Article:

Uzondu, C, Jamson, S orcid.org/0000-0001-8166-0403 and Lai, F (2018) Exploratory study involving observation of traffic behaviour and conflicts in Nigeria using the Traffic Conflict Technique. Safety Science, 110 (Part A). pp. 273-284. ISSN 0925-7535

https://doi.org/10.1016/j.ssci.2018.08.029

Exploratory Study Involving Observation of Traffic Behaviour and Conflicts in Nigeria Using the Traffic Conflict Technique

Abstract

Road traffic crashes are a major public health problem affecting those living in developing countries, exacerbated by the lack of available resources to tackle the issue (WHO, 2015). Whilst crash reduction measures have been developed and implemented, there has been limited success in developing countries and the crash rate keeps increasing. Partly to blame are the lack of empirical research and high quality crash data. Data do exist – but their reliability is questionable, with respect to the data collection methods used and underreporting. This study, undertaken in Nigeria, used surrogate safety measures based on systematic observation of traffic behaviour and conflicts to assess the behaviour of different road users and investigate the role various factors play in determining conflict severity. Data were analysed using the Traffic Conflict Technique and binary logistic regression. Results show that direction of traffic, time of day and the relevant road user's age, gender and speed are important determinants of conflict severity. This study highlights the applicability of surrogate safety measures in traffic safety assessment in a developing country and demonstrates that quality data needed for road safety assessment in developing countries could be collected over a short period of time by making use of resources which are readily available.

Key words: traffic crashes, developing countries, traffic safety, traffic conflicts

1 Introduction

Road traffic fatality and injury rates in developing countries have continued to increase. WHO (2015) reports an uneven distribution of crash rates, with nearly 90% of total crashes in the world occurring in low and middle income countries which have only 47% of the world's registered vehicles. The African region is the worst hit with a fatality rate of 26.6% per 100,000 population (WHO, 2015). Hyder (2002) highlights the heavy burden road traffic injuries places on developing nations and states that it costs them at least $100 billion a year; this is twice as much as the aid received worldwide and these losses hinder economic and social development. Those affected mostly represent the most active group of any population and represent a very large percentage of the workforce. Peden et al. (2002) has shown that road traffic injuries have become a major cause of Disability-Adjusted Life Year (DALY) losses in developing countries because a greater number of children and men in their productive ages suffer these injuries, and according to Bishai et al. (2008), the fatality rates in these countries is estimated to increase by 80% from 1990 to 2020, unless appropriate measures are taken.

Transport systems and infrastructure have expanded rapidly in developing countries, while little has been achieved in preventing crashes or lessening their severity (Almqvist and Hydén, 1994). According to Peden et al. (2004), rapid motorisation, poor road and traffic infrastructure as well as the behaviour of road users have all contributed immensely to increases in road traffic crashes and fatalities in Africa.

Over the years, road safety measures have been developed and whilst success has been recorded in developed countries, less has been achieved in developing countries; in fact, the crash rate keeps increasing (WHO, 2015). Partly to blame are the lack of empirical research and high quality crash data. This scarcity of data has been emphasised by Dowing (1991) where he estimates that there may be 20 person-years of research effort each year in developing countries compared to over 500 in developed countries.

The number of road crashes, casualties and associated consequences, all emanating from crash data are the most commonly used measure of assessment for road safety (Wegman, 2013). Data on traffic crashes are important for monitoring and assessing progress on programmes where intervention has taken place and most of all for measuring trends and targeting intervention programmes on specific and identified causes of road traffic crashes. Road crash data could also help in defining the magnitude of the matter by comparing it with other causes of death in order to make informed decisions (WHO, 2015).

Road crash data collection has been an issue of concern for a long time; whilst in developed countries methodologies have evolved from the use of traditional methods such as questionnaires (Reason et al., 1990), interviews (Nielsen, 2011), travel diaries (Stopher and Greaves, 2007) to the use of mobile phones (Aguiléra et al., 2012), GPS recorders (Gong et al., 2012), instrumented vehicles (UDRIVE and SHRP2) and driving simulators (Comte and Jamson**,** 2000), this is not mirrored in developing countries. Most research in developing countries is based on interviews and questionnaires (Batool et al., 2011; Newnam et al., 2014; Peltzer and Renner, 2003 and Persson, 2008). Lack of data in the developing countries has been a constraint to many developmental projects especially in the area of driver behaviour and road safety. This paucity of data has been attributed to the high cost of direct data collection, lack of established government information sources and low penetration of technology (Jug, 2014). One of the objectives of the Decade of Action (WHO, 2009) is to improve the quality of road safety data at the national, regional and global levels. Improving data quality makes interpretation, analysis and application of an outcome more relevant, it helps target interventions to specific and identified problems.

Nigeria has the highest fatality in Africa, with a rate of 33.7 deaths per 100,000 population per year far above the regional average of 24 deaths per 100,000 population (WHO, 2013). In Nigeria, the Federal Road Safety Corps (FRSC) and the traffic police are responsible for collecting and registering information on crashes but they are poorly harmonised resulting in under-reporting. Road traffic crash data are generally only presented as a summary with little or no detail regarding road users involved or contributory factors. As most road safety campaigns in Nigeria are based on road crash data, therein lies the problem; according to Osayomi (2013), whilst several road safety intervention efforts have been implemented, crashes keep increasing. Intervention efforts cannot yield much without proper research targeted at specific identified needs.

Properly collected, documented and analysed crash data helps to provide an understanding of why crashes occur, determination of crash severity, factors influencing the risks of getting involved in a crash and hence what measures to put in place to either reduce or prevent their occurrence. With a continued increase in crash rate in developing countries, reductions cannot be achieved without rich data including information about time of day, traffic conditions, type of manoeuvre made by those involved in the crashes and so forth. However, directly applying research methods and results from countries perceived to have made significant improvements in achieving reduction in crash rates to other countries who have achieved less may not be a viable approach. This is because circumstances, environment and conditions differ and it is very important, especially for safety purposes, to conduct country specific research in order to make reliable decisions for safety analysis. However, it is still important to explore how low and middle income countries can improve their road safety records by learning from high income countries (WHO, 2004). According to Wegman (2010), developing countries could analyse road safety problems and design road safety strategies, using the experiences of developed countries and thereby speed up progress.

Many crashes can be prevented by implementing effective road safety measures; this relies on decision makers having information on the effectiveness of different causes of action before investing in them. According to Muhlrad (1993), appropriate behavioural information can be obtained at relatively low cost and is a great advantage as support for safety policies. The observation of human behaviour in real traffic situations is a useful means of investigation as it provides greater knowledge of road user behaviour and interaction of various road users as well as means to identify and describe some of its determining features.

The magnitude of the road safety problems in developing countries will require more information than can be elicited from crash data. Lord and Mannering (2010) and Savolainen et al. (2011) have shown that to urgently address the enormous social losses caused by road crashes, there is a need to gain a better understanding of factors, events and circumstances that could lead to a crash. This cannot easily be achieved with past crash data. Crash numbers are too small, take a very long time to collect and collate, the method of collection and reporting is biased and not informative. The need for a more comprehensive and informative understanding of the connections, various factors and events leading to a crash, relationship between behaviour of road users by considering both unsuccessful and successful interactions, informed the application of the Traffic Conflict Technique (TCT) in this study. To our knowledge, the TCT has not been used for road safety assessment in Nigeria.

This study, therefore, uses direct behavioural observation to examine traffic behaviour and conflicts of various road users in Nigeria using non-crash data and to investigate the role various factors play in determining conflict severity. Cost-effective methods of data collection using locally available resources were employed, and this has provided information on the operation of different traffic systems which is important in safety diagnosis.

2 Method

2.1 The Traffic Conflict Technique

This study uses the Traffic Conflict Technique (TCT) as an alternative to analysing crash statistics. The TCT was adopted because of the limitations associated with crash data in Nigeria. The TCT is a method of observation, where near-crashes (conflicts) are recorded and used for predictions of accident risk and studies of events leading to crash situations. A conflict situation is defined as when two or more road users approach each other in time and space to such an extent that a collision is imminent if their movements remain unchanged (Amundsen and Hydén, 1977). Conflict points are locations where the travel paths of road users cross. If the paths and speeds of two road users lead to them passing a specific conflict point at the same time, then at least one road user must change their speed or direction to avoid a collision. This means that at least one road user must be aware of the other prior to the conflict point and correctly assess their location, speed and path trajectory.

According to Hyden and Stahl (1979), a serious conflict is similar to a crash, a situation that nobody puts him/herself into deliberately. One of the advantages of the TCT is that it is possible to collect sufficient data within a short period of time because traffic conflicts occur more frequently than crashes (Hyden, 1987). Other activities such as speed measurement, behavioural observation etc. can also be undertaken at the same time. With regards to the validity of the TCT (correlation between conflicts and crash frequency), Hauer and Garder (1986) showed that serious conflicts and crashes belong to the same process, just with a different degree of seriousness; crashes can be described more or less as a continuation of serious conflicts at a higher severity on the scale. The Malmo study in 1983 (Grayson, 1984) where eight teams from different countries simultaneously made conflict observations at different intersections demonstrated that differences in observer reliability were not significant and that observers were able to detect 75% of serious conflicts. Video recording is also helpful in conflict studies as it aids in checking observer reliability and confirming conflict severity (Svensson and Carsten, 2007).

The traffic conflicts observed in this study were analysed using the Swedish TCT (STCT). This method was developed by Hyden (1975), who hypothesised there to be a close relationship between conflicts and crashes. The technique uses objective units to measure the severity of conflicts and studies only serious conflicts, recorded manually by observers. The STCT has been widely adopted in many studies on conflict analysis both in developed and developing countries e.g. Thailand, Denmark, Finland, Uganda, Srilanka, Turkey, Costa Rica, Jordan, Brazil, Tanzania and Bolivia (Almqvist and Ekman, 2001) and is based on the two measures (Hyden, 1987):

i. Time to Accident (TA) - defined as the remaining time from when the evasive action is taken until a collision would have occurred if the road users did not change their speed and direction.

ii. Conflicting Speed (CS), the speed of the road user who takes the evasive action, just before the action is taken. This road user is called the "relevant road user" (rel.) while the other one is the second (sec.) road user.

In the application of the STCT, the TA is evaluated based on the subjective estimation of distance and speed carried out by a trained observer. The calculation of TA and the classification of conflicts are done after the data collection takes place. The first definition of conflicts by Hyden (1987) used a TA value of 1.5 seconds to make a distinction between serious and slight conflicts. A serious conflict was said to have occurred when the TA value is equal to or less than 1.5 seconds. This definition appeared to work well in the urban areas where speed was rather low compared to rural areas where speed is usually higher (Shbeeb, 2000). The definition was later changed by considering the speed of the relevant road user. The threshold was redefined, and a safety margin of 0.5 seconds was added and took into consideration the braking distance of the road user which Shbeeb (2000) defined as being inversely proportional to the square of the speed. Even though the STCT was designed to focus only on serious conflicts, Svensson (1998) extended the scope to include normal interactive behaviour. The aim was to show that the relationship between numbers of successive severity levels is also very important to gain insight and make a comparison between different traffic sites.

2.2 Study location

This study was carried out in Owerri, Imo State Nigeria which has been described as one of the states with the highest number of road traffic crashes in Nigeria (FRSC, 2015). According to official figures from FRSC (2015), injury rate in the state has remained very high despite variations in the number of reported crashes. In recent years, there has been an overwhelming increase in vehicle ownership; the number of tricycles (popularly called *Keke* N.A.P.E.P.) as a means of public transportation has also increased due to a ban placed on motorcyclists in the city eight years ago. It is expected that in a city where there are many vehicle types, different road user groups without much knowledge of road safety, and roads lacking properly designed road furniture (or none at all), there will exist behaviours and conflicts that might seem different to those in the developed world.

This study was conducted at three locations selected to be representative of typical road environments in Nigeria, Table 1 and Figure 1. This was to enable us to have a general understanding of behaviour at each location. It was decided that locations chosen should be such that would include different types of intersections or links on urban and sub urban roads, heavy pedestrian area and roads with mixed traffic.

Table 1: Characteristics of study locations

	Government College (LOC_1)	*Imo State University junction (LOC_2)*	*Dick Tiger (LOC_3)*
General description	Dual carriageway; with lane marking; mix traffic; good condition road	Dual carriageway; no lane marking; mix traffic; poor road condition laid in residential and commercial zone	Single carriageway; no lane marking; mix traffic; poor road condition laid in residential and commercial zone
Speed limit/posted/lane marking	50km/h; not posted; yes	50km/h; not posted; no	50km/h; not posted; no
Parking and loading	Restricted on street parking/unrestricted loading	Restricted on street parking/restricted loading	Restricted on street parking/unrestricted loading

Pedestrian crossing	None	Yes, one side	None
Pedestrian paths	Yes, all sides	None	None
Traffic lights	None	Yes	None
Road layout	Link	Roundabout, semi signalised	Four arm, un signalised
Traffic control/warden	No/part of morning peak	Yes/part of morning peak till dusk	No/part of morning peak
Presence of road divider	Yes	Yes	None

Figure 1: Study locations

2.3 Data collection

This study was carried out in real traffic, broad daylight and under good weather conditions using onsite video recording and manual data collection. 16 field assistants helped with data collection as it was carried out at the same time across all locations. Two observers carried out the conflict studies, two measured speed while two others collected behavioural data at each location. Data collection was carried out every day of the week for seven days (Monday to Sunday). The initial plan was to start on a Monday and conclude on Sunday of the same week, but Saturday was declared an environmental sanitation day and movement was restricted until 10:00. Because of this, the Saturday data collection was rescheduled to the next Saturday, in order to ensure comparability of data. In addition, speed data were collected over the course of two weeks. At the end of data collection, the field assistants were given a little financial reward as thanks for their time. This method is labour intensive and can only be used in an environment where access to field assistants is neither difficult nor expensive. The period of observation included both peak (07:30-9:00) and off-peak (11:00-12:30) periods every day of the week for seven days during June/July 2016. The video recorder was set at some distance from the junction and observers were also positioned in such a way as to reduce any influences or interference with normal road user behaviour. The following data were recorded:

i. *Traffic volume* - vehicle, tricycle and pedestrian volumes were recorded. Cyclists' volume was also recorded (cyclists were banned in the city some years ago and as a result, the volume is very low). Traffic that crossed each location during the period of data collection were included in the traffic count, via the video-recording.

ii. *Speed and other safety related behaviours* - the speed of at least 100 free flowing vehicles and tricycles were measured with a handheld radar during both peak and off peak hours. To ensure free flow conditions, all speed observations were made at average headways of 5 seconds. To enrich the dataset, observations of seatbelt use, mobile phone use, eating/drinking, headphone use, give way/red light violations and overloading were recorded. Data were collected at both peak and off-peak periods every day of the week. The total period of observation was twenty-one hours for each location.

iii. *Conflicts* - included interactions between different road users observed to be on a collision course. This implies the existence of an evasive action or manoeuvre (braking, swerving and accelerating) – action to avoid something. Also, events with an evasive action and almost a collision course were included. The speed and distance to collision point just prior to the evasive action were noted. Other road user related features such as gender, estimated age and type of conflict (same direction, crossing and opposite direction) and brief description of events leading to conflicts were noted.

2.4 Data analysis

The STCT was used to define and categorise conflicts according to severity (serious or slight). Svensson, (1992) has shown that the number of events classified as serious conflicts according to the definition of this technique has a strong correlation with the number of police-reported accidents and in some cases (when the number of accidents is small), serious conflicts can be better estimators of the expected number of accidents than the actual accident statistics.

Descriptive analysis was used to provide simple summaries of data from behavioural observation based on frequency counts. This was to identify the percentage of road users who violated traffic rules and exhibited unsafe behaviour while driving and to find out at what time of the day it was most prevalent. Following the standardized approach of analysing speed data for different time periods, univariate descriptive including mean (*M*) and standard deviation (*SD*) were generated to determine speed distribution of different road users and an independent-samples *t*-test was used to determine whether the differences in mean scores of different groups of road users for different time periods were statistically significant or not.

In addition, since the aim of this study was to use surrogate safety measures for road safety assessment, further statistical analysis was carried out on the conflict data using different methods of discrete data analysis. This allowed investigation of the influence of road user's behaviour on conflict severity. Data used in the analysis were extracted from the conflict observation form and recorded video**.** All the data are dichotomous or categorical variables. Normality tests (Shapiro-Wilk) were conducted to determine if the sample comes from a normal distribution. Small values indicate the sample is not normally distributed.

Pearson's Chi square test was used to test the relationship between different categorical variables, while Odds Ratios and Cramér's V are used to investigate the strength and direction of association of variables. Logistic regression established the most influential factors affecting conflict severity of different road users. Specifically, the aim is to determine the mean value of the dependent variable (in this case conflict severity) given the values of the independent variables (road user type, direction of traffic, etc.). Binary logistic regression is used because the dependent variable is dichotomous (0: serious, 1: slight). The resulting linear regression equation and odds ratio associated with each predictor variable are reported.

3 Results

3.1 Traffic volume

Figure 2 shows the results of the hourly traffic counts for all road users across all locations for the different time periods (peak, off peak). Generally, traffic volume was higher during the peak period compared to the off peak period for all categories of traffic across all the locations. At LOC_1, pedestrian volume was observed to be the highest during the peak period probably because of the City College very close to the study site. Vehicles and tricycle volumes were also high during the peak period. At LOC_2, the highest proportion of road users were vehicle drivers in the peak period. Pedestrian volume recorded during the peak and off peak period was also high. Results from LOC_3 shows that vehicle volume was the highest during the peak period. Pedestrian volume was observed to be lower at this location compared to the other locations.

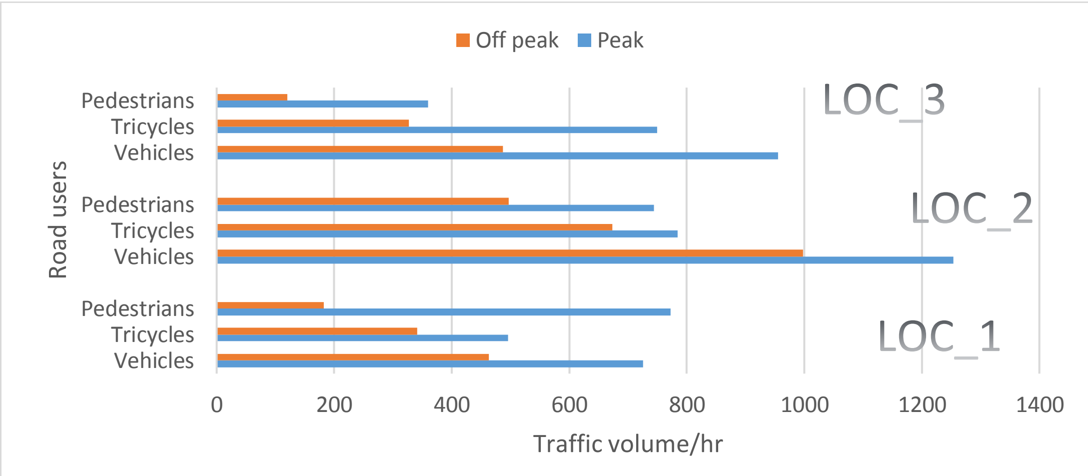

Figure 2: Traffic volume per hour

Additional analyses performed to explore differences in gender and estimated age of observed road users show that approximately 72% of the vehicle drivers were male (age range 18-75) and the remaining 28% were female (age range 22-65). Of all observed tricycle drivers during both peak and off peak period, 99.8% were male between the ages of 20-56.

3.2 Safety related behaviour

Mean speeds were significantly lower during the peak compared to the off peak period across all locations and for both vehicle types, see Table 2, likely due to traffic flow. At such, in off peak periods, vulnerable road users are exposed to higher risk as a result of these higher speeds.

Table 2: Mean speed by location and road user type

Locations	*Road user type*	*Peak mean (SD)*	*off peak mean (SD)*	*df*	*T*	*p*
LOC_1	Vehicle	43 (19.1)	57.9 (25.8)	198	-4.358	.000
	tricycle	38.4(9.8)	44.7(13.1)	198	-3.864	.000
LOC_2	Vehicle	45.4(12.7)	54.8(24.0)	198	-3.435	.001
	tricycle	39.6(7.5)	43.7(15.5)	198	-2.337	.020
LOC_3	Vehicle	35.6(9.1)	43.9(10.9)	198	-5.873	.000
	tricycle	30.9(5.6)	34.2(7.2)	198	-3.628	.000

Figure 3 shows the percentage frequency of all behavioural observations made during the study period for all locations, as a percentage of the traffic volume. For vehicle drivers across all locations, the most prevalent behaviours observed were not wearing seatbelts, red light/give way violation, speed violation and cell phone use. Speed violations by vehicles were observed at all three locations (78%, 52% and 32% respectively), as well as for tricycles (43%, 25% and 0% respectively). Red light/give way violation was more prominent during the peak period while the other behaviours were mostly observed during the off peak periods.

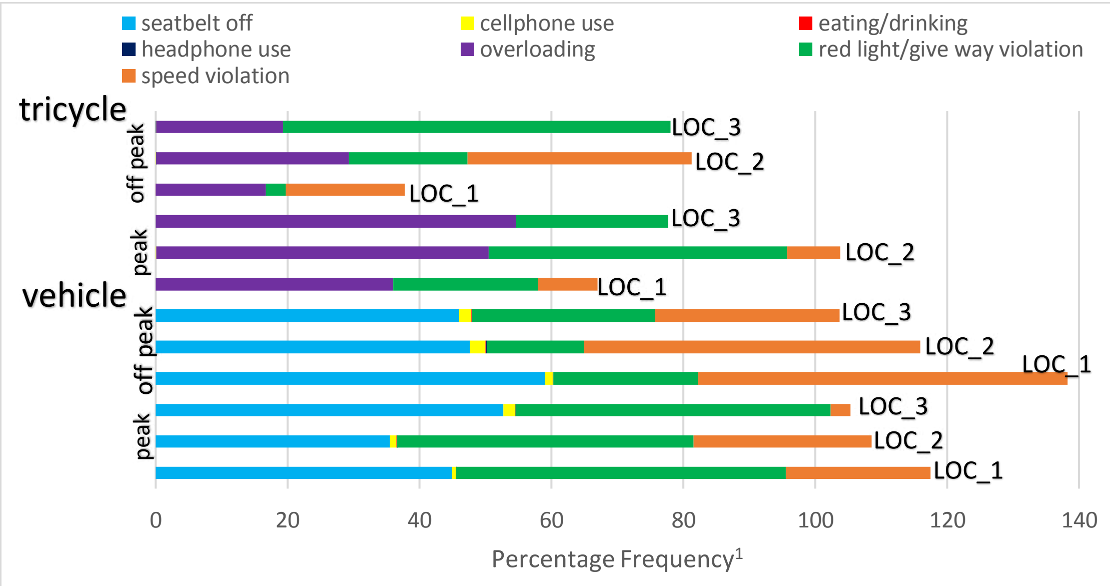

Figure 3: Results from behavioural observation

For tricycle drivers, the most prominent unsafe behaviours recorded were overloading, red light/give way violation and speed violation. There were little or no observations recorded for cell phone use, eating/drinking and headphone use during both peak and off peak periods.[1]

3.3 Conflicts

The total number of conflicts recorded was generally higher during the peak period compared to off peak, but when weighted by percentage frequency, the relationship reversed (Appendix A).

At LOC-1, 92 of the total 170 conflicts observed were serious as opposed to slight, evenly split between peak and off peak hours. The majority (86%) were either vehicle-vehicle or vehicle-tricycle conflicts. At this location, 4.4 serious conflicts occurred every hour. The majority of conflicts recorded during the peak period were crossing conflicts compared to the off peak period when there were more same direction conflicts. No opposing traffic conflicts were observed at this location.

A total of 445 conflicts were observed at LOC_2 with a marginally higher proportion occurring during the peak hours (56%) and 67% being serious. Just over half of these occurred during peak hours, and three actual collisions took place during the off peak hours, involving vehicles and tricycles. As a result of the high traffic volume and improper enforcement at this location (even though it is partially signalised), the conflict rate was very high (13.9/hr). As for LOC_1, the

[1] These were the percentages at each location based on counts. For example at LOC_1: 45% wore seatbelt and the remaining 55% didn't, 0.5% used cell phone, 99.5% didn't etc.

majority of conflicts recorded during the peak period were crossing conflicts and a particular problem here involved vehicles and tricycles approaching the roundabout from all directions

LOC_3 is quite different from the others both in layout, traffic enforcement and regulation. With 10.8 conflicts being observed at this location every hour, 62% were serious, spilt evenly across peak and off peak times. Almost 90% of these were either vehicle-vehicle or vehicle-tricycle conflicts; five actual collisions took place. Considering lower traffic volume at this location, it could be considered as being more risky than the other locations, especially for vulnerable road users. Unlike the other previously discussed locations, more conflicts involving vehicle-pedestrian, vehicle-tricycle and tricycle-tricycle were observed during the off peak period. The majority of conflicts recorded during both the peak and off peak periods were crossing conflicts. A high number of opposing conflicts were also observed here unlike the other locations. Figure 4 shows examples of some observed conflicts.

Figure 4: Examples of observed conflicts

4 Predicting conflict severity from behaviour

Appendix B shows the variables included in the regression analysis. It considered conflict severity as a dependent variable which is dichotomous (0: serious or 1: slight) and predicts the likelihood that Y=1 instead of Y=0, considering the influence of a set of X values. If P is the probability of a road user being in a slight conflict (Y=1), then the probability of not being in a slight (being in a serious) is 1-P (Y=0).

The independent variables were elicited from the conflict observation form and video recording. Out of 989 interactions recorded at the three locations, there were 501 vehicle-vehicle, 71 vehicle-pedestrian, 338 vehicle-tricycle, 67 tricycle-tricycle and 12 tricycle-pedestrian interactions. Overall, a very high percentage of observed conflicts involved male road users compared to females. In addition, more conflicts were observed in the peak compared to the off peak period.

Before developing the model, a Chi-square test was used to investigate association between the variables, Appendix C. All interactions involving different road users across the three locations were analysed. Different variables were found to be strongly related to conflict severity at different locations.

At LOC_1, a very strong relationship is observed ($p<0.05$) between variables of age_rel., gender_rel., speed, evasive action, time of day and conflict severity while at LOC_2, variables such as direction of traffic, age_rel., gender_rel., age_sec. and speed were found to be strongly related to conflict severity. Additionally a strong relationship ($p<0.05$) was observed between direction of traffic, gender_rel., speed and conflict severity at LOC_3. An important point to note is that speed and gender_rel. appears to be common across all three locations showing that they are strongly related to conflict severity regardless of where the observation was made.

4.1 The conflict severity model

To further analyse the data, a conflict severity model was developed using binary logistic regression. Table 3 shows the model estimates of the logistic regression model for different locations, along with the reference categories of the variables, parameter (beta) estimates, significance level as well as the exponential of the beta estimates.

Table 3: Binary logistic model for conflict severity

	Reference category	***LOC_1***			***LOC_2***			***LOC_3***		
Variables		***B***	*p*	O.R	***B***	*p*	O.R	***B***	*p*	O.R
Direction of traffic			003*			.000*			.000*	
same direction	crossing	1.435	003*	4.201	0.154	$.565^{o}$	1.167	1.509	.000*	2.221
opposite direction		n/a	n/a	n/a	2.507	.000*	12.274	-0.056	$.857^{o}$	0.514
Age (rel.)			.005*			.016*			.029*	
26-45	15-25	1.768	003*	5.859	0.365	$.214^{o}$	1.440	0.386	$.177^{o}$	1.471
46-64		0.335	$.592^{o}$	1.397	0.730	.017*	2.074	0.900	.005*	2.459
65+		2.340	.012*	10.382	1.580	.007*	4.855	0.985	$.066^{o}$	2.679
Gender(rel.)			.002*			.000*			.011*	
female	male	1.539	.002*	4.660	1.029	.000*	2.799	0.738	.011*	2.093
speed			.026*			.018*			.002*	
yes	no	1.546	.026*	4.690	0.831	.018*	2.295	1.161	.002*	3.192
Time of day			.010*			-			.027*	
peak	Off peak	1.129	.010*	3.091	-	-	-	0.542	.027*	1.720
constant		-0.711	.749	0.491	-0.382	.712	0.682	-0.344	.756	0.709
Nagelkerke's R^2		.438			.254			.187		
Correctly classified		75%			73%			70%		
Hosmer and Lemenshow			.150			.961			.599	

*significant at a 95%confidence level; ^{o}not statistically significant

The predictive ability of the models (75%, 73% and 70%) for the three locations is considered satisfactory. Regarding model validation, the Nagelkerke R-Square (which is between 0 and 1) is used and suggests that the new model can explain approximately 44%, 25% and 18% of the variance at each location. Finally, the *p*-value of the Hosmer and Lemeshow test indicates that the models fit the data well. The outcomes indicate that the model developed is reliable for analysis and interpretation.

Of the factors selected for analysis, direction of traffic, age and gender of relevant road user, speed and time of day when conflict was observed were found to be statistically significant. The effects of the identified factors in conflict severity were revealed by the odds ratio compared with the reference level.

The binary logistic regression method was applied to identify these factors and their statistical relationship to conflict severity which was categorised as serious or slight. The serious group was used as a basis for comparison. The same explanatory variables were identified across all three locations except at LOC_2 where there was no statistically significant relationship between time of day and conflict severity. These variables were modelled as a function of conflict severity and are shown to be statistically significant at a 95% confidence level. Variables such as evasive action and age (sec.) were not statistically significant and were removed from the model.

According to the way the models were developed, the coefficient of an independent variable is directly related to the probability of having a slight conflict. Therefore, a positive coefficient indicates a variable that increases the probability of having a slight conflict while a negative coefficient indicates a decrease in probability. Invariably, positive coefficients indicate that being in a slight conflict becomes more likely as the independent variable (predictor) increases while negative coefficients show that being in a slight conflict becomes less likely as the independent variable (predictor) increases. The interpretation of results is accomplished through the analysis of odds and probabilities, related to these variables. It is used to represent the likelihood of a slight conflict occurring instead of the likelihood of not occurring and are expressed as ODDS= (P/ (1-P)).

The most influential factors among the independent variables are discussed below:

(i) Direction of traffic

Direction of traffic in the study was defined as the direction the road users involved in the interaction were travelling when the conflict occurred. It was categorised as same direction, opposing direction and crossing (reference category). There were no opposing direction conflicts at LOC_1. Additionally, no interactions between pedestrians and other road users travelling in opposite direction were recorded.

Across all locations, this variable was found to contribute significantly to the models. At LOC_1, road users travelling in the same direction are 4.201 times more likely to be in a slight conflict than those crossing. LOC_2 shows that those travelling in the same direction and opposite direction are 1.167 and 12.274 times more inclined to be in a slight conflict compared to those crossing. The result is fairly similar in LOC_3, where the odds of travelling in the same direction and being in a slight conflict is 2.221 times compared to crossing. Results further showed that the odds of travelling in the opposite direction and being in a slight conflict is low (.514). The negative beta coefficient indicates that being involved in a conflict while travelling in the opposite direction tends to decrease the probability of being in a slight conflict.

(ii) Age (relevant road user)

Results from all three locations showed that age of the relevant road user is an important predictor of conflict severity. Table 3 shows that not all age groups are consistently significant across all locations. Compared to road users aged 15-25 (reference category), those in the age brackets 26-45, 46-64 and 65+ are (5.859, 1.397, 10.382 [LOC_1]; 1.440, 2.074, 4.855 [LOC_2] and 1.471, 2.459, 2.679 [LOC_3] times) more likely to be involved in a slight conflict. At all the locations, there were no observations made involving pedestrians aged <15.

(iii) Gender (relevant road user)

There is also a relationship between gender of the relevant road user and conflict severity at all locations. The odds of being in a slight conflict are greater for females as opposed to males. At LOC_1, females are 4.660 times more likely to be in a slight conflict than males. This is also the same at LOC_2 and LOC_3, where the odds of females being in a slight conflict are 2.799 and 2.093 times respectively. Serious conflicts were also found to be more common for males than for females, but given there was a relatively large number of male compared to female road users, this result should be treated with some caution.

(iv) Speed (relevant road user)

Speed of the relevant road user was also found to be an important factor in the models at all three locations. Road users observed to have reduced their speed at evasive action are more likely to be involved in a slight compared to those who didn't. Looking at LOC_1 which is a link road and characterised by slightly higher speed, those who reduce their speed are 4.690 times more likely to be in a slight conflict than those who do not. The same is seen in LOC_2 and LOC_3, where the odds of being in a slight conflict is 2.295 and 3.192 times more for those who reduce their speed.

(v) Time of day

The final explanatory variable included in the logistic regression model is the time of day when conflict was observed. Serious conflicts were more common during the off peak period than peak period, while more slight conflicts were observed during the peak period. The odds ratio also shows that conflicts observed during the peak period were (3.091[LOC_1] and 1.720 [LOC_3] times) more likely to result in a slight conflict than those observed during the off peak period. Invariably, road users were more likely to be involved in a serious conflict during the off peak period. However, this variable is not significant in the model at LOC_2.

5 Discussion and Conclusions

5.1 Traffic conflicts and traffic volume

The number of conflicts observed at LOC_2 seems to be higher than that recorded at the other two locations. However, the number of road users present at that location during the time of observation was also higher. This does not mean that this location is more risky than the others. This is because road users who are not interacting with each other can never be in a conflict and it may be more appropriate to take into consideration the number of interactions instead of the number of road users. Consequently, the conflict rate per interaction especially involving vehicles-vehicles is higher at LOC_3. This result is in line with literature stating that un signalized intersections represent potential hazards not present at signalized intersections because of the priority of movement on the main road (TRB, 2003). Traffic signals are very important in road design because they help to control conflicting flows of traffic entering the intersection at the same time and can subsequently reduce crash risk.

5.2 Traffic conflicts and behaviour

Traffic safety diagnosis should include not only crash data but also data about behaviours that precede crashes. This study used onsite observation of traffic behaviour and conflicts at three locations with a view to assessing safety of various road users and to investigate factors predicting conflict severity at each location. Most of the influential variables (age, gender, speed etc.) identified in this study as contributing to conflict severity are in line with results of past studies on crash rate and severity (Reason et al., 1990; Rhodes et al., 2005; Harre et al., 2005; Chen et al., 2012; Busch et al., 2002; Box, 2012; Massie et al., 1995; Vatanavongs and Sonnarong, 2014).

Direction of traffic was identified as an important variable in the model. It was observed that road users travelling in the same direction were more likely to be in slight conflicts compared to those crossing or travelling in opposite directions. This could be related to high incidence of give way violations reported from onsite behavioural observation (Figure 3). In a situation where there are no information or warning signs and right of way is neither posted nor defined, road users find it difficult to understand and communicate with each other.

The analysis of speed data showed that drivers were consistently exceeding the speed limit, especially during the off peak period, likely to increase the severity level of potential crashes (Quddus et al., 2009; Golob et al., 2004). In addition, interactions observed during the off peak period were more likely to result in a serious conflict. Comparing this to data on behavioural observation (Figure 3), more violations (seatbelt off, cell phone use, eating/drinking, speed violation) apart from overloading and give way violations (which could be as a result of high traffic density) were observed during the off peak period. This could increase the severity of conflicts considering that road users may be distracted in one way or the other.

It is important to note that the road users involved in the conflicts are not the same as the ones included in the behavioural observation. However, it could provide a possible explanation for the violations, behaviours associated with conflicts and why they happen.

5.3 Differences in conflict severity across locations

This study supports previous research that the road environment greatly affects road user behaviour (WHO, 2009). There are remarkable differences in the number and severity of conflicts recorded across the different study locations. The results demonstrate that road users tend to exhibit more unsafe behaviour at poor road layouts and where there is little or no enforcement. For example, crossing conflicts were more prevalent at LOC_3 and less at the other locations. The locations are not exactly comparable but were selected to have a general idea of traffic behaviour of road users.

At LOC_1, road users are more likely to violate the speed limit especially during the off peak period, and this eventually results in more serious conflicts. The reason could be that unlike LOC_2 and LOC_3 which are intersections, LOC_1 is a clearly demarcated link road and road users find it difficult to slow down even while approaching the City College on this road (Oron-Gilad and Ronen, 2007; De Waard et al., 1995). Speed limits which are not posted or enforced, in addition to the absence of traffic control on a very long stretch of this road contribute to this violation.

The highest traffic volume was recorded at LOC_2, which is a roundabout, with traffic control and enforcement. Most of the interactions observed during the off peak period were as a result of road users being in a hurry to beat the traffic lights. During the early part of the morning peak before the traffic police have arrived, the behaviour of road users is the same as in LOC_3 where there is no control and the rule is on a first come first pass basis. This could be part of the reason why a large number of crossing conflicts which also resulted in a number of serious conflicts were mostly observed at this location, especially at the morning peak.

Percentage frequency of conflicts especially involving vehicles-vehicles was more at LOC_3. This could be due to the nature of the intersection which is narrow and on a single carriage road, without any traffic control or proper enforcement. Road users cross the intersection as they deem fit considering that there are no posted rules on who should cross first, even though those on the major road have priority. Apart from the latter part of the morning peak where traffic wardens were seen trying to control the traffic (which seemed quite difficult for them), at the other periods (early peak and all off peak hours), there was no form of traffic enforcement. A high number of opposing conflicts were also observed here unlike the other locations. The reasons are probably because of the nature of the intersection (Table 1).

The effect of restricting the flow of simultaneous traffic stream could be seen in LOC_1 and LOC_2. Road demarcation in LOC_1, signalisation and traffic control and enforcement at LOC_2 to an extent reduced simultaneous conflicting traffic stream. This greatly reduced the incidence of conflicts and crashes that result from vehicles moving into the main traffic stream at high speed. The frequency and number of conflicts especially during the morning peak at LOC_2 reflect the greater traffic volume. Despite the lower traffic volume at LOC_3, the number of serious conflicts involving vehicle-vehicle was higher compared to LOC_2.

Svensson (1998) found that as opposed to traffic conflicts at non signalised intersections, traffic conflicts at signalised intersections are more spread out and there is a tendency towards lower severity. This could be because a lot of possible interactions have been reduced due to signalisation. The results of this study demonstrate that drivers tend to behave more erroneously where there are poor traffic regulations and enforcement or poor road layout without traffic control devices.

Serious conflicts between vehicles and vulnerable road users (pedestrians and tricycles) were predominant, representing more than 55 percent of the total across all locations. At locations where vehicle-pedestrian conflicts were observed, they were observed to be mostly crossing conflicts as a result of pedestrians trying to cross the road in spite of vehicles and tricycles approaching (there were no pedestrian crossing facilities).

Most conflicts involving tricycles were due to them making sudden and unexpected stops to pick up and drop off passengers. Some of them were observed to have stopped right at the intersection and others on the major road. Some of them were also observed entering and leaving the road without using their indicators.

Several conclusions can be drawn from this study. First of all, road users moving in the same direction were observed to be involved in more slight conflicts compared to those crossing. In addition, male road users were observed to be involved in more serious conflicts than females. Age of road users has a significant impact on conflict severity as younger road users were involved in more serious conflicts. Road users who reduced their speed prior to the evasive action were also observed to be involved in more slight conflicts and more serious conflicts were observed during the off peak compared to the peak period. Finally, It is very important to note that relevant road users' (road user who takes the evasive action) behaviour before and in the event of an interaction contributes significantly to conflict severity. And a road user being a young male travelling at high speed is more likely to be involved in a serious conflict compared to young females, older male etc. travelling at a lower speed.

5.4 Limitations

Although no research has been conducted using the TCT in this environment, the method adopted in this study provided the opportunity to observe road users in a real traffic environment and as a result record all serious and slight interactions. Data included in the analysis was limited to what could be obtained from the completed conflict recording form and video, so there could also have been variables or factors affecting conflict severity which were not captured in the study and not included in the analysis such as driver skills, road surface friction etc. To overcome these issues, further research could employ a broader behavioural observation to provide additional factors to compare traffic behaviour and conflicts and to measure conflict severity.

This study was conducted at three different locations representing the typical road environment in an urban area in Nigeria. Even though most of the factors identified were spread across all the locations, it is possible for results to diverge from what would be obtained from rural areas. In order to make a better comparison, the number of locations should be higher and of comparable nature. That is to say, locations selected should be as similar as possible especially regarding the layout. This was not done in this study because the purpose was to have an idea of general traffic behaviour at different locations.

6. Summary

Research (Abdulhafedh, 2017; WHO, 2010) has shown that the collection of crash data is an important tool to support the development and assessment of programmes that aspire to reduce road traffic crashes. According to (WHO, 2010), the data can be used to raise awareness about particular road safety issues, act as evidence and draw support for policies, programmes or allocation of resources. Crash data also provides a better understanding of road traffic problems, identifying risk factors etc. and it's a key source of information for assessing and treating risks. However, considering that the crash data in most developing countries may not be reliable or available, additional sources of data may be needed for road safety management. The method applied in this study was successful in identifying different models to predict conflict severity at the different locations of interest and provided a surrogate measure of safety that could be used for the low-cost safety assessment of these locations. The findings also show that TCT could be practically applied to road safety assessment in developing countries, providing more information, especially from pre-crash situations to complement crash data.

This type of research can be used to aid decision-making processes involving safety assessment of various road users as well as infrastructure improvements which could potentially reduce the number of future crash events. We strongly believe that the results of this study could provide a baseline to support future research related to the study of road user behaviour and traffic conflicts and will be a major ingredient to complement the inadequate crash data in Nigeria and other developing countries. Thus, further research in which more detailed analysis of each road users' behaviour is explored is needed in order to understand the impact of certain risk factors on conflicts. This would be desirable to further understand behaviour and provide important information for design and operations of road layouts, in order to adopt measures to reduce the number and severity of conflicts between different road users.

Some recommendations to reduce conflict severity and consequently reduce crashes include education on traffic safety rules and regulations, retraining during renewal of driving license, vehicle fitness checks, campaigns at public places and schools aimed at informing people of the importance of traffic safety, providing pedestrian facilities and traffic control and proper enforcement of traffic rules and regulations. Generally, calming of traffic is needed to improve traffic safety at these locations.

References

Abdulhafedh, A. (2017). Road Traffic Crash Data: An overview on sources, problems, and collection methods. Journal of Transportation Technologies, 7, 206-219.

Almqvist, S. and Ekman, L. (2001). The Swedish traffic conflict technique: Observer's Manual. Department of Technology and Society Traffic Engineering, Lund University.

Almqvist, S. and Hydén, C. (1994). Methods for assessing traffic safety in developing countries. Building issues. Lund, Traffic and Roads, Lund University. 6.

Amundsen, F. and Hydén, C. (1977). Proceedings of first workshop on traffic conflicts. Institute of Transport Economics, Oslo.

Aguiléra, V., Allio, S., Benezech, V., Combes, F. and Milion, C. (2012). Estimating the quality of service of underground transit systems with cellular network data, Procedia – Social and Behavioral Sciences, 48, 2262-2271.

Batool, Z., Carsten, O. and Jopson, A. (2011). Road safety issues in Pakistan: a case study of Lahore. Transportation Planning and Technology, 1(1), 31-48.

Bishai, D., Asiimwe, B., Abbas, S., Hyder, A. A. and Bazeyo, W. (2008). Cost-effectiveness of traffic enforcement: case study from Uganda. Injury Prevention, 14, 223-227

Box, E. (2012). Speed Limit: A review of Evidence, RAC Foundation London.

Busch, S., Zobel, R. and Kreiss, J.P. (2002). Determination of risk factors of accident Causation. In: Proceedings of the International Conference on Vehicle Safety, Imeche Headquarters, London, 11-22.

Chen, H., Cao, L. and Logan D.B. (2012). Analysis of risk factors affecting the severity of intersection crashes by logistic regression. Traffic Injury Prevention, 13 (3), 300-307.

Comte S. L. and Jamson A. H. (2000) Traditional and innovative speed-reducing measures for curves: an investigation of driver behavior using a driving simulator, Safety Science, 36, 137-150.

De Waard, D., Jessurun, M., Steyvers, F.J.J.M., Raggatt, P.T.F. and Brookhuis, K.A. (1995). The effect of road layout and road environment on driving performance, drivers' physiology and road appreciation. Ergonomics, 38, 1395-1407.

Downing, A. J. (1991). Pedestrian safety in developing countries. International Conference on Traffic Safety, New Delhi, Mcmillan India Limited.

Federal Road Safety Corps. (2015). 2015 FRSC Annual Report. frsc.gov.ng/publications.

Grayson, G.B., Hydén, C., Kraay, J.H., Muhlrad, N. and Oppe, S. (1984). The Malmö study: a calibration of traffic conflict techniques. Report R-84-12. Institute for Road Safety Research SWOV, Leidschendam, The Netherlands.

Golob, T. and Recker, W. (2004). A method for relating type of crash to traffic flow characteristics on urban freeways. Transportation Research Part A, 38, 53-80.

Gong, H., Chen, C., Bialostozky, E. and Lawson, C.T. (2012). A GPS/GIS method for travel mode detection in New York City. Computers Environment and Urban System, 36, 131-139.

Harré, N., Foster, S., and O'Neill, N. (2005). Self-enhancement, crash-risk optimism and the impact of safety advertisements on young drivers. British Journal of Psychology, 96, 215-230.

Hauer, E. and Gårder, P. (1986). Research into the validity of the traffic conflicts technique. Accident Analysis and Prevention, 18(6), 471-481.

Hyden, C. (1975). A traffic conflicts technique for risk measuring. Department of Traffic Planning and Engineering, Lund Institute of Technology, Sweden.

Hyden, C. (1987). The development of a method for traffic safety evaluation: the Swedish traffic conflicts technique. Lund Institute of Technology, Lund.

Hyden, C. and Stahl, A. (1979). Measures for the improvement of the safety of unprotected road users, Faculty of Engineering, LTH, Lund University Sweden.

Hyder, A. (2002). Road accidents take costly toll. Road Traffic Injury Research Network.

Jug, M. (2014). Information revolution from data to policy action in low-Income countries: how can innovation help? PARIS21, Partenership in Statistics for Development in the 21st century.

Lord, D. and Mannering, F. (2010). The statistical analysis of crash-frequency data: a review and assessment of methodological alternatives. Transportation Research Part A, 44(5), 291-305.

Massie, D.L., Campbell, K.L. and Williams, A. F. (1995). Traffic accident involvement rates by driver age and gender. Accident Analysis prevention. 27 (1), 73-87.

Muhlrad, N. (1993). Traffic conflict techniques and other forms of behavioural analysis: application to safety diagnoses. Proceedings of 6th ICTCT Workshop, Salzburg.

Newnam, S., Mamo, W.G. and Tulu, G.S. (2014). Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. Safety Science 68, 1-5.

Nielsen, J. S. (2011). Use of the Internet for willingness-to-pay surveys: A comparison of face-to-face and web-based interviews. Resource and Energy Economics, 33, 119-129.

Oron-Gilad, T. and Ronen, A. (2007). Road characteristics and driver fatigue: a simulator study. Traffic Injury Prevention, 8(3), 281-9.

Osayomi, T. (2013). Regional determinants of road traffic accidents in Nigeria: identifying risk areas in need of intervention. African Geographical Review, 32(1), 88-99.

Quddus, M.A. Wang, C. and Ison S.G. (2009). Road traffic congestion and crash severity: econometric analysis using ordered response models. Journal of Transport Engineering, 136 (5), 424-435.

Peden, M., McGee, K. and Sharma, G. (2002). The injury chart book: a graphical overview of the global burden of injuries. Geneva, World Health Organization, (http://www.who.int/violence_injury_prevention/injury/chartbook/chartb/en/, accessed 20 March 2018).

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A.A. and Mathers, C. (2004). World report on road traffic injury prevention. World Health Organization, Geneva Switzerland.

Peltzer, K. and Renner, W. (2003). Superstition, risk-taking and risk perception of accidents among South African taxi drivers. Accident Analysis and Prevention, 35, 619–623.

Persson, A. (2008). Road traffic accidents in Ethiopia: magnitude, causes and possible interventions. Advances in Transportation Studies an International Journal, 15, 5-18.

Reason, J., Manstead, A.S.R., Stradling, S.G., Baxter, J.S. and Campbell K. (1990). Errors and violations on the road: a real distinction? Ergonomics, 33, 1315-1332.

Rhodes, N., Brown, D. and Edison, A. (2005). Approaches to understanding young driver risk taking. Journal of Safety Research, 36, 497-499.

Savolainen, P.T., Mannering, F., Lord, D., and Quddus, M.A. (2011). The statistical analysis of highway crash-injury severities: a review and assessment of methodological alternatives. Accident Analysis and Prevention, 43, 1666-1676.

Shbeeb, L. (2000). Development of a traffic conflicts technique for different environments. Bulletin 188. Department of Technology and Society, Lund University.

SHRP2. Strategic Highway Research Program. Available on-line at: 21 http://www.shrp2nds.us, Assessed March 15, 2018.

Stopher, P. and Greaves, S.P. (2007). Household travel surveys: where are we going? Transportation Research Part A, 41, 367-381.

Svensson, Å. (1992). Vidareutveckling och validering av den svenska konflikttekniken (in Swedish) Further development and validation of the Swedish Traffic Conflicts Technique. Lund: Department of Traffic Planning and Engineering, Lund University.

Svensson, Å. (1998). A method for analysing the traffic process in a safety perspective. Bulletin 166, Department of Traffic Planning and Engineering, University of Lund.

Svensson, A. and Carsten, O. (2007). Literature review and experience on the application of conflict studies to rural roads. Highways Research Group. Deliverable number 2.

Transportation Research Board (2003). A guide for addressing un signalised intersection collisions. National Cooperative Highway Research Program, vol 5.Transportation Research Board (TRB), Washington, D.C.

UDRIVE. European Naturalistic Driving Study. Available on-line at: 19 http://www.udrive.eu Assessed March. 15, 2018.

Vatanavongs, R. and Sonnarong, S. (2014). Impacts of accident severity factors and loss values of crashes on expressways in Thailand. IATSS Research 37, 130-136.

Wegman, F. (2010). Scientific research on road safety management. Special Issue Safety Science, 48 (9), 1081-1224.

Wegman, F. (2013). Traffic Safety. In: van Wee, B., Annema, J.A. and Banister, D. (Eds.), The Transport System and Transport Policy. An Introduction, 254-280. Edward Elgar, Cheltenham, UK.

World Health Organisation (2004). The world health report 2004: changing history. www.who.int/whr/2004/en/report04_en.pdf

World Health Organization (2009). Global status report on road safety – time for action. www.who.int/violence_injury_prevention/road_safety_status/2009/en/

World Health Organization. (2010). Data systems: a road safety manual for decision-makers and practitioners, Geneva, Switzerland: World Health Organization/Global Road Safety Partnership/FIA/World Bank.

World Health Organisation (2013). Road safety in the WHO African region: The Facts 2013. www.who.int/violence_injury_prevention/road_safety.../2013/.../factsheet_afro.pdf

World Health Organization (2015). Global status report on road safety 2015. www.who.int/violence_injury_prevention/road_safety_status/2015/en

Appendix A: Results from conflict observation

Conflicts	**Vehicle-vehicle**			**Vehicle- pedestrian**			**Vehicle-tricycle**			**Tricycle-tricycle**			**Tricycle-pedestrian**		
	LOC_			**LOC_**			**LOC_**			**LOC_**			**LOC_**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Total conflicts	80	201	220	22	36	13	63	156	119	5	45	17	-	7	5
Time of day															
Peak	42	110	130	17	20	6	33	87	55	3	29	11	-	4	3
Off peak	38	91	90	5	16	7	30	69	64	2	16	6	-	3	2
Serious	38	138	129	12	25	11	41	104	74	1	27	9		3	3
Peak	14	81	79	9	15	5	23	57	30	1	20	4	-	3	3
Off peak	24	57	50	3	10	6	18	47	44	-	7	5	-	0	-
Slight	42	63	81	10	11	2	22	52	45	4	18	8	-	4	2
Peak	28	29	51	8	5	1	13	30	25	2	9	7	-	1	-
Off peak	14	34	30	2	6	1	9	22	20	2	9	1	-	3	2
Rate/hr (total)															
Peak	4	10.4	12.4	1.6	1.9	.5	3.1	8.3	5.2	.3	2.8	1.0	-	.4	.3
Off peak	3.6	8.7	8.6	.5	1.5	.6	2.9	6.6	6.1	.2	1.5	.6	-	.3	.2
% Frequency															

Peak	44.2	44	63.4	17.9	8	2.9	34.7	34.8	26.9	3.2	11.6	5.4	-	1.6	1.5
Off peak	50.6	46.6	53.2	6.7	8.2	4.1	39.	35.2	37.8	2.7	8.2	3.5	-	1.5	1.2
Conflict type															
Same direction: peak	15	39	11	1	6	-	14	42	10	1	13	4		-	-
Off peak	20	78	13	1	5	-	22	49	8	2	11	1	-	-	-
Opposing direction: peak	-	10	31	-	-	-	-	13	16	-	6	1	-	-	-
Off peak	-	-	12	-	-	-	-	3	9	-	3	1	-	1	-
Crossing: peak	27	62	91	16	13	6	19	31	29	2	11	6	-	4	3
Off peak	18	12	62	4	12	7	8	16	47	-	2	4	-	2	2

Appendix B: Variables applied in the analysis

			LOC_1		**LOC_2$^+$**		**LOC_3**	
Variables	**Description**	**Definition**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Dependent variable								
Conflict severity	condition of observed conflicts	1=serious	92	54.1	297	66.7	236	63.1
		2=slight	78	45.9	148	33.3	138	36.9
Independent variables								
Road user type	different types of road users involved in conflicts	1=vehicle-vehicle	80	47.1	201	45.2	220	58.8
		2=vehicle-pedestrian	22	12.9	36	8.1	13	3.5
		3=vehicle-tricycle	63	37.1	156	35.1	119	31.8
		4=tricycle-tricycle	5	2.9	45	10.1	17	4.5
		5=tricycle-pedestrian	-	-	7	1.6	5	1.3
Direction of traffic	of road users involved in conflicts	1=same direction	76	44.7	244	54.8	48	12.8
		2=opposite	n/a	n/a	35	7.9	67	17.9
		3=crossing	94	55.3	166	37.3	256	69.3
Red light$^+$/give way violation	of relevant road user	1=yes	87	51.2	224	50.3	218	58.3
		2=no	83	48.8	221	49.7	156	41.7
Yielding violations	of second road user	1=yes	88	51.8	172	38.7	161	43.0
		2=no	82	48.2	273	61.3	213	57.0
Age(rel. Road user)	age distribution of relevant road user	1=<15	0	0	0	0	0	0
		2=15-24	40	23.5	134	30.1	125	33.4
		3=25-45	72	42.4	169	38.0	139	37.2
		4=46-64	46	27.1	124	27.9	89	23.8
		5=65+	12	7.1	18	4.0	21	5.6
Gender(rel. Road user)	gender of relevant road user	1=male	124	72.9	338	76.2	295	78.9
		2=female	46	27.1	107	24.8	79	21.1
Relevant road user	road user who	1=vehicle	156	91.8	357	80.2	341	91.2

(rel.)	took the evasive action	2=pedestrian	4	2.4	6	1.3	-	-
		3=tricycle	10	5.9	82	18.4	33	8.8
Age(sec. Road user)	distribution of age intervals for second road user	1=<15	3	1.8	-	-	-	-
		2=15-24	39	22.9	144	32.4	110	29.4
		3=25-45	63	37.1	160	36.0	148	39.6
		4=46-64	46	27.1	117	26.3	103	27.5
		5=65+	19	11.2	24	5.4	13	3.5
Speed	Whether the relevant road user reduced speed or not	1=yes	94	55.3	246	55.3	198	52.9
		2=no	76	44.7	199	44.7	176	47.1
Evasive action	action taken to prevent a crash	1=braking	65	38.2	155	34.8	124	33.2
		2=swerving	42	24.7	115	25.8	98	26.2
		3=others	63	37.1	175	39.3	152	40.6
Gender(sec. Road user)	gender of second road user	1=male	133	78.2	371	83.4	317	84.8
		2=female	37	21.8	74	16.6	57	15.2
Time of day	period when conflict was observed	1=peak	95	55.9	250	56.2	205	54.8
		2=off peak	75	44.1	195	43.8	169	45.2

[+] red light violation observed at LOC_2; rel.= road user who took the evasive action; sec.= the other road user

Appendix C: Inferential Statistics

	Conflict severity		
	(LOC_1)	**(LOC_2)[+]**	**(LOC_3)**
Road user type			
X^2	6.805	3.171	3.402
p-value	0.078°	0.530°	0.493°
Cramér's V	0.200	0.084	0.095
Direction of traffic			
X^2	2.521	38.812	15.554
p-value	0.112°	0.000*	0.000*
Cramér's V	0.122	0.295	0.204
Red light[+]/Give way violation			
X^2	1.580	2.925	2.613
p-value	0.209°	0.087°	0.106°
Cramér's V	0.096	0.081	0.084
Yielding violation			
X^2	0.180	0.334	1.466
p-value	0.672°	0.564°	0.226°
Cramér's V	0.033	0.027	0.063
Age(rel. road user)			
X^2	11.924	15.372	5.280
p-value	0.008*	0.002*	0.152°
Cramér's V	0.265	0.186	0.119
Gender(rel. road user)			

X^2	5.705	14.934	4.248
p-value	0.017*	0.000*	0.039*
Cramér's V	0.183	0.183	0.107
Relevant road user			
X^2	0.894	2.148	0.097
p-value	0.639°	0.342°	0.756°
Cramér's V	0.073	0.069	0.016
Age(sec. road user)			
X^2	7.429	8.449	0.975
p-value	0.115°	0.038*	0.807°
Cramér's V	0.209	0.138	0.051
speed			
X^2	15.875	9.442	10.290
p-value	0.000*	0.002*	0.001*
Cramér's V	0.306	0.146	0.166
Evasive action			
X^2	13.784	4.518	2.640
p-value	0.001*	0.104°	0.263°
Cramér's V	0.285	0.101	0.084
Gender(sec. road user)			
X^2	1.233	0.011	0.095
p-value	0.267°	0.916°	0.758°
Cramér's V	0.085	0.005	0.016
Time of day			
X^2	5.279	3.440	3.239
p-value	0.022*	0.064°	0.072°
Cramér's V	0.176	0.088	0.093

°not statistically significant; *significant on a 95% confidence level; ⁺location where red light violation was observed