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Estimating road traffic injuries in Jinja district, Uganda, using the capture-recapture method

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ABSTRACT

Road traffic injuries (RTIs) are commonly under-reported in low-and-medium-income countries. This study aimed to estimate the number of RTIs and determine the magnitude of under-reporting by traffic police and hospital registries. A two-source capture-recapture method was applied to RTI data from police and hospital registries. Seven matching variables; sex of the injured, date, place, time, day of crash and road user type were used to get the matched cases. Police independently reported 46 RTIs and the hospitals reported 206 RTIs. Using the capture-recapture analysis, both sources estimated 313 RTIs (95% CI 273–343). The police registry captured 14.4% of the estimated number of RTIs and the hospitals captured 60.4%. The estimated number of RTIs was higher than reported by either the police or the hospitals alone. Neither the police nor the hospitals provided accurate data on RTIs, calling for the strengthening of both sources of data.

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Road traffic injuries; capture-recapture method; Jinja Uganda hospital data; police data

Background

Injuries are a global health concern causing over 5 million deaths per year (Chandran, Hyder, & Peek-Asa, 2010). The injury deaths that occurred in 2010 (5.1 million) alone were greater than the total number of deaths from HIV, tuberculosis and malaria, all combined (3.8 million) (Lozano et al., 2012). In 2010, more than 1.24 million died and as many as 20–50 million were injured in road traffic crashes (WHO, 2013).

Road traffic injuries (RTIs) are a significant cause of preventable death and disability in developing countries, including those in Africa (Lagarde, 2007; Patton et al., 2009).The burden is highest among young population where injuries alone contribute 5 of the top 15 causes of mortality among males (Peden, Kobusingye, & Monono, 2013) and account for more than 40% of deaths among persons aged between 10–24 years (Patton et al., 2009). RTIs not only cause deaths, but also result in temporary or long-term disabilities (Mathers, 2008; Murray et al., 2012; WHO, 2008). The burden of RTIs is highest is low- and middle-income countries (LMICs) where it accounts for 90% of all injury deaths (WHO, 2008). At the same time, there is lack of accurate RTI data in developing countries leading to significant underestimation of the RTI morbidity and mortality (Ameratunga, Hijar, & Norton, 2006).

In Uganda, injuries rank among the top 10 causes of mortality (Mutto, Lawoko, Nansamba, Ovuga, & Svanstrom, 2011) with 35%–50% caused by RTIs (Wandera, Nakiito, & Lett, 2010). As in many LMICs, in Uganda, nation-wide road traffic casualty figures usually come from police. The police data are, however, neither reliable nor sufficient means to measure road traffic deaths and injuries (Amoros, Martin, & Laumon, 2006; Loo & Tsui, 2007). While WHO estimated that Uganda suffered between 8307 and 11,004 road traffic deaths with a point estimate of 9655 in 2010 (WHO, 2013), Uganda police reported only 2954 deaths over the same period (UPF, 2010), highlighting existing discrepancies in road traffic deaths reporting in Uganda.

Two-source capture-recapture analysis could improve data quality and accuracy, and reduce under-reporting of RTIs (Hyder & Morrow, 2006; Morrison & Stone, 2000; Van, Singhasivanon, Kaewkungwal, Suriyawongpaisal, & Khai, 2006; WHO, 2009). This method has been used in various studies to estimate sex worker populations (Karami, Khazaei, Poorolajal, Soltanian, & Sajadipoor, 2017; Khan, Bhuiya, & Uddin, 2004), cancer cases (Ghojazadeh et al., 2013; Khodadost et al., 2016), tuberculosis prevalence (Cojocaru & Mihaescu, 2006; Iglesias Gozalo, Rabanaque Hernandez, & Gomez Lopez, 2002) and road traffic injuries (Abegaz, Berhane, Worku, Assrat, & Assefa, 2014; Lateef, 2010; Sango et al., 2016). No study using capture-recapture method has been conducted in Uganda. This study aimed to estimate the number of RTIs and determine the level of under-reporting by the police and the health sector in Uganda.

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Methods

Study setting

The study was conducted in Jinja municipality council, which is located 80 km east of Kampala and has an estimated population of 501,300. The municipality consists of three counties, namely Bugembe county, Jinja county and Kagoma county (UBOS, 2012). Jinja is strategically located on the Northern corridor highway that links Uganda, Kenya, Tanzania and Rwanda. The municipality is served by 4 large health facilities, which are a regional referral hospital and 3 low-tier public health centres and 30 registered private clinics, which mostly dispense drugs. Most road traffic crash victims are admitted to public hospitals. Usually those who have health insurance go to private hospitals and only 0.5% of Uganda's population have some type of health insurance (Basaza, O'Connell, & Chapcakova, 2013).

Hospital data sources: We collected data on RTIs from hospitals using characteristics recommended in the WHO injury surveillance guidelines: age, sex of the injured, date, time and place of crash, mode of transport and road user type (Holder et al., 2001). Since injury data reported by the Health Management Information System is incomplete, we conducted injury surveillance at three government hospitals. We collected data using a structured checklist purposely designed for this study; the checklist evaluated the visits of road traffic crash victims to the emergency and outpatient departments at these hospitals. We conducted our study during March–April 2014. All RTIs that occurred during this period were included in the analysis. RTIs that came to the facilities before or after this period were excluded from the analysis. Nurses from the emergency rooms and outpatient departments were trained to complete the data tool by recording information on age and sex of a patient, time and location of crash, vehicle type and road user type. The nurses work in shifts of 24 h a day and were collecting data throughout this time.

Police data sources: Traffic police officers collected data on road traffic crashes that occurred within the district, using the same tool as for the hospital. Data quality was achieved by training the data collection team and reviewing the data collected for errors. The data collection tool was also carefully worded and pretested for consistency of the data collected.

Data matching

The police and the hospital datasets were compared and causalities were matched using two matching standards: the low matching standard (more sensitive) using variables of date, place, time, day, type of crash and road user type; and the high restrictive (more specific) matching standard with date, place, time and type of crash, road user type and sex of the injured. Causalities were considered matched if they included all selected variables in both datasets.

Data analysis

We used the Chapman 1951 formula (Chapman, 1951) to generate an unbiased capture-recapture estimator for the two samples (Figure 1). As the true value of the parameter to be estimated (number of RTIs) is unknown, the estimate was accompanied by the confidence limits to give an idea of its reliability. The records were entered into statistical package for the social sciences (SPSS) to create a database and data were analysed in SPSS. We conducted multivariate analysis by comparing reporting of characteristics among datasets and the variables chosen were sex, vehicle type, place and time of crash.

Ethical considerations

We obtained ethical approval from the Makerere University School of Public Health Higher Degrees Research and Ethics Committee, and written permission from the administrators of the traffic police and the hospitals. All identifiable information such as names of the injured patients was removed from the data to ensure confidentiality.

Results

Data availability

In the police crash data and the hospital data, we identified 46 and 206 RTIs, respectively for the study period of March–April 2014. In the hospital registry records, 17 cases had missing data on such variables as date, time and type of crash, road user and vehicle type. In the police records, only 1 case had missing information on vehicle type. We assumed that the data were missing at random and excluded the cases with missing data from the analysis; thereby we included 45 and 189 RTIs from the police and the hospital records in the analysis, respectively. We applied two-sample capture-recapture analysis methods and came to an estimate of 313 (95% CI 273–343) RTIs for the low matching standard using this more sensitive standard. Using the high restrictive (more specific) standard revealed 485 (95% CI 305–665) RTIs (Table 1).

Table 1. Linking and ascertainment of RTI cases in police, hospital and matched datasets.

Linking standard	Number of unique records				Capture-recapture estimates (95% CI)[a]	Case ascertainment (%)[b]		
	Matched	Only police	Only hospital	Aggregate registry	Number	Police	Hospital	Aggregate
High	14	45	189	220	485 (305–665)	9.3	38.9	45.4
Low	21	45	189	213	313 (273–343)	14.4	60.4	68.1

[a]Obtained using the Chapman formula

[b]The number was derived by dividing total RTIs (n = 45) in the police records, total RTIs (n = 189) in the hospital records and aggregate registry by the total estimated number of RTIs.

$$\text{Estimated number of RTIs } N = \left[\frac{(x+1)*(y+1)}{(z+1)}\right] - 1$$

$$\text{Variance } N = \frac{[(x+1)*(y+1)*(x-z)*(y-z)]}{[(z+1)*(z+1)*(z+2)]}$$

$$95\%\ \text{CI} = N \pm 1.96\ \sqrt{\text{var}}$$

Where x = number of RTIs in the first capture by the police

y = number of RTIs in the second capture by the hospitals

z = number of RTIs identified in both police and hospital records as the recaptures

Figure 1. Chapman formula.

The police and the hospitals reported 45 and 189 RTIs, respectively. Both were lower when compared to the total estimate of 313 RTIs or observed total of 234 RTIs. (Observed being the sum of RTIs from the individual primary sources of police and hospital.) This estimate suggests that the police dataset ascertained only 14.4% of the estimated number of RTIs and the hospital ascertained 60.4%. By combining two sources and ignoring overlapping cases, we identified an aggregate total of 213 RTIs or 68.1% of the corrected RTIs (Table 1).

The most frequent victims of the road traffic crashes were males and the age group 25–49 years. The most affected road user categories were pedestrians and motorcycle riders (Table 2).

Compared to the police records, the characteristics associated with the likelihood of appearing only in the matched records were: being male (OR = 0.18, 95% CI 0.04–0.70), traffic crashes occurring in Jinja municipality county (OR = 0.07, 95% CI 0.02–0.30) compared to Bugembe and Kagoma counties, and crashes involving non-motorized crashes (OR = 4.0, 95% 1.01–16.40) (Table 3). Additionally, compared to the police records, the characteristics associated with appearing in the hospital records were: being male (OR = 0.3, 95% CI 0.09–0.90), crashes occurring in Jinja municipality (Adj.OR = 0.06, 95% CI 0.02–0.20) and crashes involving non-motorized vehicles (Adj.OR = 3.0, 95% CI 1.2–7.7).

Table 2. Major characteristics of RTIs reported in Jinja district.

Characteristic	Matched no.(%)	Police only no.	Hospital only no.
Sex			
Male	11 (52.4)	33 (86.8)	109 (62.3)
Female	10 (47.6)	5 (13.2)	66 (37.7)
Age groups			
0–14 years	2 (9.5)	2 (5.3)	28 (16.0)
15–24 years	10 (47.6)	4 (10.5)	37 (21.1)
25–49 years	9 (42.9)	31 (81.6)	93 (53.1)
≥50 years	0 (0.0)	1 (2.6)	17 (9.7)
Education status			
None	2 (9.5)	2 (5.3)	32 (18.3)
Primary	2 (9.5)	16 (42.1)	70 (40.0)
Secondary	16 (76.2)	16 (42.1)	56 (32.0)
Tertiary	1 (4.8)	4 (10.5)	17 (9.5)
Road user type			
Bicycle rider	2 (9.5)	1 (2.6)	9 (5.1)
Pedestrian	7 (33.3)	8 (21.1)	61 (34.9)
Motorcycle rider	2 (9.5)	13 (34.2)	38 (21.7)
Vehicle driver	0 (0.0)	5 (13.2)	4 (2.3)
Bicycle passenger	0 (0.0)	1 (2.6)	8 (4.6)
Motorcycle passenger	10 (47.6)	8 (21.1)	45 (25.7)
Vehicle passenger	0 (0.0)	2 (5.3)	10 (5.7)
Total	21 (100.0)	38 (100.0)	175 (100.0)

Table 3. Major characteristics associated with RTIs reported in matched (RTIs reported by both police and hospital) and hospital-only datasets.

Variable (Reference category)		Matched OR (Adjusted)	Hospital only OR (Adjusted)
Sex	Female	1.0	1.0
	Male	0.18* (0.04–0.7)	0.3* (0.09–0.9)
Education	Tertiary	1.0	1.0
	None	0.5 (0.02–11.0)	0.7 (0.09–5.1)
	Primary	0.18 (0.01–2.9)	0.4 (0.1–1.6)
	Secondary	2.3 (0.2–27.2)	0.4 (0.1–1.6)
Place of crash	Bugembe	1.0	1.0
	Jinja municipal	0.07* (0.02–0.3)	0.06* (0.02–0.2)
	Kagoma	0.8 (0.03–12.8)	1.2 (0.1–12.1)
Vehicle type	Motorized	1.0	1.0
	Non-motorized	4.0* (1.01–16.4)	3.0* (1.2–7.7)
Time	12 pm–11:59 pm	1.0	1.0
	12 am–11:59 am	1.6 (0.5–5.7)	2.5* (1.1–5.8)

Goodness of fit: Pearson $\chi^2 = 101.4$, $p = 0.998$, Nagelkerke's Pseudo $R^2 = 37.6\%$

*Statistically significant at 95% Confidence Interval

Discussion

This study illustrates the usefulness of the capture-recapture method for assessing completeness of official RTI data sources. Using data collected by traffic police and nurses at hospitals, we estimated the number of RTIs in Jinja district, Uganda, and found that the estimates from the capture-recapture analysis were much higher than those from either of the police or the hospitals.

The findings showed that combining both sources resulted in higher number of RTIs. This is consistent with other studies that have found that using capture-recapture analysis on combined data sources leads to higher estimates of RTIs than using single sources (Amoros, Martin, Lafont, & Laumon, 2008; Bhatti, Razzak, Lagarde, & Salmi, 2011; Samuel et al., 2012). Police under-reporting could be explained by the limited capacity of traffic police to be present on all roads and crash-hotspots and by victims being transported directly to hospital by relatives or bystanders without waiting for the traffic police (Razzak, Cone, & Rehmani, 2001), which could result in missing a number of RTIs. Previous research found that police reporting rates vary from 24.6% of non-fatal RTI cases presenting to emergency departments in Hyderabad, India (Dandona, Kumar, Ameer, Reddy, & Dandona, 2008) to 2.6% in Nicaragua (Tercero & Andersson, 2004) and 48% in New Zealand (McDonald, Davie, & Langley, 2009).

In our study, the hospitals reported four times more RTIs than the police. This is in agreement with previous research that showed that for non-fatal injuries, hospital data were more reliable than police data (Dhillon, Lightstone, Peek-Asa, & Krausa, 2001; Kudryavtsev et al., 2013). Possible explanations for this could be the lack of knowledge among road users about the importance and benefits of reporting RTIs to police for investigation as well as the victims not reporting RTIs if they consider the crash not serious.

The most frequent victims of RTIs in both police and hospital sources were males with the mean age of 29 years. This is consistent with previous studies that have reported that males in their most productive years bear the biggest brunt of RTIs (Chalya et al., 2012; Patil, Kakade, Durgawale, & Kakade, 2008; Singh, Singh, Gupta, & Kumar, 2014). This could be due to the

fact that men are more exposed to transport especially as vehicle and motorcycle drivers, which increases their chance of being involved in road traffic crashes. Pedestrians and motorcycle riders were the most frequent RTI victims, consistent with previous research that have reported that motorcycle users (Lin & Kraus, 2009) and pedestrians (Hsia et al., 2010) are vulnerable road users. The increasing number of motorcycles and low rates of helmet use (30.8% among riders and less than 1% of passengers) in Uganda can explain this finding (Roehler et al., 2013). This clearly shows that there is a need for concerted efforts to establish effective interventions for these road users.

The results of regression analysis suggest that the hospitals are more likely to report non-motorized crashes. This can be explained by the differences in the nature of crashes; the police tend to record serious crashes that involve motorized traffic because the vehicle owners need a police report to seek compensation from insurance companies. This category of road users (pedestrians and bicyclists) also belongs to the lower economic social class (Nishtar et al., 2004) and as such would prefer to avoid expensive legal procedures by settling their issues without the intervention of the police.

Limitations

The main limitation is small sample size, which affected the regression analysis and the percentage of matching. Using a longer study period could overcome this by enabling the attainment of a larger sample size.

In addition, there are underlying assumptions made for the capture-recapture (CRC) method (Hook & Regal, 1995; IWGDMF, 1995). First, the population under study should be closed. This was not met because the municipality is close to a highway. Second, the procedure for identifying matching cases across sources should identify all true duplicates. This was achieved by using the same matching standard and indicators across both sources. Third, the sources must be independent from each other, whereby reporting to one source is not affected by the probability of reporting to another source. While previous research recommends the use of three or more sources of data to control independency (Meuleners, Lee, Cercarelli, & Legge, 2006), this was not possible in this study due to inaccessible alternative data options. In this study, there could have been a positive dependence because traffic police also operates ambulances that transports injured people to the nearest hospitals. This positive dependence increases the number of matches and thus underestimates the total number of injuries by biasing CRC estimate downwards and therefore the projected counts from this research study should be interpreted as lower limits. The fourth assumption requires perfect matching of subjects. For this study, we collected data using the same tool across the police and hospitals to ensure that both the traffic police and the hospital staff obtained similar data.

Recommendations

We recommend the use of this method in other locales where RTI estimates are incomplete. To better refine the estimates of RTIs, additional sources of injury data such as mortuary and insurance data in Uganda would be useful. Further research should make use of multiple sources such as insurance data, ambulance data and community surveys.

Conclusion

This study showed that the capture-recapture method might be a useful technique for estimating RTIs in areas that suffer from under-reporting. The study findings demonstrated that the neither of the two sources (police or hospital) independently provided an accurate estimate of the RTIs. Strengthening both systems is therefore necessary to obtain reliable and accurate information on road traffic injuries.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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