision related injuries, managed by outpatient care.

Part 5: Riders who recovered well enough and continued with bicycle *boda boda* riding.

CHAPTER THREE:

METHODOLOGY

Qualitative and quantitative methods were employed in this study. The qualitative study designs, informal interviews and key informant interviews, were carried out on purposively selected *boda boda* stakeholders. This was both an engagement process and opportunity to gather information for formulating the study tools and to acquire background information on the study area, study population, local bicycle crash injury trends and the role of natural visibility on local bicycle crash injuries, among others.

Interviews, using structured key informant interview guides **(Appendix IV)** among *boda boda* group leaders, Municipal Council Officials, Records personnel in two main hospitals and the Eldoret Deputy Traffic police Commandant were carried out. The Principal Investigator interviewed the key informants in their offices or work places and wrote down their responses.

The leadership of three *boda boda* groups, namely Eldoret *Boda Boda* Transporters (EBBT), Uasin-Gishu Bicycle Transporters (UGBT) and North Rift Bicycle Transporters Association (NORBITA) were interviewed, as their unique large sizes and location of work stations at the town centre made them likely to have required information on issues under investigation, like bicycle road traffic crashes and the use of non infrastructural visibility aids, among others. NORBITA, as the umbrella organization for all pedal bicycle *boda boda* groups in Eldoret, had access to information from affiliated groups which were distributed throughout the municipality. The Municipal: Engineer, Medical officer, Chief Enforcement Officer and Planner, were interviewed since they were the implementers of road traffic related

mandate bestowed on the Municipality by the local government act, Chapter 265, section 201A of the constitution of Kenya.

Magnitude and trends of pedal bicycle crash injuries based on hard evidence were accessed by interviewing Traffic Police, hospital records information officers at Moi Teaching & Referral Hospital (MTRH) and Eldoret East District Hospital. The Traffic Police were the enforcers of chapter 403, the traffic act and related traffic rules of the laws of Kenya. They were also the custodians of police reported road traffic crash and injury data. MTRH was the main health facility that provided medical care for road traffic crash injuries in the town and the region.

Insight gained through the interviews and reviews of injury data and literature on the study area, population and issues evolving around pedal cyclists' injuries were described hereafter.

3.1: Study Area

Eldoret Municipality was the fifth largest urban centre in Kenya. It covered an area of 147 square kilometers. Its population was 197,449 in 1999, but was projected to about 255, 000 by 2008 (KNBS, 2009). The town is situated on a cool highland at approximate altitude of 2100 – 2700 metres. Its latitude is 0.5667^{o}, longitude of 35.2833^{o} and a temperature range from 9^{o}C to 25^{o}C, with a mean of 17^{o}C. Mean annual rainfall was 1124mm, with peaks in April - May and July – August. Sunrise and sunset in Eldoret were at 6.38am and 6.46pm respectively (http://eldoret municipal.co./bginfo.php).

3.1.1. Transport

Main mode of transport within Eldoret was exclusively road based, by walking, cycling or motor vehicles, among others. The town was bisected by major roads which ran East-West and North – South. All town centre and peri-urban road network was estimated at 300km, of which 40 km were constructed with tarmac. Most of the roads were narrow (9m width), had uneven surfaces and steep gradient which made them relatively unsuitable for safe and easy pedal cycling, according to sources at the Municipal Engineers Office. The only existing separate road for bicycles was a 2km cycle path along one side of Malaba road, part of the Nairobi – Kampala Highway within Eldoret. Road lights were available on most of the town centre streets, partly on highways through the town and some residential estates; however they were only 70% functional due to managerial problems. Plans were underway to start constructing bicycle lanes by around 2011 or soon thereafter, according to sources at the office of the Municipal Engineer and Kenya Urban Roads Authority.

The town roads were shared by all types of road vehicles, which included: Lorries, cars, buses, bicycles, motor cycles, *tuk tuks*, hand carts, *matatus*, among others. Traffic calming was attempted by various means, including targeted control of traffic flow by police, enforcement of the mandatory 50Km/hour urban road speed limit, bumps and even reorganization of traffic flow. Despite the measures, roads remained congested. The Municipal Council enacted the *boda boda* by-laws of 2008 **(Appendix V)**, which brought extensive measures to regulate operations of all *boda boda*, with renewed hope of reducing road congestion and related bicycle crash injuries.

The Nairobi – Kampala railway line ran East-West through the town, provided rail transport in and out of Eldoret. Eldoret International Airport was 15km south of the town, along the Eldoret – Kisumu road. The Airport together with an Airstrip north of the town centre, provided air transport between the town and other cities **(Appendix VII: Map of Eldoret)**.

3.1.2. Health

Health services were provided by a wide range of health facilities within the Municipality. Hospitals included: Moi teaching and referral hospital (MTRH), Eldoret Hospital, Elgon View Hospital, Medi Heal Hospital, Eldoret East District Hospital, Eldoret West District Hospital, among others. Over 10 Health Centres and Dispensaries distributed within the Municipality offered mainly outpatient services. Private clinics numbering between 20 and 30, also offered mainly outpatient services.

MTRH supplied the bulk of both in-patient and outpatient health services to the town residents and the surrounding region. This was a 710 bed facility, including 211 beds in the injury wards (Surgery, Orthopaedics and Private wing I & II). It had a well equipped trauma centre, complete with skilled clinical personnel, including paramedics, nurses and specialists in diverse branches of Medicine. Sources within the Municipal Council's health department stated that MTRH was the main supplier of health services for the town's residents, due to its lower user fees and good reputation.

3.1.3. Traffic Police

The Base Commandant headed the traffic police department at the Eldoret Divisional Police Head Quarters. He had a team of traffic police officers to enforce traffic regulations and investigate road traffic offences in Eldoret and its environs. Other stakeholders in the regulation of pedal bicycle related injuries were the Eldoret municipal council and the pedal bicycle *boda boda* leadership.

The police were mandated to enforce traffic regulations (laws, rules and by-laws) among all road users; including the pedal bicycle *boda boda* riders. These regulations included: Chapter 265 (local authority by-laws) and Chapter 403 (the traffic act), of the laws of Kenya.

Details of each investigated road traffic accident were entered into a standard document called Police 41. Data was disaggregated by vehicle type, but not the actual age or occupation of the operator e.g. pedal bicycle *boda boda* rider. Presence or absence of non infrastructural visibility aids were not regularly entered, except in some specific circumstances. Access to relevant road traffic injury data e.g. demographics among other details was quite difficult.

The international police classification of crash injuries was employed in the road traffic crash injury data at the Eldoret police station. Crash injuries were categorized as: fatal, serious or slight. Fatal injuries, were entered whenever there was instant death. If the injured received in-patient care, then the injury was serious, while injuries where care was only received in outpatient department and the injured

released, was categorized as slight. Summaries of road traffic accidents were done monthly, quarterly and annually, for onward transmission to Provincial and National police offices. According to police sources at the key informant interviews, pedal cyclist injuries had declined progressively in recent years due to increased random police checks, rider training and road safety campaigns; however the Eldoret police reported injury data showed increasing trend in pedal cyclist injuries since 2006.

Figure 3.3, shows the distribution of Eldoret police reported pedal cyclists' crash injuries.

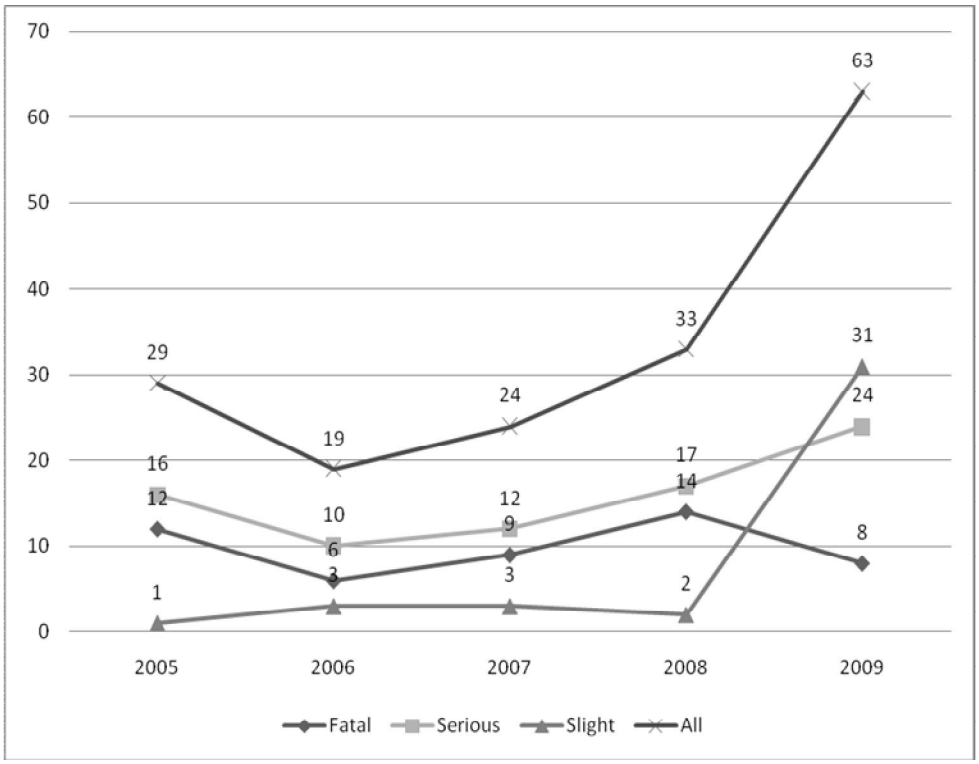

Figure 3.3: Eldoret Police Reported Pedal Cyclists' Injuries

3.2. Study Population

Key informant interviews were carried out to gain insight into the study population. The results were as described hereafter.

Commercial transport pedal bicyclists, known locally as pedal bicycle *boda boda* riders, hereafter referred to as riders, started operations in the town around the year 2000. Their numbers rose rapidly over the years, reaching a peak between 2006 and 2007. By 2008, they began declining in numbers for various reasons, including competition from increasing numbers of motor cycle *boda boda*, rider's and passenger's preference for motor cycle *boda boda*, declining riders income, unfavourable regulatory measures by the local authority, among others. Riders within the town were estimated by NORBITA leadership at about 1616, distributed among 25 pedal bicycle *boda boda* groups by January 2009 **(Appendix IIIa)**. One year later (2010), the population had reduced to only 1000. To illustrate the rise and fall in the rider population, a boda boda leader key informant provided actual membership for a bicycle group (UGBT) as follows: 268 riders (2004), 188 riders (2009) and 68 riders (2010).

The pedal bicycle *boda boda* is a human powered bicycle with a rear cushioned carrier used for transportation of goods and or passengers. The bicycle *boda boda* arrived in Eldoret by the year 2000. The riders were predominantly young men. They were organized in groups, registered at the Uasin Gishu district offices of the department of social services. The main objectives of these groups could be summarized as: provision of self employment, savings, advocacy, trainings, work

discipline and social welfare. Group officials encouraged compliance with traffic laws and council by-laws, including the use of non infrastructural visibility aids and these were entrenched in their constitutions. They also linked the *boda boda* fraternity with other road traffic stakeholders, including the police and council officials **(Appendix IV,** a *boda boda* group constitution). Road traffic crash injuries, initially was a major concern for the interviewed group leaders, but they reported that the crashes had been brought down significantly following seminars and trainings earlier organized by riders' leaders and traffic police, however Eldoret Police reported data showed increased pedal cyclist injury counts for the year 2009. The leaders decried decreasing support from the Traffic Police in enforcement of discipline and compliance with road traffic regulations, which they believed could reduce crash injuries even further among the *boda boda*.

3.2.1. Regulation of the bicycle *boda boda* in Eldoret

Pedal bicycle *boda boda,* like other bicycles, were regulated by traffic laws and additional regulations enacted by local authorities under section 201A of Chapter 265, local government act of the laws of Kenya, to manage local bicycling issues. In Eldoret, the '*Boda boda* by-laws of 2008' were enacted to manage both commercial transport pedal bicycle *boda boda* and motor cycle *boda boda*. The by-laws specified terms and conditions for conducting *boda boda* business and penalties for contravention of the *boda boda* by-laws **(Appendix V: Eldoret *boda boda* by-laws 2008).**

Chapter 403(Revised 1988), the traffic act, of the laws of Kenya, section 69(a) mandated Police officers to regulate all traffic and keep order to prevent obstruction

to roads, parking and public places, while section 55 (1) dictated the maintenance of all vehicle parts in good working condition, including lights and tyres, then section 87 of the same act, prohibits and specifies penalties for careless driving of vehicles other than motor vehicles (e.g. bicycles) on roads or any public places. Section 89, also of the same act, specifies how persons and goods should be carried on any bicycle. Traffic rules in the traffic act, specify mandatory requirements for functional bicycle lights [number 24 section (b), part i & ii], rear reflectors and signs [number 25 section (1), parts (a) i & ii].

None of the traffic rules mandated the use of bicycle riders high visibility garments or helmets!

Individual *boda boda* groups' and NORBITA's constitutions contained articles for self (riders) regulation of some aspects of their commercial transport bicycle *boda boda* business. Among these were: compliance with traffic related regulations, laws of Kenya, penalties for indiscipline, maintenance of bicycles in good condition, requirements for safety equipments etc

(Appendix VI).

3.2.2. Bicycle *boda boda* riders

These riders began working in Eldoret around the year 2000 according to sources from among the *boda boda* leaders, yet other key informants placed their arrival, a year or two later. However, all were in agreement that their numbers peaked between 2006 and 2007.

Estimates from bicycle *boda boda* group registers in early 2009, placed their numbers at about 1600. Decline in numbers became noticeable by mid 2009 and a year later,

just around 1000 were still active in the town. Possible reasons for the decline were many. Relocation of riders from bicycle *boda boda* to motor cycle *boda boda*, unfavourable regulations from the municipality, stiff competition from motor cycle *boda boda* and declining income, were advanced by several key informants as the most probable reasons.

3.2.3. Bicycle *boda boda* riders' organization

Riders were organized in 25 *boda boda* groups, by early 2009. These were registered at the social services office of the then Uasin Gishu district and the Eldoret municipality. Most of these groups were affiliated to an umbrella association called North Rift Bicycle Transporters Association (NORBITA) which was registered by the registrar of societies in 2002. Groups had a constitution, officials including one in charge of *boda boda* road traffic, unique uniforms and designated work stations called bases. They were guided by the constitutions' articles which dictated compliance with all traffic regulations and Kenyan laws **(Appendix IV)**.

3.3. Study Design

Cross sectional survey, was used to access riders' characteristics, crash injuries and observations to determine visibility aids on riders and bicycles.

3.4. Sample size determination

3.4.1. Numbers needed for analysis

Multiple regressions require large samples (200 to 500 elements) to allow adequate disaggregation of the effects of explanatory variables on the outcome variable. Whenever comparative analyses are anticipated, further sample size adjustments are

required. In multivariate logistic regression, the odds ratio (OR) is one of the measures that determine relations between the predictor and outcome variables. An OR value of one (1), means no association between the predictor and outcome (Israel, 1992). Bias in determination of OR is inversely proportional to the sample size. Small sample sizes lead to skewed distributions of the values of OR, which then do not give true relations between the predictors and the outcome variable (Nemis *et al*, 2009). Sudman (1976, cited in Israel, 1992) suggested a sample of between 20 to 50 elements for each minor subgroup. Kish (1965, cited in Israel, 1992) says 30 to 200 elements are adequate for attributes that appear 20% to 80% of the time in a sample.

This investigator, after inspecting the groups' sizes (**Appendix IIIa**), settled for a minimum of 35 elements in each bicycle group to cater for numbers needed for possible comparative analysis in the main study, after excluding groups used in the pilot study.

3.4.2. Factors in sample size determination

Cochran (1992) formulated the formula for calculating sample sizes for proportions. Factors considered include:

- The estimated population of commercial pedal bicycles in Eldoret town, belonging to bicycle groups having 35 or more bicycles, N = 1513.
- The estimated number of commercial pedal bicycles in each bicycle group (stratum) = N_h. Values of N_h were listed in Appendix IIIb.
- Level of precision in estimating the proportion of the desired population characteristic in study subjects or objects, d = 0.05
- Level of risk, $\alpha = 0.05$.
- z_α = abscissa of the normal curve that cuts off an area of α at the tails=1.96

- Proportion of the studied characteristic (bicycle crash injury) being unknown, was therefore set at P = 0.5. Consequently, 1- p = q = 0.5.

Population sample size, before finite population correction,

$n_o = (z^2_\alpha\, pq) / d^2 = (1.96^2 \times 0.5 \times 0.5) / 0.05^2 = 384.16 = \underline{385.}$

Population sample size, after finite population correction,

$n_{fc} = n_o / [1 + (n_o - 1) / N] = 385 / [1 + (385 - 1) / 1513] = \underline{307}.$

The calculated finite population sample size (307) was raised by 40% as Israel (1992) advises, to cater for any contact failures and non-response, to give the estimated population sample size (n_e). $\mathbf{n_e}$ = 307+(40% of 307)=307+(40/100 ×307)=429.8=430. $\mathbf{n_e}$ = 430.

Population sampling fraction (f) was calculated as follows: $f = n_e / N$= 430/1513=0.2842.

Bicycles were selected proportionately from the seventeen (17) strata (bicycle groups) by multiplying the strata sizes (N_h) by the population sampling fraction (f) to create 17 strata samples (n_1 to n_{17}). The actual values of the 17 calculated strata samples (n_1 to n_{17}) are listed in Appendix IIIb. These samples were then added up to make up the actual population sample size (n_s). Therefore, $n_s = n_1 + n_2 + \ldots.. + n_{17}$ = 438, where n_1 is the sample size for stratum (bicycle group) number 1 and n_{17} is the 17^{th} or last stratum. n_s is greater than n_e, due to the effect of rounding up! The actual calculated population sample size (n_s) was 438.

3.5. Sampling Design

Stratified random sampling.

All the **s**eventeen bicycle groups (strata), each with 35 or more bicycles, were the only bicycle groups that were not used in the pilot study. Each stratum contributed a stratum sample (n_h), which was proportional to its size (N_h), to make up the study population sample (n_s). Study subjects to represent each stratum, were selected from a set of n_h computer generated random numbers, which represented the unique bicycle registration numbers between 1and a number equal to each stratum size, n_h i.e. simple random sampling. The first n_h random numbers were picked from each stratum without repetition. The number of study subjects selected was equal to each stratum sample size.

3.6. Sampling criteria

3.6.1. Inclusion:

1. Members of a ***boda boda*** group having 35 or more pedal bicycles registered at their office,

   as reported by their group leadership. Note: It was only this group, which remained after conducting the pilot study!

2. Registered ***boda boda*** riders who cycled in this study area anytime within the period February to December 2008 and were found in ***boda boda*** work stages and working during the survey from 23-26th January 2009.

3.7. Sampling Procedure

All (twenty five) bicycle ***boda boda*** groups in Eldoret Municipality were identified and listed, as at January 20, 2009. They were divided into two groups. The groups with less than 35 bicycles per group were listed without regard to any order and were all used in the pilot study. The remaining seventeen bicycle ***boda boda*** groups, each with 35 or more bicycles per group, were used in the main study. They were listed in alphabetical order **(Appendix: IIIa**). Using the computer Program, M/S EXCEL, random numbers were repeatedly generated between 1 and 17, till 17 numbers were achieved and listed in the order in which they were generated. Each number was picked and listed only once! These numbers which were assigned to the bicycle groups were termed 'Group ID'. The ***boda boda*** group **names** in alphabetical order were assigned **'Group ID'** in the order in which they were generated. Each ***boda boda*** Group ID became a stratum.

Using M/S Excel 'RAND BETWEEN COMMAND' Random numbers were generated between **1** and $\mathbf{N_h}$ and listed in Appendix IIIb. The first $\mathbf{n_h}$ random numbers which were listed without repeating any one number, were the actual sampled bicycle registration numbers for that bicycle group (or Group ID).

These numbers were listed per bicycle group (or Group ID) and used to identify the ***boda boda*** riders to interview and the bicycles to observe, through the ***boda boda*** riders or leaders contacted at their working stages.

These sampled bicycle numbers were listed in the order in which they were generated and replaced with serial numbers termed **'Respondent ID's.**

The number of respondents interviewed was equal to the number of bicycles observed in a ***boda boda*** group and was represented by the letter $\mathbf{n_r}$. Knowledge of 'Group ID' and 'Respondent ID' together, enabled only the Principal Investigator to identify the individual ***boda boda*** rider or real bicycle number, through the questionnaire serial number, in case some need arose. This computer assisted procedure ensured reduction of selection bias and assured confidentiality! The exact number of bicycles (or riders) sampled for each of the seventeen bicycle groups, were listed in Appendix IIIc.

3.8. Data collection

Research assistants

Two ongoing Masters of Public Health Students from the School of Public health, Moi University, were given a two day theory and practical training on the data collection tools and procedures involved. Together with the Principal Investigator, they tested the tools in the field. The two, were thereafter appointed as Supervisors for the pilot study and main study. They were involved in the training of the Research Assistants.

Ten Ordinary-level graduates, who had passed Kenya Certificate of Secondary Education at level 'C' and above, were selected purposively from contacts within Eldoret. They were given a two day training, which covered basic information on the data collection tools and they implemented the pilot study together with the two Supervisors and Principal Investigator. This provided the opportunity for research assistants to refine their practical skills.

Data for the main study was collected in daytime between 8.30am and 5.30pm from 23rd to 26th January 2009. Trained research assistants collected data under strict supervision by the Principal Investigator and the two Supervisors, using the pretested English version of the research tools

(Bicycle *boda boda* riders' questionnaire-Appendix I & observation checklist-Appendix II) for recording data. They also carried along the Swahili version during the survey to read to the interviewees.

Riders belonging to specific groups, owned designated bicycle *boda boda* stages, it was therefore found practically easier to organize data collection by groups. The data collection team was split into two, with each supervisor heading one, while the Principal investigator covered the teams alternately.

Data collection began in every bicycle *boda boda* stage with a talk from the Principal Investigator, a Supervisor or a selected Research Assistant. The purpose of the survey was explained, including its importance to the - riders themselves, their trade, and passengers among others. The importance of bicycling to the individual and population in general, was also included. Voluntary participation, confidentiality and absence of penalties for those who chose to decline the participation request, were equally stressed. Finally, appeal for corporation and truthfulness was made. Verbal consent was sought and granted by each respondent before the interview and observation. The subjects' concerns or questions were channeled to the Supervisor or Principal Investigator for responses as other team members continued with the interviews.

Both *boda boda* drivers' questionnaire and observation checklist were completed at the *boda boda* stages, where the Supervisor or Principal Investigator checked samples of the completed tools to confirm completeness. Completed questionnaires and checklists were finally jointly checked for any other errors and bound per *boda boda* group for safe custody by the Principal Investigator. Data collection took a total of four days from January 23rd to 26th 2009.

3.9. Data Management

Injury data used was that which occurred from February to December 2008, to ensure the collection date did not exceed 12 months, so as to reduce recall bias. This data was entered into an Epi_Info data base, cleaned using the 'data compare program' and analysis carried out. In Epi_Info data base, categorical variables in the 'YES/NO' format are automatically log transformed (coded) as follows: one (1) for YES and Zero (0) for 'NO'. These binary dummy variables represented the presence or absence of visibility aids and occurrence or non-occurrence of the specified injury outcomes.
Data tables were opened for visual inspections and updating every time missing values were suspected in the course of analysis.

Numerical summary measures e.g. frequencies etc, were generated for: visibility aids, characteristics of the riders and specified crash injury outcomes. Two by two tables and multivariate logistic regression, determined significant relations between specific non-infrastructural visibility aids and riders' crashes or injuries, specified by both defined crash periods (night, non-daytime or whole day), received management (self care, outpatient care or in-patient care), and accident circumstances (self involved, motor vehicle, pedestrian, objects, etc).

Odds ratios, 95% confidence intervals, coefficients and p-values were the outputs. Significant -regression models and crash injury predictors among the visibility aids were determined.

Data was presented in numerical summary measures and tables.

3.9.1. Operational definitions of variables

Daytime = Time from 6.31am to 6.30pm, **Dusk** =Time from 6.31pm to 7.30pm,

Night = Time from 7.31pm to 5.29am, **Dawn** =Time from 5.30am to 6.30am

Non-daytime = Time from 6.31pm to 6.30am and includes dusk, night and dawn only.

Whole day = Period of 24 hours or daytime, dusk, night and dawn all together.

Self care = injury management directed by self, not done in a health facility and includes: off the counter medications, massage, wound dressing etc.

Outpatient care = injury management administered in the outpatient section of a health facility and patient released on the same day.

In-patient care = injury management administered in the in-patient section of a health facility for one or more days.

3.10. Ethical considerations

The three basic principles of ethics, i.e. beneficence, respect and justice, were adhered to in the - planning, implementation and dissemination of the study findings.

Beneficence

- Following experiences of the Pilot study, the researcher concluded that persuasion was more cost-effective in gaining the subjects consent.

Consequently, once the study subjects had understood the possible benefits of the study, they voluntarily consented for the interviews without demanding monetary compensation. However, they requested for feedback, which the researcher undertook to avail after successful defense.

- The investigator plans to give feedback to the study subjects and local road safety stakeholders.

Respect

- The study was implemented only after the Institutional Research and Ethics Committee (IREC) at Moi Teaching and Referral Hospital had given formal approval.
- Further approval was sought and was granted by other stakeholders in *boda boda* transportation. These included the *boda boda* groups' leadership, Eldoret Municipal Council and the Officer Commanding Police Division (OCPD), of the then Uasin Gishu District.
- Informed verbal consent was obtained from each study subject before the interviews.

Justice

- Measures to protect confidentiality and privacy were built into the study e.g. anonymous data collection tools, secret serial numbers to represent *boda boda* group names and respondent bicycle registration numbers. These measures also included-safe custody of the completed data collection tools by the researcher.
- No harm to the subjects was noted during the study.

3.10.1. Challenges

- The emergence of motor cycle *boda boda*, among others, reduced membership of – UBBT, EXRBT and TMBB below the cut off for the criteria for inclusion in the Main Study. TMBB and UBBT were therefore replaced by LBBT and EBT respectively, in the Main Study.
- Reduction in bicycle groups' membership also necessitated the inclusion of a larger number of bicycle groups in the Pilot Study.
- Previously unknown subdivision of some bicycle registration numbers e.g. 52A, 52B, 52C etc, forced additional sampling to be done in the field. Sealed numbered papers were used to select randomly, the actual number to represent the registration number 52, as an example.
- Discrepancies were noted in *boda boda* group sizes from different sources. The Principal Investigator directed that only one source, the *boda boda* group leadership be used to supply the group size, as this was also found to be verifiable from the interviewees in the field.

- Earlier suspicions about the purpose of the *boda boda* survey were overcome by the regular interactive talks delivered by the survey teams before the interviews.

3.10.2. Limitations of the Study

- Reliance on self reported injury information, with its known risks for recall bias.
- The 2007/2008 post-election conflict in Kenya, which increased insecurity and caused population displacements in the study area, affected some *boda boda* group sizes.

- Inability to confirm consistent use of non-passive visibility aids e.g. bicycle headlights, during the study period.

3.10.3. Mitigation

- Bias in self reported data was reduced by the following maneuvers:
  - Applications of multiple probing questions to confirm responses e.g. did you ride at night? And much later in the questionnaire, they were asked 'when do you depart your residence to go to work'?
  - Analysis of injury data within a period not exceeding 12 months, i.e. from February 2008 to December 2008, to reduce recall bias.
- Visibility aids data accessed by direct observation, also increased the validity of results.

3.10.4. Assumptions of the Study

- The proportions of independent variables, non-infrastructural visibility aids in the study population remained constant during the study period.

CHAPTER FOUR:

RESULTS

Out of the population sample size of 438, respondents who were interviewed and their bicycle *boda boda* observed were 364. Response rate therefore, was (364/438) ×100 =83.1%.

Results were presented under the following subheadings:

(i) Riders' cultural, demographic, economic and social characteristics.

(ii) Distribution of Non-infrastructural visibility aids.

(iii) Distribution of riders crashes and injuries

(iv) Effects of visibility aids on riders' crashes and injuries.

UNIVARIATE ANALYSIS RESULTS

4.1.1. Riders' cultural, demographic, economic and social characteristics.

Research assistants were instructed to determine a rider's gender by observation of features and dressing. Riders were predominantly male 100% (N=364). The majority, 70.9% (N=258) were in age group 21-30 years, 63.5% (N=231) had primary education, 80.8% (N=294) with 4 years or less riding experience, while 75.0% (N=273) rode at least once at night, 99.2% (N=361) spoke Swahili, 51.9% (N=189) spoke English and 90.4% (N=329) owned the observed bicycle *boda boda*.

Table 4.1, summarizes the riders' characteristics

Table 4.1: Distribution of Riders' characteristics (Continued to next page)

N=364

Demographic, social, economic & cultural characteristics (Yes)		Freq. (%)		Demographic, social, economic & cultural characteristics (Yes)		Freq. (%)
Sex	Male	364 (100)		**Language**	Spoke Swahili	361 (99.2)
	Less than 21	22 (6.0)		**Language**	Spoke English	189 (51.9)
Age group	21-30	258 (70.9)			Less than 1	61 (16.8)
in years	31-40	73 (20.1)			1-2	110 (30.2)
	41-50	9 (2.5)		**Years of**	3-4	123 (33.8)
	More than 50	2 (0.5)		**riding in**	5-6	41 (11.3)
Marital	Married	286 (78.6)		**Eldoret**	7-8	22 (6.0)
Status	Single	76 (20.9)			9-10	5 (1.4)
	Separated	2 (0.5)			More than 10	2 (0.5)
	None	53 (14.6)		**Night ride**	Yes	73 (75.0)
Formal	Primary	231 (63.5)		***Boda Boda***	Group	124 (34.1)
Education	Secondary	79 (21.7)		**Inspected**	Council	70 (19.2)
	College	1 (0.3)		**by?**	Police	26 (7.1)
	University	0 (0.0)			None	144 (39.6)

Table 4.1: Distribution of Riders' characteristics (Continued from previous page)

Demographic, social, economic & cultural characteristics (Yes)		Freq. (%)		Demographic, social, economic & cultural characteristics (Yes)		Freq. (%)
Accident Reduction	4 or more true responses	309 (84.9)		**Cycling Income / Day Kshs.**	Less than 101	8 (2.2)
Drugs used	Mira	18 (4.9)			101-200	96 (26.4)
	Alcohol	100 (27.5)			201-300	130 (35.7)
	Cannabis sativa	11 (3.0)			301-400	86 (23.6)
	Cigarettes	73 (20.1)			401-500	32 (8.8)
	None	162 (45.5)			More than 500	12 (3.3)
Drug time	After work	79 (21.7)		**Riders depart their residences**	Before 5.30 am	30 (8.2)
	Anytime	53 (14.6)			5.30 – 6.30 am	143 (39.3)
	Before work	19 (5.2)			6.31 -7.30 am	10 3 (28.3)
	Others	8 (2.2)			After 7.30 am	88 (24.2)
	Nil	205 (56.3)		**Riders depart stages**	Before 5.30 pm	48 (13.2)
Drug Reasons	Leisure	54 (14.8)			5.30 - 6.30 pm	80 (49.5)
	Reduce stress	49 (13.5)			6.31 – 7.30 pm	65 (17.9)
	More Strength Or courage	17 (4.7)			After 7.30 pm	71 (19.5)
	Others	38 (10.4)		**Visibility Aids' Cost**	4 out of 4 Correctly stated	111 (30.5)
	Nil	206 (56.6)				

N=364

4.1.2. Distribution of Non-Infrastructural Visibility Aids

Non-infrastructural visibility aids include visibility enhancement devices and treatments e.g. high visibility paints or colours. Both types were sought from riders and the bicycles, using observation checklists. Bicycle *boda boda* with specific visibility aids e.g. rear reflectors, were enumerated. Proportions of bicycles with the specified visibility aids were: 67.0% (N=244) any bicycle reflector, 62.9% (N=229) rear reflectors, 27.2% (N=99) working headlight and 1.1% (N=4.0) had bicycle helmets.

Top garments worn by the bicycle *boda boda* riders were also observed. Inquiries were made to confirm whether they were the designated group uniforms. Research assistants were under strict instructions to observe the visibility properties of the garments. A proper search for reflective strips was also stressed. Distinctions had to be made between dull garments and bright ones, among others. If a bicycle helmet was seen, attempts had to be made to look for any reflectors on it.

Certain riders were noted during the pilot study, to have devised own visibility devises. An example was a compact disc as a front reflector. Others were flags, bright coloured paint etc. These were termed conspicuity innovations.

Riders' proportions with reflective strips and group uniform were 55.5% (N=202) and 69.2% (N=252) respectively. Reflective or fluorescent garments were on 27.5 %(N=100) riders.

Results are summarized in table 4.2.

Table 4.2: Distribution of Non Infrastructural Visibility Aids

Observed (Yes)	**Freq. (%)**		**Observed (Yes)**	**Freq. (%)**
Group uniform	252 (69.2)		Rear, amber or red reflector	206 (56.6)
Garment, with reflective strips	202 (55.5)		Front white reflector	51 (14.0)
Garment, Dull	191 (52.5)		Working headlight	99 (27.2)
Garment, Bright	175 (48.1)		Working taillight	66 (18.1)
Garment, reflective or fluorescent	100 (27.5)		Rear carrier, green	115 (31.6)
Bicycle helmet	4 (1.1)		Rear carrier, blue	105 (28.8)
Frame, black colour	342 (94.0)		Rear carrier, red	87 (23.9)
Frame, light colour	28 (7.7)		Rear carrier, white	33 (9.1)
Frame, reflective or fluorescent	11 (3.0)		Rear carrier, yellow	45 (12.4)
Frame, other colours	10 (2.7)		Rear carrier, black	58 (15.9)
Any bicycle reflector	244 (67.0)		Rear carrier, other colours	31 (8.5)
Rear reflector	229 (62.9)		Conspicuity innovations	117 (32.1)
Front reflector	102 (28.0)		Contrasting paint on parts	43 (11.8)
Side reflector	49 (13.5)		Coloured flags / linen	29 (8.0)
Red reflector	221 (60.7)		Improvised reflectors	5 (1.4)
Amber reflector	54 (14.8)		Multiple: reflectors / colours	3 (0.8)
White reflector	29 (8.0)		Other innovations	40 (11.0)
Yellow reflector	24 (6.6)			
Blue reflector	25 (6.9)			
Green reflector	53 (14.6)			

N=364

4.1.3. Self reported Riders' Crashes and Injuries

Injury crashes mostly, affected riders only once or less, occurred in daytime, was self involved and managed by self care. Out of the thirty in-patients, 18 (60%) injured within non-daytime were given in-patient care.

Table 4.3, summarizes the results.

Table 4.3: Distribution of Riders' Crashes and Injuries (Continued to next page)

Self reported (Yes)		**Freq. (%)**		**Self reported (Yes)**		**Freq. (%)**
Any crash (N=364)	Yes	308 (84.6)		**Injuries by time of crash (N=369)**	Daytime	235 (63.7)
Injury crash (N=364)	Yes	239 (65.7)			Night	48 (13.0)
Injury Crashes Per rider (N=364)	Zero	125 (34.3)			Dusk	57 (15.4)
	One	153 (42.0)			Dawn	29 (7.9)
	Two	49 (13.5)		**Motor Vehicle Related injuries by Crash Time (N=103)**	Daytime	63 (61.2)
	Three	27 (7.4)			Night	14 (13.6)
	Four	9 (2.5)			Dusk	19 (18.4)
	Five	1 (0.3)			Dawn	7 (6.8)
All injuries (N = 475)	Riders only	369 (77.7)		**Injuries by month (N= 369)**	Februar y - April	135 (36.6)
	Others	106 (22.3)			May - August	89 (24.1)
Riders' injuries by collision opponent (N = 369)	None (Self involved)	200 (54.2)			Septemb er-Decemb er	145 (39.3)
	Motor Vehicle	103 (27.9)				
	Pedestrian	30 (8.1)				
	Others	36 (9.8)				

N/B: N, less or greater than 364, if some riders' crashes (or injuries) = 0 or more, respectively.

Table 4.3: Distribution of Riders' Crashes and Injuries (Continued from previous page)

Self reported (Yes)		**Freq. (%)**		**Self reported (Yes)**		**Freq. (%)**
Injuries by management (N= 369)	Self care	216 (58.5)		**Motor Vehicle Related injuries by Management (N=103)**	Self care	39 (37.9)
	Outpatient care	123 (33.3)			Outpatient care	52 (50.5)
	In-patient care	30 (8.1)			In-patient care	12 (11.7)
Injuries Managed by In-patient care (N=30)	Daytime	12 (40.0)		**Non-daytime Motor Vehicle Related Injuries by Management (N=40)**	Self care	17 (42.5)
	Night	8 (26.7)			Outpatient care	16 (40.0)
	Dusk	6 (20.0)			In-patient care	7 (17.5)
	Dawn	4 (13.3)				
Injuries Managed by Outpatient care (N=123)	Daytime	84 (68.3)				
	Night	17 (13.8)				
	Dusk	15 (12.2)				
	Dawn	7 (5.7)				
Injuries Managed by Self care (N=216)	Daytime	140 (64.8)				
	Night	23 (10.6)				
	Dusk	35 (16.2)				
	Dawn	18 (8.3)				

N/B: N, less or greater than 364, if some riders' crashes (or injuries) = 0 or more, respectively.

BIVARIATE ANALYSIS RESULTS

4.2.1. Crash Period and Injuries

Time of bicycle crash, when operationalized as daytime, non-daytime or night, predicted specified riders' crash injuries. Crashes occurring within daytime or daytime crashes, predicted

69% increase (OR=1.6888, 95%CI: 1.0921-2.6115) in injuries managed by any type of care. Day crash was associated with fewer in-patient managed injuries. Table 4.4a, summarizes the relations between various crash periods and injuries.

Table 4.4a: Crash period, as a predictor of injuries.

Day crash		**All Injuries, managed by any care**		**1.6888** (1.0921-2.6115)
	Yes	235	54	
	No	134	52	
Dusk, Night & Dawn (Non-daytime) Crashes	Yes	134	52	**0.5921** (0.3829-0.9157)
	No	235	54	
Day crash		**All Injuries, managed by In-patient care**		**0.4043** (0.1900-0.8604)
	Yes	12	277	
	No	18	168	
Night Crash	Yes	8	55	**2.5785** (1.0944-6.0754)
	No	22	390	
Dusk, Night & Dawn (Non-daytime) Crashes	Yes	18	168	**2.4732** (1.1622-5.2630)
	No	12	277	

4.2.2. Visibility Aids' Relations with Specified Riders' Crashes and Injuries.

Rear reflectors in red or amber colours, were associated with 64% reduction (OR=0.3609, 95%CI: 0.1483-0.8784) of night crashes. Bright garments were associated with reduction of non-daytime crashes, while dull garments had the opposite effect, on the same crashes.

Table 4.4, summarizes the results.

Table 4.4b: Univariate Predictors of Riders' Crashes

EXPOSURE		**(OUTCOME) Night Crashes**		**OR (95% CI)**
		Yes	**No**	
Rear - amber or Red reflectors	**Yes**	30	239	**0.3609** (0.1483-0.8784)
	No	8	23	
		Non-daytime (Dusk, Night & Dawn) **Crashes**		
Bright garments	**Yes**	81	156	**0.6577** (0.4539-0.9530)
	No	105	133	
Dull garments	**Yes**	104	127	**1.6178** (1.1162-2.3449)
	No	82	162	

4.2.3. Univariate Predictors of Riders' Injuries

Any bicycle reflector was associated with 67% reduction, OR=0.3290, 95% CI: (0.1150-0.9412) of non-daytime injuries from *boda boda* crashes involving motorcycles, other *boda boda* and objects. Reflective or fluorescent garments reduced whole day injuries from *boda boda* pedestrian crashes. Table 4.5, summarizes significant relations between visibility aids and crashes involving *boda boda* and other vulnerable road users, within non-daytime and whole day periods.

Table 4.5: Univariate Predictors of Riders' Injuries

EXPOSURE		**Non-daytime** (Dusk, Night & Dawn) **injuries, from *boda boda* crashes with: motor cycles, other *boda boda* & objects**		**OR** 95% CI
		Yes	**No**	
Any bicycle reflector	**Yes**	**6**	**308**	**0.3290** (0.1150-0.9412)
	No	**9**	**152**	
Reflective strips	**Yes**	**4**	**259**	**0.2822** (0.0885 - 0.8994)
	No	**11**	**201**	
Bright non-reflective or fluorescent uniforms	**Yes**	**5**	**156**	**0.2926** (0.1115 - 0.7677)
	No	**31**	**283**	
Reflective or fluorescent garments		**Whole day** (Day, Dusk, Night & Dawn) **Injuries from *Boda boda*-pedestrian Crashes**		**0.3427** (0.1176 - 0.9986)
	Yes	4	134	
	No	27	310	
Rear-amber or red reflectors		**Non-daytime** (Dusk, Night & Dawn) **injuries, managed by Self care**		**0.4270** (0.1834 – 0.9941)
	Yes	40	220	
	No	9	22	
Red reflectors	**Yes**	45	237	**0.4177** (0.1853 – 0.9415)
	No	10	22	

4.2.4. Univariate predictors of In-patient managed riders' injuries

Any bicycle reflector and reflective strips, were associated with 56% and 58% reduction, respectively, of whole day in-patient managed injuries but they reduced similar injuries at non-daytime by between 76% and 78%. Table 4.6, summarizes the effects of visibility aids prediction of in-patient managed injuries.

Table 4.6: Univariate Predictors of In-patient managed riders' injuries

EXPOSURE		**Whole day** (Day, Dusk, Night & Dawn) **Injuries, Managed by In-patient care**		**OR** 95% CI
		Yes	**No**	
Any bicycle reflector	**Yes**	**14**	300	**0.4229** (0.2009-0.8901)
	No	**16**	145	
Reflective strips	**Yes**	**11**	252	**0.4434** (0.2061 – 0.9537)
	No	**19**	193	
Any bicycle reflectors		**Non-daytime** (Dusk, Night & Dawn) **injuries, Managed by In-patient care**		**0.2419** (0.0890 – 0.6571)
	Yes	**6**	308	
	No	**12**	149	
Rear reflectors	**Yes**	**6**	294	**0.2772** (0.1021 – 0.7524)
	No	**12**	163	
Reflective strips	**Yes**	**4**	259	**0.2184** (0.0708 – 0.6738)
	No	**14**	198	
Group Uniforms	**Yes**	**7**	291	**0.3630** (0.1381 – 0.9544)
	No	**11**	166	

4.3. MULTIVARIATE ANALYSIS RESULTS

Modeling was done to determine significant multivariate predictors for the injury outcomes specified by injury time and management. Backward elimination was used to determine the best fitting models. In each model, a unit change in a specific visibility aid, significantly predicted change in the specified crash injury outcome, when other injury predictors in the model were held constant.

4.3.1. Multivariate predictors of self care managed injuries

Front, side and rear reflectors predicted 40% to 72% reduction in whole day, self care managed injuries. Table 4.7, summarizes the multivariate predictors of self care

Table 4.7: Multivariate Predictors of Self care managed injuries

Outcome (Yes/No)	Predictors (Yes/No)	OR	95% CI	P Value
Whole day Injuries, managed by Self care	Bright	0.6511	0.3692 - 1.1483	0.1382
	Front reflectors	**0.5965**	**0.3696 - 0.9626**	**0.0343**
	Rear reflectors	**0.2837**	**0.0822 - 0.9794**	**0.0463**
	Red reflectors	1.1923	0.5337 - 2.6636	0.6679
	Reflective strips	1.2830	0.7210 - 2.2829	0.3967
	Side reflectors	**0.5059**	**0.2723 - 0.9402**	**0.0311**
	Working taillights	1.6787	0.9830 - 2.8667	0.0578
	CONSTANT	*	*	**0.0423**
	Likelihood ratio	*	*	**0.0228**
Night Injuries, Managed By Self care	**Front reflectors**	**0.0987**	**0.0104 - 0.9377**	**0.0438**
	Rear- amber or red reflectors	0.3681	0.0676 - 2.0049	0.2478
	Working headlights	9.9563	0.5796 - 71.0204	0.1132
	Rear-amber or red reflectors *Working headlights	0.0948	0.0041 - 2.1746	0.1405
	CONSTANT	*	*	**0.0119**
	Likelihood ratio	*	*	**0.0211**

4.3.2. Multivariate predictors of Non-daytime, Outpatient managed injuries

Working headlights predicted 75% significant reduction in non-daytime injuries which were managed by outpatient care, when other predictors were held constant. Table 4.8, summarizes the results.

Table 4.8: Multivariate predictors of Outpatient managed injuries

Outcome (Yes/No)	Predictors (Yes/No)	OR	95% CI	P value
Non - daytime Injuries, Managed by Outpatient care	Dull garments	0.0000	0.0000->1.0E12	0.9529
	Front reflectors	2.7171	0.9803 - 7.5309	0.0546
	Rear-amber or red reflectors	1.1937	0.2373 - 6.0037	0.8299
	Working headlights	**0.2539**	**0.0771 - 0.8358**	**0.0241**
	Dull garment*Working headlight	9.0160	0.9734 - 3.5140	0.0528
	Dull garment*Front reflectors* Rear- amber or red reflectors	567853.8	0.0000->1.0E12	0.9582
	CONSTANT	*	*	0.0113
	Likelihood ratio	*****	*****	**0.0002**
Non - daytime Injuries, Managed by Outpatient care	Working taillights	8.2537	0.9148 - 4.4683	0.0600
	Bright garments	6513940.5	0.0000 - 1.0E12	0.9697
	Front reflectors	2762044.6	0.0000 - 1.0E12	0.9713
	Rear-amber or red reflectors	1.5090	0.3155 - 7.2175	0.6064
	Working headlights	0.3932	0.0994 - 1.5550	0.1833
	Working taillights*Bright garments	**0.0638**	**0.0063 - 0.6411**	**0.0194**
	Front reflectors*Bright garments	0.0000	0.0000 - 1.0E12	0.9730
	CONSTANT	*****	*****	**0.9653**
	Likelihood ratio	*****	*****	**0.0002**

4.3.3. Multivariate predictors of Non-daytime, In-patient managed injuries

Any bicycle reflector and reflective strips, predicted 72% and 75% significant reduction in non-daytime, in-patient managed injuries, respectively.

Table 4.9: Multivariate predictors of Non-daytime, In-patient managed injuries

Outcome (Yes/No)	**Predictors (Yes/No)**	**OR**	**95% CI**	**P value**
Non -daytime Injuries, Managed by In-patient care	Any bicycle reflector	0.2775	0.1011 - 0.7613	0.0128
	Reflective strips	0.2499	0.0802 - 0.7782	0.0167
	CONSTANT	*	*	0.0000
	Likelihood ratio	*****	*****	**0.0005**

CHAPTER FIVE

DISCUSSIONS

These results' based discussions were organized into the five broad subheadings:

(i) Riders' selected characteristics.

(ii) Visibility aids on bicycle *boda boda* and riders.

(iii) Details of riders' crashes and injuries.

(iv) Defined crash periods and injuries

(v) Relations of visibility aids with riders' crashes and injuries.

The first three relate to respective specific objectives, while the last two both handle the fourth specific objective of this study.

5.1. Riders' demographic, economic, social and cultural characteristics

The riders were predominantly young male primary school graduates, with low income. Majority who were inexperienced riders in the town, regularly cycled in some hours of darkness, were well aware of accident reduction measures, but only one third could correctly cost visibility aids. Half of them consumed drugs, mainly alcohol and cigarettes, while small numbers used Mira or Cannabis sativa *(Refer table 4.1)*.

Poverty, male gender, young age, driving inexperience, travelling in darkness, are known crash injury risk factors, particularly among the vulnerable road users like bicyclists (Breen, 2004, Promising, 2002)

5.2. Non-infrastructural visibility aids on bicycle boda boda and riders

Only 1.1% (N=4.0), were observed with bicycle helmets. Two thirds of the bicycle *boda boda* had at least a reflector and almost all of these were rear reflectors, however those with the recommended rear reflector colours, red or amber, were just half the population. Half the riders had bright top garments or reflective strips which could improve their visibility in traffic, while only one third had the brighter reflective or fluorescent garments. The proportion of bicycles with lights and improvised conspicuity improvements were just about one third only *(Refer table 4.2).*

Inadequate visibility plays a key role in causation of road traffic crashes (Koornstra, 1993 cited in Breen 2004). Head injury was the main cause of death for over 70% of Finnish bicyclists between 1982 and 1988. Studies have documented head injury reductions of 68% to 88% following mandatory helmet wearing regulations (Thomson, 1996, cited in Breen, 2004).

5.3. Riders' crashes and injuries

Two thirds of the riders experienced injury crashes and of these, a similar proportion had it only once in the eleven month period, from February to December in 2008. Half the riders were injured in self involved crashes and the majority was managed by self care.

The ratio of daytime to non-daytime injuries was 3:2 when all injuries were considered; however the ratio was reversed when only in-patient managed injuries were considered *(Refer table 4.3).*

More severe injuries occur in darkness (Breen, 2004).In populations, the true ratios of road deaths: patients seeking hospital care: minor injuries are 1:15:70, therefore within the Eldoret bicyclist population, fatalities were expected (Gururaj, 2000, cited in Breen, 2004.

5.4. Crash period and injuries

Defined crash periods were shown to be significant predictor's of crash injuries *(Refer table 4.4a)*. Night crashes increased in-patient managed injuries by 158% (OR=2.5785, 95%CI: 1.0944-6.0754).

This concurs with previous study findings in injury risk literature, which identify travelling in darkness as a major risk factor for crash injuries (Breen, 2004).

5.5. Relations between visibility aids with crashes and injuries

Daytime crashes were associated with increased injuries managed by any care. Non-daytime crashes were associated with increased injuries managed by in-patient care *(Refer table 4.4a)*. Any bicycle reflector and reflective strips were associated with significant reduction of non-daytime in-patient managed injuries *(Refer table 4.9)*. Working headlight, working taillight and bright garments reduced non-daytime outpatient managed injuries *(Refer table 4.8)*. Rear, front and side reflectors, were each associated with significant reduction of whole-day self care managed injuries *(Refer table 4.7)*.

To help in accomplishing objectives 4 and 5, injury data (objective 3) was either disaggregated or combined to create new variables specifying crashes or injuries by different combinations of- time periods of crash / injury occurrence, circumstances

involved and received management. The resulting crash time periods namely: whole-day, non-daytime and night, were assumed to have different and decreasing average natural visibility, from ‘whole day’, ‘non-daytime’ to ‘night’. The received management was assumed to be a reflection of increasing injury severity, from ‘self care’, ‘outpatient care’ to ‘in-patient care’. These maneuvers created the opportunity to test the effect of individual visibility aids by any selected cell, each of which represented an injury outcome, from 1 to 47 or more.

Table 5.1, shows the cells representing new variables, each defined by two primary variables.

Table 5.1: Creation of New Variables

Period	**Management**			**Circumstances**			
	Self care	Outpatient care	In-patient care	Self involved	Motor Vehicle	Pedestrian	Others /Objects
Non-daytime	1	2	3	4	5	6	7
Night	8	9	10	11	12	13	14
Whole-day	15	16	17	18	19	20	21
Dusk	22	23	24	25	26	27	28
Dawn	29	30	31	32	33	34	35
Circumstances							
Self involved	36	37	38	**Visibility aids:** Any bicycle reflector Red reflectors Rear reflector Group uniform Front reflector etc etc Side reflector Rear-amber or red Working headlight Working taillight Reflective strips Reflective or fluorescent garment			
Motor vehicle	39	40	41				
Pedestrian	42	43	44				
Others / Objects	45	46	47				

The last objective was described under the following subheadings:

(i) Visibility aids and self care managed injuries

(ii) Visibility aids and outpatient care managed injuries

(iii) Visibility aids and in-patient care managed injuries

(iv) Visibility aids and *boda boda*-pedestrian collision related injuries

5.5.1. Visibility aids and self care managed injuries

Self care managed injury was assumed to group minor injuries, which were the most numerous, at 58.5% (N=216) among all riders' injuries in this study results *(Refer table 4.3).*

Rear-'amber or red' reflectors and red reflectors were significant predictors of self care managed injuries which occurred within non-daytime. They reduced this category of injuries by between 57% and 58% respectively, at the bivariate level *(Refer table 4.5).*

Front, side and rear reflectors, reduced whole day-self care managed injuries by 40%, 49% and 72% respectively, at the multivariate level *(Refer table 4.7).*

These findings provide support for expectations from previous studies, which concluded that reflectors by increasing detection and recognition distances were likely to improve conspicuity thereby will possibly reduce crashes and injuries (Kwan & Mapstone, 2006).

At the multivariate level, front reflectors were shown to be associated with 40% (OR=0.5965, 95%CI: 0.3696-0.9626) significant reduction in whole day injuries which had been managed by self care. In night time, the reduction even increased to 99%, with other factors held constant *(Refer table 4.7).*

It concurs with previous findings. Earlier, it was determined that if bicyclists in Netherlands used both front and rear lights, there would be an 8% reduction in casualties at night (Schoon, 2003, cited in SWOV, 2006).

5.5.2. Visibility aids and Outpatient care managed injuries

No visibility aids predicted significant changes in outpatient care managed injuries, at the bivariate level.

Working headlight, working taillight and bright garments, significantly reduced this injury category, within non-daytime period when other factors were held constant, at the multivariate level. Working headlight significantly predicted 75% (OR=0.2539, 95%CI: 0.0771-0.8358) reduction in outpatient care managed injuries within non-daytime. Working taillight and bright garments were associated with 99% significant reduction of non-daytime outpatient managed injuries *(Refer table 4.8).*

Schoon (2003, cited in SWOV, 2006) determined an 8% possible reduction of casualties in Netherlands, if all bicyclists used both back and front lights at night.
And Blokpoel (1990, cited in SWOV, 2006) determined a 5% reduction in casualties at twilight and darkness in the after period, following the introduction of the 'wheel circle law' in Netherlands.

In a cross sectional study in New Zealand, use of visibility aids and crash injury involvement were determined by E-mail. No association was found between use of backlight or headlight and injuries (Thornley *et al*, 2008).

Bicyclists and even bicycles in high income countries were likely to vary significantly from this study population, being drawn from the poorest segment of society in a developing country. Differences in visibility aids data collection methods might also have contributed to the differences in results.

5.5.3. Visibility aids and in-patient care managed injuries

In-patient care management was most likely given mainly to those who suffered severe crash injuries, since their frequency was the lowest at only 30/369 or 8.1%, as would be expected of severe crash injury outcomes. Conservative estimates give the ratio of –road deaths: injuries requiring hospital care: minor injuries are 1:15:70 (Gururaj, 2000, cited in Breen, 2004).

Any bicycle reflector, rear reflector, reflective strips and group uniform each predicted significant reduction of in-patient managed injuries, which had occurred at non-daytime and night. Percentage reductions varied from 58% within whole day period to 78% in non-daytime.

Reflective strips were associated with 56% (OR=0.4434, 95%CI: 0.2061-0.9537) significant reduction in whole daytime injuries, but a 78% (OR=0.2184, 95%CI: 0.0708-0.6738) reduction of similarly managed injuries, within non-daytime *(Refer table 4.6)*.

At the multivariate level, any bicycle reflector and reflective strips were associated with 72% (OR=0.2775, 95%CI: 0.1011-0.7613) and 75% (0.2499, 95%CI: 0.0802-0.7782) significant reductions of in-patient care managed injuries sustained within non-daytime period *(Refer table 4.9*.

In Netherlands, it was determined that 100% use of front reflectors could prevent two bicyclists death per year (Schoon & Polak, 1998, cited in SWOV, 2006).

The mandatory ‘wheel circle law’ in Netherlands was evaluated in a ‘before and after’ study, results showed a 5% decline in non-daylight bicyclist casualties in the ‘after’ period (Blokpoel, 1990, cited in OECD, 1998).

In across sectional study in New Zealand, use of visibility aids and crash injury involvement were determined by E mail. No association was found between use of reflective colours and injuries (Thornley *et al*, 2008). Contextual differences between the study sites and populations may explain the differences.

5.5.4: Visibility aids and pedestrian collision related riders’ injuries

Reflective or fluorescent garments were associated with 66% (OR=0.3427, 95% CI: 0.1176 - 0.9986) reductions in whole day injuries which resulted from *boda boda* – pedestrian collisions.

Results concur with those of a previous study *(Refer table 4.5)*.

In across sectional study in New Zealand, use of visibility aids and crash injury involvement were determined by E-mail. They found significant reduction of crash injuries among bicyclists who reported always wearing fluorescent colours (Thornley *et al*, 2008).

CHAPTER SIX:

CONCLUSIONS AND RECOMMENDATIONS

The chapter is broadly divided into two parts, conclusions and recommendations. Each section is guided by the objectives, while relying on relevant results.

6.1. CONCLUSIONS

- Known crash injury risk factors e.g. alcohol consumption, riding in darkness, young male, poverty and riding inexperience were identified among the riders' demographic, economic and social characteristics.
- Most of the bicycle *boda boda* and riders had inadequate conspicuity, particularly in conditions with low natural visibility.
- Riders experienced more crash injuries requiring hospital care mostly in non-daytime hours and most of them were motor vehicle collision related.
- Non-infrastructural visibility aids were associated with reduction of crashes and injuries.

6.2. RECOMMENDATIONS

This section is divided into four parts, and proposes possible countermeasures to the identified risk factors among the riders' characteristics, non-infrastructural visibility aids usage as well as the experienced crashes and injuries.

The effects of specific non-infrastructural visibility aids were used to recommend them as interventions against the specified injuries.

1. Education, awareness and publicity campaigns to reduce:

- Night riding without visibility aids, drug consumption, lack of awareness of visibility aids and other risks which are common among these young bicycle riders
- Dangers posed by motor vehicles.

2. Campaigns to increase the use of visibility aids (reflectors, bicycle lights, high visibility garments), on riders and their bicycles.
3. Increased enforcement of the use of visibility aids on bicycles, since that was already mandated by the Traffic act, Municipal by-laws and the *boda boda* constitutions.
4. Municipal authorities to expedite traffic calming measures and / or separate bicycle roads, among others.
5. Further research using more rigorous methods e.g. prospective designs to raise the level of evidence for the usefulness of visibility aids in bicycle crash injury prevention.

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APPENDICES

Appendix I: BICYCLE BODA BODA RIDERS' QUESTIONNAIRE

SERIAL NUMBER: ……..…… Date: …….……

STUDY SITE: Eldoret Municipality

BICYCLE **STAGE** **NUMBER:**

……..

INTRODUCTION / CONSENT STATEMENT

Must be read to any respondent, before interview and observation!

1. The Researcher: Dr Kowiti Joseph Omol

   School of public Health, Moi University, P.O. Box 4606 Eldoret

   Tel: 0721 869 093, E-mail: jkowiti1@yahoo.com
2. This Study seeks knowledge for prevention of bicycle crash injuries.
3. Your voluntary participation in this Study will be highly appreciated.
4. However, declining to participate will not expose you to any penalties.
5. YOUR NAME OR IDENTITY WILL NOT BE RECORDED
6. Information you give will never be traced to you or used against you.
7. DO YOU AGREE TO PARTICIPATE?

YES	NO

Instructions:

- Tick (√) appropriate response or responses.
- Do not write names of *boda boda* rider or bicycle number on this document.

Section I: Cultural, Demographic, economic and Social Characteristics of the bicycle *boda boda* **rider**

1. Which sex is the bicycle ***boda boda*** rider? **Observe, and then tick □√ one response.**

Male □ Female □

2 (a). When were you born? …… Or: (b). How old are you? ……..

(c). What is your marital status? Tick □√ one response.

Single □. Married □. Separated □. Widowed □

3. What is your highest level of formal education? Tick □√ one response.

None □ Primary □ Secondary □ College □ University □

4. (a). Which languages do you speak? Tick □√ one or more responses.

Swahili □. English □. Mother Tongue □.

(b). Which language is your mother tongue? .....

Section II: Accident Experiences from February to December in the year 2008

Answer questions 5 to 12, only for bicycle accidents which occurred in the year 2008.

Section II (a): Injury to *boda boda* **rider or Other Road Users from February to December in the year 2008**

5. (a) Did you have an accident anytime when riding?

Tick □√ one response. Yes □. No □. If your response is 'NO', move to number 9.

(b) i. Did you get physical harm during your bicycle accident(s)?

Physical harm include: bruises, cuts, pricks, scratches, swellings, sprains, fractures, internal organ injuries, among others.

Tick □√ one response. Yes □. No □. If your response is 'NO', move to number 9.

(b) ii. Did any other road user(s) get physical harm during your bicycle accident(s)?

Tick □√ one response. Yes □. No □. If your response is 'NO', move to number 9.

(c). How many times did you get an accident with your bicycle, which led to physical harm to you or anyone?

1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10 or more □

Record responses to questions 6(a) to 8, for each accident which led to injuries to the *boda boda* driver or anyone. **Indicate the serial number of each accident with an Arabic n**umeral in ascending order, i.e. 1 for 1st accident, 2 for the 2nd etc, which happened in the year 2008 only.

Insert 1, 2 etc, into the box or boxes with appropriate response(s) to each question.

6 (a). Within which month did this accident take place? One accident, one Response.

February	March	April	May	June	July
August	September	October	November	December	

(b). In which part of the day or night, did this accident take place? One accident, one response.

Day time	Night time	Dawn	Dusk	Don't know

(c). Who was or were injured in this bicycle accident? One accident, one or more responses.

Boda boda driver .	*Boda boda* passenger .	Pedestrian	Motor Cyclist
Another bicyclist	Others ,		state

.	……

(d) How many people were injured in this accident? One accident, one response.

One	Two	Three	Four	Five	Six or more

7. Which circumstances led to this bicycle accident? One accident, one or more responses.

Self involved, *boda boda* only crash	*Boda boda*-Motor vehicle collision
Boda boda – pedestrian collision	*Boda boda* - *boda boda* collision
Boda boda –objects collision e.g. animals, posts, walls, etc	*Boda boda* – motor cycle collision
Others , state……..	

8. Following this accident, what actions were taken? One accident, one or more responses.

Out-patient care
In-patient care
Self care

Section II: Other Characteristics of the bicycle *Boda Boda* rider

Tick □√ one response each, for questions: 13, 14, 15 and 16(i).

9. How many years have you worked as a *boda boda* rider?

Below 1 □ 1-2 □ 3-4 □ 5-6 □ 7-8 □ 9-10 □ Above 10 □

10. How many years have you worked in this town, as a *boda boda* rider?

Below 1 □ 1-2 □ 3-4 □ 5-6 □ 7-8 □ 9-10 □ Above 10 □

11. Did you ride a bicycle in this town anytime, even once at night, in the year 2008?

Yes □. No □.

12 (i). Was your bicycle ever inspected in the year 2008?

Yes □. No □. If response is 'No', move to number 17.

Tick (√) one or more responses for each of the questions: 12(ii), 13, 14 and 15(a).

(ii). Who did the inspection? Police Officer □. Council Official □. Bicycle group Official □.

Tick (√) one or more responses for each of the questions: 17, 18 and 19(a).

13. Which of the following may help in reducing the number of bicycle accidents in this town:

You must tick □√ one response for each statement from number 17(a) to 17(e)

(a). Riding bicycles in good working condition. Yes □. No □. Don't know □

(b). Regular Traffic Police patrols. Yes □. No □. Don't know □

(c). When all road users obey road traffic rules. Yes □. No □. Don't know □

(d). Motor vehicles moving at low speeds. Yes □ No □. Don't know □

(e).Not cycling or driving any vehicle, after taking alcohol. Yes □ No □ Don't know □

(f). Others □, state- nil, one or more responses ……..……

……

14. Do you use any of the following?

Miraa □ Alcohol □ Cannabis sativa □ Cigarettes □ None □

If your response is 'none', move to number 20.

15. (a). If you use any item listed in number18 above, at what time or times?

Anytime □. Before work □. After work □. Lunch time □.

Others □, State …….

(b). Why do you use the item or items you have selected?

……..

16. Do you own this bicycle? Tick □√ one response. Yes □ No □

17. How much money in Kenya shillings, do you earn from *boda boda* per day?

Tick □√ one response.

Less than 101 □. 101-200 □. 201-300 □. 301-400 □. 401-500 □. 501or more □.

18. When (e.g. 10 am) do you start the journey from your house to your bicycle stage?.....……..

19. When (e.g. 10 am) do you leave your bicycle stage for your house, at the end of theworking day?.....……

20. Do you <u>know the cost in Kenya shillings</u>, of each of the listed items?

You must tick □√ one response for each statement from number 24(a) to 24(d).

If your response is 'Yes', fill the 'cost' in the dotted lines!

(a) One <u>rear</u> bicycle <u>reflector</u> of any type. Yes □. Shillings . ……. No □.

(b) One bicycle <u>headlight</u> of any type. Yes □. Shillings …… No □.

(c) Any one type of <u>high visibility riding clothes</u>. Yes □. Shillings ....…… No □.

(d) <u>Your group uniform</u>. Not applicable □. Yes □. Shillings …… No □.

Appendix II: BODA BODA OBSERVATION CHECKLIST

Instructions:

Observe the bicyclist and his bicycle carefully, then give appropriate responses.

Numbers: 1-5(d), 6, 7 & 8. Tick □√ one response each.

Other numbers: Insert appropriate responses in the dotted lines.

1. Is the *boda boda* rider in group uniform? If in doubt, ask! Yes □. No □.

2. Main description of the *boda boda* rider's clothes, worn above the waist.

(a) Uniform or clothes, are dull and not easy to see. Yes □. No □.

(b) The colours are bright and easy to see. Yes □. No □.

(c) Uniform or clothe has reflective strips. Yes □. No □.

(d) Top clothe is reflective or fluorescent. Yes □. No □.

(e) Others, state……

3 (a). Is the *boda boda* rider - wearing, carrying or hanging on the bicycle, a bicycle helmet?

Yes □. No □.

If the response above is 'No', move to number 4.

(b). Does the helmet have reflectors? Yes □. No □.

4. State the main description of the bicycle *boda boda* frame, from choices.

(a). Black colour. Yes □. No □.

(b). Fluorescent or reflective colours. Yes □. No □.

(c). Lighter colours. Yes □. No □.

(d). Other colours □, state……

5. Observe the *boda boda* carefully for any reflectors. Note colours and Count them!

(a). Any reflectors on the bicycle? Yes □ No □. Total number? …….

If the response above is 'No', move to number 6.

(b). Backward facing (rear) reflectors? Yes □ No □. Number? Amber & red Others……

(c). Forward facing (front) reflectors? Yes □ No □. Number? White …… Others.

(d). Reflectors facing other directions? Yes □ No □. Number? ……

If the response above is 'No', move to number 5(f).

(e). To which bicycle parts are reflectors facing other directions fitted? Tick □√ true responses.

Spokes □. Forks □. Rear carrier □. Improvised fittings □.

Others □, state ……

(f). Colours of reflectors seen on the bicycle? Tick □√ true responses.

Red □. Amber □. Blue □. Green □. White □. Yellow □. Others □.

6. Look at the *boda boda's* lighting parts. If dynamo and either tail light, head light or both are present, request the *boda boda* rider politely, to put on the lights.

(a) Working head light present? Yes □. No □. (b) Working tail light present? Yes □. No □.

7. Description of cushion cover on the rear *boda boda* carrier: Tick □√ true responses.

(a) Cover made with reflective or fluorescent materials. Yes □. No □.

(b) Main colours: Red □. Blue □. Green □. White □. Yellow □. Black □. Others □

8. Are there any innovative method(s) that this *boda boda* rider uses to improve his or her conspicuity and that of the bicycle? Yes □. No □.

If response is 'Yes', briefly describe the method(s) seen on this *boda boda* or its rider.

……

……

Appendix IIIa: Details of Documented Boda Boda Groups – Eldoret (20-01-2009)

Serial Number	**Names**	**Abbreviated Names**	**Number of bicycles**
1	Eldoret Bondeni Bicycle Services	EBBS	115
2	Eldoret *Boda-Boda* Transporters	EBBT	110
3	Eldoret Bicycle Youth Group	EBYG	070
4	Eldoret Chinese Bicycle Transporters	ECBT	040
5	Eldoret East Bicycle Transporters	EEBT	050
6	Eldoret KCC Bicycle Transporters	EKBT	110
7	Eldoret Langas Bicycle Group	ELBT	100
8	Eldoret Racecourse Bicycle Group	ERBT	090
9	Eldoret Town Bicycle Services	ETBS	125
10	Elgon View Boda Bicycle Services	EVBBS	040
11	Langas *Boda Boda* Transporters	LBBT	070
12	Hawaii Bicycle Transporters	HBT	070
13	Kamukunji Town bicycle group	KTBT	070
14	Rift Valley Bicycle transporters	RVBT	170
15	64-bicycle Transporters	64-BTS	050
16	Uasin Gishu bicycle Transporters	UGBT	188
17	Eldoret Bicycle Transporters	EBT	045
18	Eldoret Arya Bicycle Transporters	EABT	30
19	Eldoret X-Rivertex Bicycle Transporters	EXRB	25
20	Eldoret Yamumbi Bicycle Transporters	EYBT	15
21	Huruma *Boda Boda* Transporters	HBBT	8
22	Maili Nne Bicycle Transporters	M4BT	8
23	Moi Girls-Town Bicycle Transporters	MTBT	8
24	Uchumi *Boda Boda* Transporters	UBBT	5
25	Mti Moja Bicycle Transporters	MMBT	4
	TOTAL	**ALL GROUPS**	**1616**

Appendix IIIb: Details of Boda Boda Groups used in Pilot Study

Serial Number	**Group Name**		**Number of Bicycles**
	In Full	**Abbreviated**	
1	Eldoret Arya Bicycle Transporters	EABT	30
2	Eldoret X-Rivertex Bicycle Transporters	EXRB	25
3	Eldoret Yamumbi Bicycle Transporters	EYBT	15
4	Huruma *Boda Boda* Transporters	HBBT	8
5	Maili Nne Bicycle Transporters	M4BT	8
6	Moi Girls-Town Bicycle Transporters	MTBT	8
7	Uchumi *Boda Boda* Transporters	UBBT	5
8	Mti Moja Bicycle Transporters	MMBT	4
	TOTAL		**103**

Appendix IIIc: Details of Boda Boda Groups used in Main Study

Group ID (Secret)	Group Size (N_h)	Sample Size (n_h)	Respondents' Number	Response Rate (%)
1	050	15	14	93.33
2	040	12	9	075.00
3	070	20	18	090.00
4	110	32	32	100.00
5	115	33	26	78.79
6	040	12	12	100.00
7	125	36	36	100.00
8	090	26	17	065.38
9	100	29	10	034.48
10	110	32	23	071.88
11	070	20	17	085.00
12	070	20	10	050.00
13	070	20	17	085.00
14	170	49	46	093.88
15	188	54	52	098.11
16	045	13	13	100.00
17	050	15	12	080.00
Total	**1513=N**	**438=n_s**	**364=n_r**	**083.11**

Appendix IV: Interview Guide for Key Informants

Selected institutions:

1. Eldoret Municipal Council: Enforcement, Engineering & Health Depts.
2. Eldoret Police Station.
3. Health facilities: Moi Teaching & Referral Hospital & Eldoret East District Hospital.
4. *Boda boda* Leadership: Groups & Association (NORBITA).
5. Kenya Urban Roads Authority (KURA), Eldoret Office.

Section I: Questions to all informants

1. When did bicycle *boda boda* start operating here?
2. Which are the working hours of bicycle *boda boda* here?
3. Comment on changes in numbers of the riders since then. State possible reasons!
4. Are riders and / or their bicycles registered? By whom and why?
5. Benefits from bicycle *boda boda* in this town*?*
6. Major problems associated with bicycle *boda boda?*

   If so, state: magnitude, trends, countermeasures and results to date

   If not, ask: bicycle accidents' - magnitude, trends, interventions & results.
7. State the stakeholders and their roles in Eldoret bicycle *boda boda*.
8. How are the *boda boda* organized in Eldoret?
9. Is the bicycle *boda boda* business regulated? By whom, how and regulations relied on.

   If not, ask for laws, by-laws and group constitutions. Sources and / or copies to carry.
10. Any regulations mandating use of reflectors, lights, high visibility garments or identification uniforms on bicycle *boda boda* and riders?

Section II: Questions to specific informants

(a) Chief Enforcement Officer

- Any register for all bicycle *boda boda* and their riders?
- When you inspect bicycle *boda boda*, what exactly do you look for?
- How do you organize the regulation of the riders?

(b) Municipal Engineer

- Eldoret road network (Km): Total ……

  -Central & peri-urban, all bitumen……
- Road space for bicycles? Now: ……..Planned: ……

  Comments on road state and others……

  ……
- Functional Street / Road lighting: Town centre…….Highways…

  Estates……Comments……

  ……...……
- Traffic calming measures: Speed limits……

  Speed bumps / rubble strips…….....

  Others, state……

(c) Municipal Medical Officer of Health

- List health facilities within the Municipality and categorize by functional level.
- Facility serving largest proportion of accident patients, including injured bicyclists? Why?
- Morbidity and mortality causes in Eldoret: Top 10 & position of accidents?

(d) *Boda boda* Group Leadership

- When was your group formed?
- What are the objectives of your group?
- Do some members work anytime between 6.31pm and 6.30am?
- Do you have a group constitution? May I have a copy?
- When you inspect your members' bicycles', what exactly do you look for?
- Reflectors, lights, uniform and high visibility garments: use mandated by your constitution?

(e) Traffic Base Commander, Eldoret Police Station

- Do you enforce road traffic regulations among the bicycle *boda boda*?
- Are there standard documents for receiving and reporting road traffic accidents? State document numbers and show blank copies.
- How do the Kenya police categorize crash injuries?
- Reported pedal bicycle accidents, from 2005 to 2009: Counts by period daytime or night. Was it mandatory to report visibility aids on bicycle or rider?
- Were the bicycle *boda boda* separated from other bicyclists in the injury data?
- Any bicyclists' prosecution for drug or visibility aids offences in 2008?
- Additional information!

(f) Records: Moi Teaching & Referral Hospital / Eldoret East District Hospital

- Road traffic injury data, 2005 to 2009, broken by:

  -Vehicles responsible?

  -Occupation of bicycle operator, i.e. private or *boda boda*?

- What were the bicycle injury counts for the period 2005 to 2009, by: crash time, received management, sex, age and treatment outcome? Same information for all road traffic accidents
- Top 10 causes of morbidity and mortality, 2007-2009. Position of accidents?
- Bed capacity in 2008: Total……Injury wards only…….

(g) Engineer, Kenya Urban Roads Authority (KURA), Eldoret.

- What is the role of KURA in this town?
- Separate road space for bicyclists in this town: Now or planned?
- If planned, when is it likely to be implemented?

Appendix V: *Boda boda* By-Laws 2008

THE LOCAL GOVERNMENT ACT
(CAP 265)

IN EXERCISE of powers conferred by section 201 of the Local Government Act, the Municipal Council of Eldoret makes the following By-Laws.

THE MUNICIPAL COUNCIL OF ELDORET BICYCLE AND MOTOR CYCLE TAXIS-BODA BODA BY-LAWS 2008

Citation1: These by-laws may be cited as bicycle and motor cycle Taxis-Boda Boda by-Laws, 2008.

Interpretation 2: In these by-laws, except where the content otherwise requires;

" Boda Boda'' means bicycle transportation.

" Clerk" means the Town clerk, his Deputy or his Assistant.

" Council" means the Municipal council of Eldoret.

" Operator" means the person riding or cycling Boda Boda.

" Permit" means a permit issued under these By-laws.

" Parking Places" means a space in a parking place which is provided for the parking of Boda Boda.

" Sticker" means the official libel of municipal Council of Eldoret, signifying payment of relevant charges.

" Charge" means payments to be made to municipal Council of Eldoret.

"Enforcement Officer" means an Officer of the municipal Council of Eldoret, authorized by the Town Clerk to control and enforce By-Laws by doing inspection, bonding, arrest or detention and impounding.

" Highway" means the busy roads leading to and out of Eldoret designated in Schedule 5.

" Good condition" means having reflectors, side mirrors, passenger seats and effective brakes.

Application 2: Any person wishing to be a Boda Boda operator or Motor cyclist shall apply to the Town Clerk on the application form in Schedule 1.

3. The Council may reject an application if the form is not filled correctly and when the number of people is beyond what can be accommodated in particular stages according to the second schedule.

(i) All operators must be registered with the Council and given a registration number.

Designation of parking place **4.** The areas of the roads under the second schedule of these By-Laws are designated as parking places.

Permit **5.** Operators shall pay permit charges or parking fees of Kshs. 140 a week, 600 a month, 7200 a year and be given receipts.

6. Every person in operation shall produce on demand a permit issued under these By-Laws.

Certificate from Engineer 7. The Engineer shall certify that a Boda Boda is in condition before registration. The certificate is under third schedule.

Instructions 8 Operator shall comply with and obey all instructions, directions and orders

given by the Enforcement Officer.

Design of parking Places 9. The number and situation of parking places shall be such as are determined by the Council.

Requirements 10. Before registration, operators shall

a) Have a certificate of good conduct

b) Have a training certificate from the traffic commander

c) The boda boda be in good condition

d) Operator be in uniform as prescribed by the second schedule

e) An identification card as prescribed in fourth schedule

Rules of operations 11. No operator shall:

a) Willfully interfere with or obstruct the Enforcement Officers acting in the performance of their duties.

b) Behave in a disorderly manner'

c) Park within 2 meters from the road'

d) For the purpose of taking up or dropping passengers or loads, stop on the road except at the side of a road.

e) Smoke, drink while riding, a fare- paying passenger in such a bicycle.

f) Operate Boda Boda without a registration certificate from the council.

g) Operate on the Highway.

h) Operate without protective gear provided to their clients.

i) Refuse to abide by traffic rule.

Offence 12. Any person who contravenes the provision of these By –Laws shall be guilty of an offence.

Penalty 13. Any person who contravenes the provision of these By-laws shall be liable:

a)To a fine of Kshs. 1000 or imprisonment for a term not exceeding three weeks.

b) Impounding of the Boda Boda and payment of storage charges of Kshs.50 an hour. or imprisonment for a term of two months.

c)For a second offence, to a fine of Kshs.4000 or imprisonment for a term of two months.

Examination By the Medical Officer of Health 14. The Medical Officer of Health shall examine the health of the person riding in the bicycle or motor cycle taxi.

Police 15. Offences under these by-Laws shall be cognizable to the police.

FIRST SCHEDULE

APPLICATION FORM

Serial No……..

1. Name……
2. Identification……
3. Parking Areas ……..
4. Parking Address……
5. Frame No: …….
6. Phone No: …….

I hereby apply for a Boda Boda permit and promise to abide by the By-Laws governing it.

Sign ……

Date ……

SECOND SCHEDULE
PARKING AREAS IN CBD

S/No	Area uniform	colour	Other areas	colour
1	Arya	Blue	Elgon view	Silver
2	Kobil	Green	Pioneer	Silver
3	Petreshar	Yellow	Kidiwa	Silver
4	Miyako	Red	Huruma	Silver
5	Naivas	Purple	Langas	Silver
6	Sirikwa Hotel	pink	KCC	Silver
7	Fims	Brown	Kimumu	Silver

THIRD SCHEDULE
CERTIFICATE OF BICYCLE CONDITION

Date……..
Name of operator……
Route or Parking Area: ……
Condition of Bicycle: …….
Approved / Not Approved ……
Signature ……

FOURTH SCHEDULE
IDENTITY CARD

Name : ……
ID / NO: ……..
Application No: ……..
Route / Parking Stage …….

FIFTH SCHEDULE
HIGH WAY REGISTRATION

1. Kisumu Road – up to fims stage.
2. Iten Road – up to Central Primary junction
3. Uganda Road (i) up to Lions Branch
4. Uganda Road (ii) up to Nyathiru

Made this ……Day of ……2008
By order of Municipal Council of Eldoret

Appendix VI: A boda boda group constitution
UASIN GISHU BICYCLE TRANSPORTERS
SELF HELP GROUP
(UGBT)
P.O. BOX……ELDORET

CONSTITUTION
Section 1
REGISTRATION

a) Any person joining this group must pay registration fee.
b) The registration fee for a new comer must be more than Kshs 500.
c) A new comer must be given the rules and regulations of the group and he should comply with it before being registered.
d) The registration must be made through the secretary and registration fee to be forwarded to treasurer.

Section 2

ADMINISTRATION

a) There shall be a patron.
    i. The patron will be mandated to give direct advice on the group's progress
    ii. He/she will stand by for any support on any problems encountered by the group.
    iii. The group patron shall be the spokesman of the group.
b) There shall be a Chairman.
    i. Chairman is the leader of the group
    ii. He will chair all meetings
    iii. The chairmanship shall be alternating to the members forming the group
c) There shall be a secretary
    i. The secretary will be mandated to keep all records and documents concerning the group (group custodian).
    ii. He will be mandated to take all minutes during the group meetings.
d) There shall be a treasurer.
    i. The treasurer shall be mandated to deal with all financial issues.
e) There shall be assistant chairman.

i. The assistant chairman shall be the chair and take all his responsibilities in case there is absence of chairman.

f) There shall be assistant secretary

i. The assistant secretary will take all responsibility as secretary in case there is absence of secretary.

g) There shall be four subcommittees

i. Organizing committee

ii. Steering committee

iii. Financial committee

iv. Social welfare committee

Section 3

COMMITTEES AND ITS RESPONSIBILITIES

(a) **Organizing committee**

i. The committee will be mandated to organize all meetings concerning the group

ii. The other committees shall forward the agendas of this committee for discussion in the general meeting.

iii. To forward the information to the required people.

iv. To organize all events concerning the group.

N/B: The committee to be headed by chairman and secretary of the group.

(b) Steering committee

i. To run day to day group's programmes on development

ii. The committee to inquire for support from the donors and bring the report to the group's head office for follow –up.

N/B: chairman and secretary of this committee to be elected by the members of the group.

c) **Finance committee**

i. To manage and balance all financial activities of the group.
ii. To collect and record all groups income and expenses
iii. Withdrawal of any amounts should be attached by minutes from the committee.

N/B: The group treasurer shall be the chairman of this committee and the secretary of this

committee to be elected by members.

Social welfare committee

i. To deal with general welfare of members who are within the group.
ii. The committee to set the welfare contribution fee to be paid by all members in the group. All members must contribute to the welfare.
iii. The committee to base the assistance on:-
    - Death
    - Sickness
    - Stolen bicycle (the source of income)
iv. The committee will basically assist the close family member of the group member.

    Those are:
    - Member himself
    - Wife and children
    - Parent (father and mother)

N/B: The group shall only assist one member. Wife (first to be recognized).

Section 4

(a) Election of leaders to be carried out after every one year, after the first election.
(b) Election to be carried out through ordinary secret ballot.
(c) The patron being the ex-officio shall be the returning officer during election.
(d) Any registered member is allowed to contest for any post and to vote.
(e) The candidate which emerges with a greater number of votes is declared a winner.

This goes to candidate who stands unopposed who becomes winner.

(f) The elected leader to sit in office in a term of one year and new election to be held as stated in section 4(a).

(g) In case of death or resignation, the assistant of the elected post shall take over or interim leader to be appointed to run the office for six days and election must be done within or before expiry of this period.

(h) Incoming officials assume office immediately or 14 days after election and outgoing leaders to hand over office documents before the expiry of this period.

(i) The members can vote NO CONFIDENCE to the leader of a certain post or as the officer as all, but should be supported by 65% of total registered members.

(j) If vote of confidence wins the post remains vacant and election to be done within 14 days period or sixty days if it agrees with section 4(g).

(k) All the elected leaders can seat in the office for two terms of one year each only if his work satisfies the members and shall not contest the similar post forever.

Section5

GENERAL BY-LAW

(a) The group shall use its law to judge its member found in any misconduct unless the group requests for legal assistance from NORBITA.

(b) The group leaders are urged to enforce law and order among its members.

(c) NORBITA shall not interfere with its groups programme anyhow.

(d) The bicycle of our members must be in good condition.

- Must have good brakes, bell, cushion, and headlights.
- Must have good tyres.

(e) Members should have discipline

- No use of abusive language
- Must follow road signs and use the road in the right way.
- Must honour the elected officials and all the other members in the group/project.
- The members and officials must keep and abide by the secret in the group

(f) All members must follow all the rules and abide by the regulations of the group

- Must not misbehave when cycling the bicycle.
- Shall not carry any suspect or law breaker.
- Must not break the laws of Kenya
- Must not mislead other members.

(g) The problems which are beyond the group can be forwarded to the umbrella body (NORBITA).

(h) The group members should not forget the laws of the country, traffic law and Municipal council.

(i) The secretary shall prepare and present the year returns, which involve report from all other sub committees to the executive official 14 days before the end of the financial year and the AGM.

(j) The group shall have its security department which shall assist on enforcing the law and order among the *boda boda* members. The security shall have a commander who is elected by members.

(k) The security department to work cooperatively with NORBITA, the Municipal and traffic police for easy flow of *boda boda* operations in the town and road.

OBJECTIVES

1. For unity of *boda boda* members
2. For recognition of the *boda boda* project in town.
3. To make sure *boda boda* welfare is well represented.
4. To create self-employment and discourage idleness among the youth.
5. To create availability of public transport.

The constitution was adopted on **20th September 2008** by all members and signed by:

1.	UGBT Patron	Ramadhan Ali	Sign
2.	UGBT Interim –Chairman	Wilson Kidandi	Sign
3.	Security Commander	Ernest Mukotso	Sign

Appendix VII: Map of Eldoret Town