Estimating the burden of road traffic crashes in Uganda using police and health sector data sources

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ABSTRACT

Background In many low-income countries, estimates of road injury burden are derived from police reports, and may not represent the complete picture of the burden in these countries. As a result, WHO and the Global Burden of Diseases, Injuries and Risk Factors Project often use complex models to generate country-specific estimates. Although such estimates inform prevention targets, they may be limited by the incompleteness of the data and the assumptions used in the models. In this cross-sectional study, we provide an alternative approach to estimating road traffic injury burden for Uganda for the year 2016 using data from multiple data sources (the police, health facilities and mortuaries).

Methods A digitised data collection tool was used to extract crash and injury information from files in 32 police stations, 31 health facilities and 4 mortuaries in Uganda. We estimated crash and injury burden using weights generated as inverse of the product of the probabilities of selection of police regions and stations.

Results We estimated that 25 729 crashes occurred on Ugandan roads in 2016, involving 59 077 individuals with 7558 fatalities. This is more than twice the number of fatalities reported by the police for 2016 (3502) but lower than the estimate from the 2018 Global Status Report (12 036). Pedestrians accounted for the greatest proportion of the fatalities 2455 (32.5%), followed by motorcyclists 1357 (18%).

Conclusions Using both police and health sector data gives more robust estimates for the road traffic burden in Uganda than using either source alone.

INTRODUCTION

The 2018 Global Status Report on Road Safety identifies road traffic injuries (RTIs) as the leading killer of children and young adults worldwide.[1] An estimated 1.35 million road traffic deaths occur annually. These deaths are not uniformly distributed across the world. Death rates are estimated to be three times higher in low-income countries (LICs) than in high-income countries.[2] Africa has the highest rates of road traffic deaths globally, estimated at 26.6 per 100 000 people per year.[1] Data from the Global Burden of Disease (GBD) 2010 show that between 1990 and 2010, the African region registered an average of 84% increase in road traffic deaths.[3]

In many LICs such as Uganda, data on road traffic crashes, injuries and deaths are mostly derived from the police reports. However, these do not capture the complete burden, as some injuries may not be reported to the police.[4,5] In addition, data on fatalities, non-fatal injuries, economic costs, as well as monitoring and evaluation indicators (eg, seat belt usage and deaths related to alcohol) are scanty, as are reliable vital statistics in these settings. Where such data exist, they are often incomplete.[6]

Furthermore, some countries (eg, Uganda) define a road traffic death as one occurring within a year after involvement in a road traffic crash.[7] This increases the imprecision in the estimates because of challenges of following up patients for such a long period with limited resources. For example in 2016, the Uganda Police reported 3503 road fatalities,[8] which for a population of 41 million people would put Uganda in the same road safety bracket as Australia and the UK.[1] In order to address these data problems, and to allow for comparisons across countries, WHO and the GBD, Injuries and Risk Factors project use complex models to generate estimates for their Global Status Report on Road Safety and GBD report, respectively.[1,3] However, there are limitations in the numbers generated by these models, a key one being the quality of the data provided by most LICs for use in the models. For example, WHO relies on police data (for Uganda) while the GBD project uses multiple data sources but involves complex modelling processes that maybe prone to strong assumptions.[9,10] There is, therefore, a need for alternative approaches that can generate national estimates for road injury burden in LICs and provide readily understood numbers that can inform prevention targets (which are important rallying points for actors in road safety).

In this study, we used data from three major data sources: police stations, health facilities and mortuaries to provide weighted national estimates of the burden of road traffic crashes and injuries in Uganda for the year 2016. This is the first study to describe the Ugandan road traffic burden using data from the three sources.

METHODS

Study design, population and sampling methodology

We used a cross-sectional study design to estimate Uganda's burden of road traffic crashes and injuries in the year 2016. The target population was all road crashes and injuries in Uganda in 2016. Crashes and injuries were classified as fatal, serious (requiring admission to a health facility) or minor (requiring little or no medical attention). The accessible

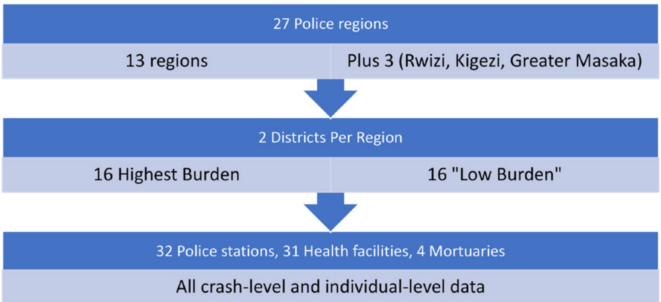

Figure 1 Visual representation of the study sampling methodology.

population comprised the incidents recorded at the selected police stations, health facilities and mortuaries. The sites were selected through a multistage sampling strategy using a combination of purposive and random sampling techniques. First, 13 out of the 27 police regions (A police region is an administrative area comprising several districts that fall under the jurisdiction of one regional police command. We chose to randomly select about 50% (13) of the police regions.) of the country were selected using cluster sampling proportional to size (ie, proportional to the number of crashes reported per region for 2016). Second, three additional regions, not in the initial sample, were purposively included due to their location along a major transnational highway.

From each of the 16 selected regions, two districts were sampled as follows: the district with the highest crash burden in the region (as reported by the police) and one other district, randomly selected from the remaining pool in the region; these were deemed 'low burden' relative to the district with the highest burden. From each district, the highest-level health facility (regional referral hospital, a general hospital or a health centre IV), one mortuary (where available) and the main police station were selected (The Uganda health system is organised as follows: national referral hospitals, regional referral hospitals, general hospitals, health centres IV, III, II, and I, IV being the largest.) (figures 1 and 2). There is typically one general hospital per district in Uganda and a regional referral hospital that serves several geographically adjacent districts. Where a regional

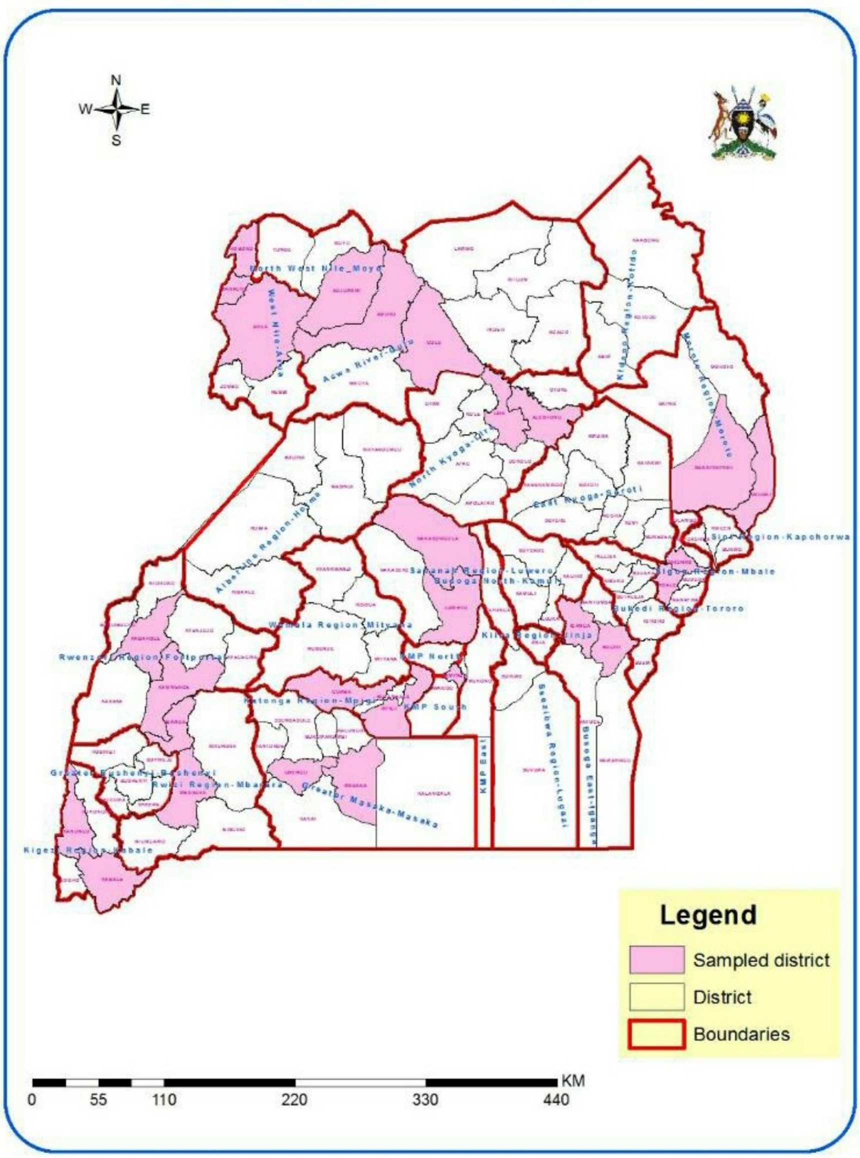

Figure 2 Map of Uganda highlighting districts included in the study.

referral hospital was available in the sampled district, we selected it instead of the general hospital. Similarly, where a general hospital was available, it was selected instead of any health centre IV facilities. Majority of the districts in Uganda have one general hospital. All available crash-level and individual-level data at the selected police stations, health facilities and mortuaries were then included in the study (Only 4 of the 32 districts had a mortuary attached to the highest-level health facility; one district had a health centre III as the highest-level health facility, hence only 31 health facilities were included in the sample.).

Data collection

We collected crash-level data (eg, crash scene, type of road and road surface) and individual-level data (eg, age, type of road user and injury severity) using a standardised tool (online supplementary figure S1 and materials) adapted from the WHO manual, 'Data systems: a road safety manual for decision-makers and practitioners'.[11] This tool was digitised using Open Data Kit Collect and loaded onto password-protected Android-powered tablets.[11 12] Crash-level and individual-level data for each police-recorded crash were extracted from paper-based police 'traffic accident registers' and original crash scene reports and sketches; and witness statements. The Uganda police currently do not have a functioning electronic system for relaying data from the police stations to the regional and national levels. Aggregated totals are passed in paper form from the stations to the regional and national levels. Crash-level data were only available for records from the police stations. Individual-level crash data at health facilities and mortuaries were extracted from inpatient and outpatient, and mortuary registers, respectively. The management information system for the health sector uses both paper and electronic formats. Data are initially captured on paper at the health facility with digitisation occurring when summaries are being created from the paper-based registers for transmission to the district and national levels. Statistical analyses were conducted using STATA V.14.

Crash-level data

The outcome variables in the crash-level data analysis were: (1) crash burden (ie, the absolute estimated number of crash incidents from the three data sources), and (2) crash severity, defined as any crash involving a fatality of at least one person. A crash was considered 'fatal' if a person died within 365 days as a result of the crash.

Since the study sites were selected through a multistage cluster sampling approach, the data were assigned weights using the selection probabilities of the police regions and police stations (ie, the weights were calculated as the inverse of the product of the probabilities of selecting the police region, and of selecting a police station within the police region). As described in the sampling section, 16 out of the 27 police regions in the country were selected in the first sampling stage, and then 2 police stations and 2 health facilities were selected from within each sampled police region in the second sampling stage, after which all available records on road traffic crashes at the selected police stations, health facilities and mortuaries were abstracted. The selection of police regions and police stations into the study sample formed the basis for assigning the weights.

The joint distribution of crash severity and several independent variables were summarised using weighted frequencies and the corresponding percentages. In order to identify factors associated with fatal crashes, we used multilevel bivariable and multivariable Poisson regression models that considered random intercepts for police region and station. These accounted for intracluster correlation in the data. Only variables that had a p value of 0.2 or less in the bivariable models were included in the final multivariable model.

Individual-level data

The outcome variables in the individual-level analysis were: (1) injury burden and (2) injury severity. An injury was defined as fatal if it resulted in death within 365 days following the crash.

We applied the same weights for the crash-level data to the individual-level data because all the available records of individual injuries at the selected police stations, health facilities or mortuaries were extracted, implying that the probability of extraction was essentially one (100%). Given that the police region was the basis for our sampling decisions, heath facilities and mortuaries were assigned weights based on the selection probabilities of the police region within which they are situated and the nearest police station in the sample.

The distribution of injury severity and several independent variables was summarised as described in the crash-level data section. We then applied to the weighted data, multilevel bivariable and multivariable Poisson regression models that considered random intercepts for police region and police station, in order to identify factors associated with fatal injuries. Only variables that had a p value of 0.2 or less in the bivariable models and did not exhibit multicollinearity were included in the final multivariable regression model.

Handling duplicates of individual-level records from the three data sources

Each of the three data sources used a different personal identifier, such as a police case number, hospital inpatient number or mortuary number, therefore, identifying unique records of injured individuals appearing in more than one data source was difficult. We generated a unique ID, which was a combination of the following variables; district, source document ID, age, sex, date of the crash and injury severity, to identify duplicates. However, due to the high proportion of observations with missing information, it was not possible to uniquely identify and match all the observations. Therefore, only records that appeared only twice across data sources were considered duplicates and were dropped from the analysis. Records that appeared more than twice had more variations in information collected and were therefore included in the analysis.

Missing data were included within the respective variables as separate categories. No imputation was done for missing observations.

Patient and public involvement

This research did not involve consultation or engagement of patients or the public at any of its stages.

RESULTS

Crash-level data

In 2016, there were 7065 recorded crashes in the 32 study districts (there are 127 districts in Uganda). On weighting, we estimated that 25 729 crashes occurred on Ugandan roads in 2016, of which 5123 were fatal.

Table 1 shows the weighted frequencies and percentages of crash fatality and the prevalence ratios (PRs) and their corresponding 95% CIs for several independent variables. Fatal crashes were higher on all roads (paved or unpaved) outside of town boundaries (59.5%), on roads that were deemed by the police to be in good

Table 1 Weighted crash-level analysis of injury outcomes

Characteristic	Non-fatal crashes	Fatal crashes	Total	Unadjusted PR (95% CI)	Adjusted PR (95% CI)
	(n=20 606)	(n=5123)	(n=25 729)		
	n (%)				
Proximity of the crash to a town/township					
Within town	7712 (37.4)	1145 (22.3)	8857 (34.4)	1.00	1.00
Outside town	9589 (46.5)	3050 (59.5)	12 638 (49.1)	1.55 (1.16 to 2.08)	1.86 (1.38 to 2.51)*
Missing	3305 (16.0)	928 (18.1)	4230 (16.4)	1.77 (1.25 to 2.51)	1.86 (1.18 to 2.29)*
Road condition					
In good (normal)	4477 (21.7)	1540 (30.1)	6017 (23.4)	1.00	1.00
Needs repair	1018 (4.9)	342 (6.7)	1360 (5.3)	1.01 (0.67 to 1.52)	0.97 (0.63 to 1.45)
Under repair	1021 (5.0)	161 (3.2)	1182 (4.6)	0.46 (0.28 to 0.74)	0.64 (0.34 to 1.20)
Missing	14 089 (68.4)	3080 (60.1)	17 169 (66.7)	–	–
Road surface at the spot where the crash occurred					
Wet	159 (0.8)	36 (0.7)	195 (0.8)	1.00	1.00
Dry	7171 (34.8)	2163 (42.2)	9334 (36.3)	1.18 (0.49 to 2.79)	–
Missing	13 276 (64.4)	2924 (57.1)	16 200*(63)*	–	–
Lighting condition at the crash location					
Daylight	11 492 (55.8)	2522 (49.2)	14 014 (54.5)	1.00	1.00
Darkness	5101 (24.8)	1492 (29.1)	6593 (25.6)	1.15 (0.88 to 1.53)	1.28 (1.00 to 1.64)*
Missing	4013 (19.5)	1109 (21.6)	5122 (19.9)	–	–
Class of the road where the crash occurred					
Highway	7468 (36.2)	2526 (49.3)	9994 (38.8)	1.00	1.00
Urban road	9523 (46.2)	1762 (34.4)	11 284 (43.9)	0.78 (0.65 to 0.95)	0.83 (0.61 to 1.13)
Other	585 (2.8)	255(5)	841 (3.3)	1.16 (0.85 to 1.59)	1.06 (0.47 to 2.38)
Missing	3030 (14.7)	581 (11.3)	3610(14)	–	–

*designates a statistically significant result (p = 0.05).
PR, prevalence ratio.

condition (30.1%), on roads where the surface was dry (42.2%) and on highways (49.3%). Crashes occurring at night were 28% more likely to result in a fatality compared with those occurring in daytime (adjusted PR=1.28, 95% CI1.00 to 1.64).

Individual-level data

In 2016, there were 14 049 individuals (5026 from police, 8425 from health facility and 598 from mortuary records) recorded to have been involved in road traffic crashes, resulting in 2002 fatalities in the 32 study districts. On weighting, we estimated that 59 077 individuals countrywide suffered an RTI in 2016, of which 51 519 were non-fatal and 7558 were fatal (table 2). The distribution of the injury burden by data source was as follows; police 20 406 (34.5%), health facilities 37 167 (62.9%) and mortuaries 1505 (2.5%). In addition, the following regions had the highest injury burden; Kampala East Metropolitan 8419 (14.3%), followed by Rwizi 7780 (13.2%) and Mount Moroto 6624 (11.2%). Pedestrians followed by motorcyclists were the most affected road users with fatalities at 32.5% and 18.0%, respectively (online supplementary table S1 and materials).

Adjusted analysis results showed a lower fatality among females compared with males (adjusted PR=0.82, 95% CI 0.68 to 0.98). In addition, compared with persons under 5 years of age, individuals between 5 years and 44 years of age, had a lower risk of fatalities during a crash (table 2). Conversely, there was a 37% higher risk of fatality among vulnerable road users (those not travelling in four-wheeled vehicles) compared with non-vulnerable road users (adjusted PR=1.37, 95% CI 1.07 to 1.75).

Comparison of study findings to estimates from the Uganda police report (2016) and the 2018 Global Status Report on Road Safety

The police report estimated that 3502 road fatalities occurred on Ugandan roads in 2016. Based on the 2016 police data, WHO Global Status Report on Road Safety (2018) estimated that Uganda had 12 036 fatalities (95% CI 9454 to 14618), a rate of 29 fatalities per 100 000 population. Our study estimated 7558 fatalities (~18.2 fatalities per 100 000 population based on the 2016 population).

DISCUSSION

Using three data sources, we estimated that 7558 RTI-related deaths occurred in Uganda in 2016. This estimate is more than twice the number reported by the Uganda police for the same year. The 2016 GBD estimate for road traffic fatalities in Uganda was 2.5% of total deaths. One explanation for the discrepancy between the study and police estimates of injury deaths is that individuals who die from RTIs after police investigations have wrapped up, are unlikely to be included in the numbers reported by the police. Also, people may not want to involve the police when a crash occurs (due to various reasons including fear of arrest and prosecution), so such crashes would go unreported by the police. Moreover, police may have misplaced some records. Other times, the lengthy processes associated with reporting cases to police impose prohibitive costs to the victims, which discourages reporting. The Uganda police also have limited resources to follow up individuals involved in road traffic crashes beyond a day or two following admission.

We found that the absolute risk of dying from an RTI was almost three times higher for males than for females, which is consistent with estimates reported by WHO and other studies.[13–15] The absolute risk of dying was also higher for people aged 5–44 years, which is both a reflection of their increased mobility and the fact that the Ugandan population is quite young.[16] Consistent with previous studies and reports, pedestrians and motorcyclists had higher risk of fatal injury, although for a large proportion of the participants (39.3%), information on the road user category was missing.[1 17 18]

Table 2 Individual-level crash analysis of injury outcomes

	Non-fatal injuries	Fatal injuries	Total	Unadjusted PR (95% CI)	Adjusted PR (95% CI)
	n=51 519	n=7558	n=59 077		
	n (%)				
Age group					
<5	1615 (3.1)	435 (5.7)	2050 (3.5)	1.00	1.00
5–14	4094 (7.9)	558 (7.4)	4652 (7.9)	0.54 (0.21 to 1.41)	0.59 (0.36 to 0.99)*
15–24	12 520 (24.3)	1013 (13.4)	13 533 (22.9)	0.36 (0.13 to 1.04)	0.38 (0.21 to 0.71)*
25–34	14 268 (27.7)	1353 (17.9)	15 621 (26.4)	0.42 (0.14 to 1.25)	0.42 (0.22 to 0.82)*
35–44	7911 (15.4)	826 (10.9)	8737 (14.8)	0.46 (0.16 to 1.26)	0.42 (0.21 to 0.84)*
45–54	3931 (7.6)	424 (5.6)	4355 (7.4)	0.43 (0.15 to 1.26)	0.48 (0.22 to 1.02)
55 and above	3517 (6.8)	515 (6.8)	4033 (6.8)	0.63 (0.20 to 2.00)	0.66 (0.34 to 1.29)
Missing	3663 (7.1)	2434 (32.2)	6097 (10.3)	–	–
Sex of road user					
Male	37 576 (72.9)	5856 (77.5)	43 432 (73.5)	1.00	1.00
Female	13 447 (26.1)	1585(21)	15 032 (25.4)	0.83 (0.67 to 1.04)	0.82 (0.68 to 0.98)*
Missing	496 (1.0)	117 (1.5)	613 (1.0)	–	–
Road user type					
Not vulnerable	5793 (11.2)	882 (11.7)	6675 (11.3)	1.00	1.00
Vulnerable	24 338 (47.2)	4864 (64.4)	29 202 (49.4)	1.5 (1.21 to 1.87)	1.37 (1.07 to 1.75)*
Missing	21 389 (41.5)	1811(24)	23 200 (39.3)	–	–
Type of activity of pedestrian before crash†					
Other activity	166 (0.3)	65 (0.9)	231 (0.4)	1.00	–
Crossing the road	1916 (3.7)	882 (11.7)	2798 (4.7)	1.26 (0.59 to 2.7)	–
Pedestrian on the road	386 (0.7)	83 (1.1)	469 (0.8)	0.83 (0.33 to 2.06)	–
Pedestrian by the roadside	1240 (2.4)	415 (5.5)	1654 (2.8)	0.88 (0.36 to 2.17)	–
Missing	47 812 (92.8)	6114 (80.9)	53 925 (91.3)	–	–
Personal protective measures†					
Did not have protective measure	3838 (7.5)	972 (12.9)	4810 (8.1)	1.00	–
Had protective measure	504 (1.0)	67 (0.9)	571 (1.0)	0.57 (0.33 to 0.97)	–
Missing/not applicable	47 176 (91.6)	6520 (86.3)	53 696 (90.9)	–	–
Driver possess a driving permit‡					
Does not possess a driving permit	720 (1.4)	165 (2.2)	885 (1.5)	1.00	–
Possess a driving permit	1355 (2.6)	136 (1.8)	1490 (2.5)	0.7 (0.35 to 1.38)	–
Missing/not applicable	49 444(96)	7257(96)	56 702(96)	–	–

*Significant at α=5%,.
†Variables that exhibited multicollinearity.
‡Driving licence possession was only collected for motorcyclists.
PR, prevalence ratio.

Similar to the findings for fatalities, the risk of non-fatal injuries was also higher for males, persons aged between 6 and 44 years, and vulnerable road users (eg, pedestrians). The large number of people with non-fatal injuries (87.2% of those injured) underscores the hidden costs of lost productivity and disability associated with road traffic crashes. According to the GBD Compare tool, RTIs accounted for 2.3% of total years of life lost and 1% of total years lived with disability in Uganda in 2016.

The African region has some of the highest rates of road crashes and fatalities in the world.[1] For most African countries, the Global Status Report on Road Safety provides the figures reported by the countries alongside estimates generated from modelling the data provided. In Uganda's case, the reported figures are from the police annual traffic report.[19] However, the completeness and accuracy of these figures have been questioned in the past.[4 5 20] Uganda's efforts to improve road safety were given impetus by the Decade of Action for Road Safety (2010–2020) that aims to reduce by half the number of deaths on the world's roads over the 10-year period.[21] In order for these efforts to be meaningful, countries should have a good estimate of the baseline burden. The very wide rift between Uganda's reported figures (3503 deaths) and WHO estimate from modelling (12 036 deaths (95% CI 9454 to 14 618) for 2016 are a source of concern. Are the Uganda police missing two thirds of all road deaths? Would the use of three data sources—police, health facility and mortuary—improve the estimates? Using the three sources have the advantage of identifying injury cases that would be missed by the police although this comes at the risk of duplicating records in the absence of a unique personal identifier. Based on our findings, we believe that the three-sources method, although still an approach that rely on model estimates, can be useful in other countries where reported figures and WHO estimates of road traffic fatalities are difficult to reconcile. Other examples already exist of countries that have improved their estimates by using alternative data sources.[22–24] Data from India, Thailand and Vietnam were not modelled in the same manner because these countries have provided alternative sources.[1]

Our study had several limitations. First, it was not possible to completely deduplicate police, health sector and mortuary records. While we attempted to identify duplicate records by generating a unique identifier (based on variables such as age, sex and date of the crash), we were able to identify and drop only a small number (90 records) of duplicates due to the high rates of missingness. Therefore, it is still possible that our results might overestimate the burden of road traffic crashes in Uganda.

Second, RTIs, even serious ones, might not be treated at the main hospitals and health centres, which was where we collected data. A study by Magoola *et al* using the capture–recapture method showed that hospitals in Uganda were capturing about 60% of the RTIs in their catchment areas, while the police recorded only 14% of the injuries.[25] This inability to capture all injuries from crashes in our data sources could have the effect of underestimating the burden in this study. Our estimate is about 63% (7558/12 036) of the estimate from the WHO models. Third, it is possible that the purposive addition of three regions along a major transnational highway (where crashes are likely to be higher) and the inclusion of one district per region with the highest crash burden may have led to a weighting that overestimated road traffic crash burden for Uganda. This has implications on the representativeness and generalisability of our findings. Moreover, our weighting approach assigned weights to health facilities and mortuaries based on the selection probabilities for the nearest police region and station. Fourth, while the police define a road fatality as one occurring within 365 days of the crash, health facilities observe no time limit, but are usually only able to record deaths that occur during the hospitalisation. Lastly, for the age group comparison, we used the under 5 years old group as the reference group, but we recognise that young children for many reasons (eg, physical and cognitive development) have a different set of risk factors for both fatal and non-fatal injuries, so our age-related findings should be interpreted with this in mind.

CONCLUSION

The use of three sources of data provides an alternative approach for estimating the burden of RTIs and deaths in Uganda, and we would recommend this method to countries that currently use only one source. This study provides a more robust estimate of the road traffic burden than that from the police data alone and may provide an alternative to the WHO and GBD estimates for Uganda, especially since this method can be conducted yearly or even on a continuous basis. Efforts to reduce the burden should include improvement of data collection and management systems in Uganda and other LICs in order to aid the setting of meaningful targets.

What is already known on the subject

- Estimates of road traffic burden derived from police reports may not represent the complete picture of the burden in many low-income countries (LICs).
- The WHO and Global Burden of Diseases project use complex models to generate country-specific estimates for road traffic burden for LICs.

What this study adds

- Using three major data sources (police, health facilities and mortuaries) to estimate road traffic burden in an LIC setting.
- An alternative approach for estimating the burden of road traffic crashes and injuries in an LIC setting.

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Contributors All authors conceived the question and study design. SN and AN supervised data collection. KMM, MN and AN conducted statistical analysis. All authors contributed to the writing. All authors read and approved the final version of the manuscript for publication.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Study approval was obtained from Makerere University School of Public Health (approval #: 469) and the Uganda National Council for Science and Technology (registration #: SS 4319. The heads of the respective police and health facilities approved access to data.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The corresponding author can work with any interested investigators to secure approval from relevant authorities (the Uganda Police and Ministry of Health) to reuse the dataset for research.

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