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ABSTRACT

Background: Mortality from road traffic injuries in sub-Saharan Africa is among the highest in the world, yet data from the region are sparse. To date, no multi-site population-based survey on road traffic injuries has been reported from Nigeria, the most populated country in Africa.

Objective: To explore the epidemiology of road traffic injury in Nigeria and provide data on the populations affected and risk factors for road traffic injury.

Design: Data from a population-based survey using two-stage stratified cluster sampling.

Subjects/setting: Road traffic injury status and demographic information were collected on 3082 respondents living in 553 households in seven of Nigeria's 37 states.

Main outcome measures: Incidence rates were estimated with confidence intervals based on a Poisson distribution; Poisson regression analysis was used to calculate relative risks for associated factors.

Results: The overall road traffic injury rate was 41 per 1000 population (95% CI 34 to 49), and mortality from road traffic injuries was 1.6 per 1000 population (95% CI 0.5 to 3.8). Motorcycle crashes accounted for 54% of all road traffic injuries. The road traffic injury rates found for rural and urban respondents were not significantly different. Increased risk of injury was associated with male gender among those aged 18–44 years, with a relative risk of 2.96 when compared with women in the same age range (95% CI 1.72 to 5.09, $p<0.001$).

Conclusions: The road traffic injury rates found in this survey highlight a neglected public health problem in Nigeria. Simple extrapolations from this survey suggest that over 4 million people may be injured and as many as 200 000 potentially killed as the result of road traffic crashes annually in Nigeria. Appropriate interventions in both the health and transport sectors are needed to address this significant cause of morbidity and mortality in Nigeria.

Injuries are becoming recognised as a leading cause of global death and disability, with road traffic injuries (RTIs) being the greatest contributor.[1–5] Injuries due to road traffic crashes are estimated to be the second leading cause of lost disability-adjusted life-years (DALYs) in developing countries by 2020.[6] Mortality due to RTI in Africa is among the highest in the world, at 28.3 deaths per 100 000 population.[4 7] The economic costs associated with RTIs in Africa were estimated to be US$3.7 billion in 2000, translating to approximately 1–2% of each country's gross national product.[8 9]

According to the World Health Organization (WHO), RTIs ranked as the 11th leading cause of death and the 6th leading cause of DALYs lost in Nigeria for 2002, and constituted the leading cause of death and DALYs lost from unintentional injuries.[10] In the 1990s, the cost of RTIs for Nigeria was estimated to be >US$25 million, an amount that is thought to have greatly increased in the past two decades.[11] Existing sources of injury information in Nigeria include hospital data and police records.[12–20] Although hospital data are useful in revealing certain trends, the inferences that can be drawn from these results are limited, as both hospital and police data are subject to selection bias and do not allow estimation of the population-based impact of RTIs.

Community-based survey data for RTIs are available for several other countries in sub-Saharan Africa, including one from Nigeria, but data are limited to one region of the country.[21–23] This study sought to extend the information on RTIs in Nigeria beyond police and hospital data by performing a larger population-based household survey. The objectives of this study were: (1) to estimate incidence rates for RTIs in selected parts of Nigeria; and (2) to describe the population-based epidemiology of RTIs, especially in terms of gender, age and urban and rural distribution. This study is an attempt to test methods for community-based surveys for RTIs and to inform the work of those involved in national and international health in Nigeria.

METHODS

Nigeria is the most populous country in Africa, with an estimated 126 million inhabitants, and comprises a great diversity of climate and topography, with a mostly rural-dwelling population.[24] It is divided into six geopolitical zones, 37 states and multiple local government areas within each state. The survey was conducted in early 2006 in seven states: Lagos, Anambra, Rivers, Borno, Plateau, Kaduna and the Federal Capital Territory. These states range in population from 1 million (Federal) to 9 million (Lagos) and from a per capita household monthly income of US$7.50 and official poverty rate of 88% (Borno) to US$36.00 and 70% (Lagos).[25] The main rationale for the selection of these areas was to ensure representation from each of the six geopolitical zones in the country: South-West, South-East, South-South, North-Central, North-East, North-West.

The survey sample was drawn from an existing sampling frame, the National Integrated Survey of Households sample design, run by the National Bureau of Statistics in Nigeria. A two-stage stratified, cluster sampling was used, with a power analysis for a cross-sectional survey at the 95% confidence level. Assuming an RTI rate of 0.04, a precision within 5%, and an average household size

Table 1 Demographic data for survey sample population (n = 3082) and Nigerian population

	Survey (n = 3082)	Nigeria*
Gender (%)		
Male	50.91	49.64
Female	49.09	50.36
Years of age (%)		
<5	14.55	16.6
5–17	36.75	53.6†
18–29	21.93	
30–44	17.59	14.8
45–59	3.79	9
⩾60	5.4	6
Sector (%)		
Rural	39.49	65.41
Urban	60.51	34.59
Education (%)		
No formal education	30.18	38.4†
Pre-primary	7.04	
Some primary	19.34	22.72
Completed primary	9.9	8.99
Some secondary	13.3	15.62
Completed secondary	14.28	7.64
Post-secondary	5.97	5.28
Marital status (%)		
Never married	64.11	31.88
Currently married	33.1	61.53
Separated/divorced	0.75	2.57
Widowed	1.85	1.81

*From the 2003 Nigerian Demographic and Health Survey.
†Data from 2003 Demographic and Health Survey: age only available in increments of 5 years; no formal education and pre-primary only available as collapsed single category, "no education."

of five people, a sample size of 330 individuals (66 households) per state was calculated. In order to account for possible low response rates, the number of households per state was increased to 80, yielding a total estimate of 560 households and 2880 individuals. Four enumeration areas—two rural and two urban—were selected randomly within each of two local government areas in seven states, totalling eight enumeration areas for each state. The enumeration area was the primary sampling unit for the survey from which 10 households were randomly selected using the existing sampling frame of the National Bureau of Statistics. All residents of the 80 households in each state were included in the study.

Data were collected through household interviews using questionnaires adapted from household injury surveys previously implemented in Ghana and Uganda.[21 22] Pilot interviews were carried out in areas not included in the survey, before the implementation of the survey, and questions were refined on the basis of cultural sensitivity. In each of Nigeria's states, up to 40 languages may be spoken, therefore questionnaires were written in English and orally translated into local languages by the interviewers. The most commonly used languages were: English, Yoruba, Hausa, Ijaw, Ikwere and Pidgin. The surveys were administered by experienced local translators from the National Bureau of Statistics. A 2-day training of master trainers was held first, and then each master trainer conducted a 2-day workshop to train interviewers for the field work and translation. Quality control was achieved by designated state coordinators via on-the-job supervision, random spot checks of completed questionnaires, and on-site interviews ensuring accuracy of translation.

Interviews were obtained from the head of the household, who served as proxy respondent for people less than 18 years of age, the legal age of adulthood in Nigeria. Demographic information was collected for every person, including age, gender, education, marital status, occupation and rural/urban status. RTI was defined as any physical body damage resulting from a motor vehicle crash, being hit by a motor vehicle, or other transport mechanism in the past 12 months. Injuries were categorised by severity; for the purposes of this analysis, "severe" injuries were defined as any injury requiring hospitalisation or resulting in permanent disability. Otherwise injuries were defined as "slight". In addition, the mechanism of injury, time of day, location, part of body injured, disability, treatment and cost data were collected. During pretesting of the questionnaire, it was found that there were negative cultural perceptions associated with asking about a death within 30 days of the event. These cultural issues were not relevant when death was discussed in terms of where it occurred. For this reason, mortality from RTI was counted if a death occurred at the scene of the crash, on arrival at the hospital, or before discharge from the hospital only. As restricting death events to these criteria would underestimate the number of deaths due to RTI, this definition was felt to be a reasonable pragmatic adjustment.

The data were entered in Epi-Info, edited and converted into Stata 10.0 statistical software for analysis. Univariate and bivariate analyses were performed for all demographic characteristics and injury responses, and incidence rates for age, gender, educational status and rural/urban designation were generated. Corresponding standard errors were calculated and multiple regression analysis was performed using a Poisson distribution, with an adjustment for potential clustering effects by household.[26] Multivariate logistic regression analysis was also conducted, and the estimations were found to be robust and consistent through both methods. Only the results of the Poisson regression are reported here. An additional analysis was performed that included an interaction term between age and gender to explore potential effect modification between male gender, which has been associated with an increased risk of RTI, and age.

Annual numbers of events for the country were calculated using 126 million as the total population of Nigeria, as reported in the 2003 Demographic and Health Survey.[24] This community survey was jointly conducted and approved by the Nigerian Office of WHO and the Nigerian Ministry of Health. Anonymous, secondary, deidentified data were shared with authors at the International Injury Research Unit, Department of International Health, Johns Hopkins University for joint analysis.

RESULTS

The actual number of households that responded was 553, resulting in a total of 3082 individual respondents, a household response rate of 98.8%. Among the respondents, 50.9% were male, 60.5% lived in urban areas, and the mean (SD) age of study subjects was 22.5 (18) years, with the majority (36.8%) in the 5–17-year age range. The breakdown of the survey population was largely similar to the Nigerian population, except for the proportion married and geographical distribution; this study had a higher representation of urban residents, as well as participants who responded "never married" (table 1).

Of the 3082 people included, 348 (11.3%) reported having any injury in the previous 12 months, and 127 of them reported an RTI (table 2). For all injuries, the estimated injury rate was

Table 2 Incidence of road traffic injury (RTI) in Nigeria based on survey data

		All injury		RTI	
	No	Number	Rate/1000	Number	Rate/1000
Age (years)					
0–17	1502	118	78.6	34	22.6
18–44	1157	176	152.1*	69	59.6*
⩾45	423	54	127.7*	24	56.7*
Gender					
Male	1569	217	138.3†	89	56.7†
Female	1513	131	86.6†	38	25.1†
Residence					
Rural	1217	142	116.7	45	37
Urban	1865	206	110.5	82	44
Overall	3082	348	112.9	127	41.2

*Significant to the $p<0.02$ level when compared with age group 0–17 years as reference group in a Bonferroni analysis.
†Significant to the $p<0.01$ level in an unadjusted bivariate analysis.

112.9 per 1000 population (95% CI 101.4 to 125.4), and the estimated annual RTI rate was 41.2 per 1000 population (95% CI 34.3 to 49.0). The rate of RTI for men of all ages was significantly higher than that of women (table 2). The RTI rate was higher, but not significantly so, in rural areas than urban areas.

The mean (SD) age of people who had an RTI was 29.4 (15.9) years, which differed significantly ($p<0.001$) from the mean age of their uninjured counterparts (22.2 (18) years). The age group with the highest reported rate of RTI was 18–44 years, comprising 54.3% of all reported RTIs and an estimated annual rate of 59.6 per 1000 population (95% CI 46.4 to 75.5). Five deaths due to RTIs were reported, reflecting an annual death rate of 1.6 per 1000 population (95% CI 0.5 to 3.8), and an estimated case fatality ratio of 3.94% (95% CI 1.29% to 9.19%).

The most common location of RTIs was paved roads (accounting for 72.4%), followed by at or near the home (table 3). The lower extremities were the most commonly injured body part (47.2%), followed by the upper extremities. The most common road user category reported for RTIs was motorcyclists (54.3%), with pedestrians contributing 11.8% (table 3). Although private vehicles were the most commonly involved single type of vehicle (37.4%), if public buses and taxis are combined, these commercial vehicles comprised nearly half of those involved. Seventy (55.6%) RTIs were considered "slight", and 53 (42.1%) were considered "serious" or resulted in disability.

When not stratified by gender, membership in the 18–44-year age group was associated with a relative risk (RR) of RTI of 2.15, and the ⩾45-year group was associated with a relative risk of 2.46, compared with the reference group of 0–17 years (table 4). In an adjusted analysis (table 4), male gender was associated with an increased risk of RTI (RR = 2.04). When an interaction term was included for age and gender, the risk associated with male gender was found to be limited to the 18–44-year age group (RR 2.96) compared with women in the same age range.

Educational status was also evaluated, and people who replied that they had "some secondary" schooling or had "completed secondary" school contributed the greatest proportion of RTIs (28% for each group). When compared with the reference group of "no formal education" in the adjusted analysis, the group with "some secondary" education had a RR for RTI of 4.09. Of the remaining categories, the groups who responded that they had completed "primary", "secondary" and "post-secondary" education were also associated with a significantly increased risk of RTI in the adjusted analysis (table 4).

Table 3 Epidemiological characteristics of road traffic injuries in Nigeria

Characteristic	Number	Proportion
Location (n = 127)		
Paved road	92	72.44
Home	17	13.39
Unpaved road	14	11.02
Paved intersection	4	3.15
Body part injured (n = 127)		
Lower extremity	60	47.24
Upper extremity	30	23.62
Head or neck	27	21.26
Chest	5	3.94
Abdomen	3	2.36
Spinal cord	2	1.57
Road user category (n = 127)		
Motorcyclists	69	54.33
Motor vehicle users	38	29.92
Pedestrians	15	11.81
Pedal cyclists	5	3.94
Role of injured person (n = 114)		
Passenger	86	75.44
Self-driver	20	17.54
Professional driver	8	7.02
Missing	*13*	–
Type of vehicle (n = 107)		
Private car	40	37.38
Commercial bus or lorry	29	27.1
Other	21	19.63
Taxi	17	15.89
Missing	*20*	–
Injury severity (n = 126)		
Slight	70	55.56
Serious or disability	53	42.06
Death	3	2.38
Missing	1	–

DISCUSSION

In Nigeria, a country that has been undergoing an epidemiological transition, increasing unease regarding the contribution of RTIs has been documented since the mid 1980s.[27–30] This paper represents the results of one of the first multi-state household surveys on RTIs carried out in Nigeria. Although hospital data are valuable, it is reasonable to suspect that a large proportion of injuries are not captured by hospital data.[23 31 32] Performing a population-based survey in this context provides an opportunity to assess RTIs that are potentially not represented in hospital data. The estimated RTI rate in Nigeria was 41 per 1000 population, which approximates the overall RTI rate from the community survey carried out in Uganda (38.9 per 1000 person-years), but is more than the rate reported from Tanzania (5.98 per 1000 population).[21 33] The Tanzania study methodology may account for this difference, as fatal RTIs or RTIs resulting in restriction of activity lasting less than 1 day were not included.

The age group most affected by RTI in this survey was 18–44 years, which reaffirms the findings from community surveys performed in much of the developing world.[7 21 22 34] Also, male

Table 4 Relative risk for road traffic injury (RTI) by age, gender and education status (unadjusted and adjusted analyses), Nigeria (n = 3082)

	Relative risk for RTI			
	Unadjusted (95% CI)	p Value	Adjusted (95% CI)	p Value
Age (years)				
0–17	Referent (RR = 1)		Referent (RR = 1)	
18–44	2.63 (1.75 to 3.97)	<0.001	2.15 (1.36 to 3.39)	0.001
45 and older	2.51 (1.49 to 4.23)	0.001	2.46 (1.44 to 4.18)	0.001
Gender				
Female	Referent (RR = 1)		Referent (RR = 1)	
Male	2.26 (1.54 to 3.30)	<0.001	2.04 (1.46 to 2.85)	<0.001
Urban/rural status				
Rural	Referent (RR = 1)		Referent (RR = 1)	
Urban	1.19 (0.83 to 1.71)	0.351	1.12 (0.78 to 1.61)	0.553
Education				
No formal education	Referent (RR = 1)		Referent (RR = 1)	
Pre-primary	1.07 (0.36 to 3.20)	0.902	1.53 (0.52 to 4.56)	0.441
Some primary	1.46 (0.72 to 2.96)	0.29	2.04 (0.93 to 4.49)	0.076
Completed primary	4.19 (2.20 to 7.98)	<0.001	3.3 (1.79 to 6.08)	<0.001
Some secondary	3.97 (2.15 to 7.34)	<0.001	4.09 (2.24 to 7.45)	<0.001
Completed secondary	3.7 (2.00 to 6.84)	<0.001	2.62 (1.33 to 5.15)	0.005
Post-secondary	4.42 (2.16 to 9.06)	<0.001	2.8 (1.22 to 6.44)	0.015
Age analysis with interaction term				
Females 0–17	–	–	Referent (RR = 1)	
Males 0–17	–	–	1.52 (0.74 to 3.12)	0.255
Females 18–44	–	–	Referent (RR = 1)	
Males 18–44	–	–	2.96 (1.72 to 5.09)	<0.001
Females ⩾45	–	–	Referent (RR = 1)	
Males ⩾45	–	–	1.11 (0.48 to 2.58)	0.811

gender was associated with an increased risk of RTI in this survey, consistent with findings from previous studies and attributed to potential increased freedom of mobility given to men in these settings, primarily for economic purposes.[4 35 36] However, the increased risk of RTI in men was found to be concentrated in those aged 18–44 years. There was no significant gender difference in risk of RTI in the 0–17-year age group, indicating that males of this age group may not have the same increased exposure to RTI risk as their older counterparts.

The RTI rate in the Nigerian rural population was 37 per 1000 population per year, which is higher than that reported in the only other community-based survey on injury carried out in Nigeria: 25 per 1000 population per year.[23] One possible explanation for this discrepancy is that the survey carried out by Olawale and Owoaje[23] was restricted to one rural, homogeneous community, whereas that described in the present report consisted of rural communities sampled from seven different states throughout Nigeria. The difference may also be due to methodological reasons, including sampling strategy and length of recall used. The results of this survey did not show any significant difference between RTI rates in urban and rural Nigerian populations. In contrast, the transport-related injuries in the Tanzanian urban population was found to be four times that of the rural population, and, in Uganda, the urban population was more often affected by RTIs than their rural counterparts.[21 33] Interestingly, the RTI rates found in the rural population in Ghana (38 per 1000 population per year) were higher than in the urban population (22 per 1000 population per year).[22]

Motorcycle injuries accounted for more than half of RTIs reported (54%) in this survey. Olawale and Owoaje[23] also reported that motorcycle injuries accounted for the majority of RTIs in their community survey. Prior hospital data reported from Nigeria reflect a much lower contribution to RTIs by motorcycles, ranging from 10.3% to 19%,[29 37] while, in Tanzania, the proportion of RTIs attributable to motorcycles was 18.7%.[33] The reason for the higher proportion of motorcycle involvement in RTIs found in this survey merits further exploration but may be due to an increasing use of motorcycles in Africa.

This report represents a higher estimate of annual mortality due to RTI than previously found for a part of Nigeria, at 1.6 per 1000 population. WHO reported 0.27 deaths due to RTI per 1000 population in 2002 using regional data.[10] The Nigerian Federal Road Safety Commission estimated that 4519 deaths occurred in 2005, a decrease from 5777 in 2004, yielding an estimated mortality of 0.036 and 0.046 per 1000 population for 2005 and 2004, respectively.[38] WHO estimates are influenced by the quality of regional data around 2000–01 and are for the whole population of Nigeria. Road safety commissions tend to rely on police statistics, which have been noted for under-reporting of RTI cases in low-income countries.[39 40]

The use of an English survey with translations performed by experienced and trained interviewers has been used in Nigeria[23] and Pakistan.[34] This may have caused some misunderstanding in respondents; however, it is likely that this would result in under-reporting of events, and thus underestimation of rates reported here. This study relied on a 12-month recall period, which has been shown to result in under-reporting of less serious injuries because of a "memory decay" phenomenon,[41] although severe injuries are thought to be consistently reported up to 12 months. The net effect of this bias would result in some underestimation of less serious RTIs, but was consistent

What is already known on this topic

- Road traffic injuries are an increasing cause of death and disability in developing countries.
- Mortality due to road traffic injuries in sub-Saharan Africa is among the highest in the world.

What this study adds

- The population burden of road traffic injury is high in Nigeria, at 41 per 1000 population (95% CI 34 to 49).
- Surprisingly, motorcycle injuries comprise over half of road traffic injuries in this sample.
- There was no significant difference in the estimated road traffic injury rates of urban and rural populations in Nigeria.

with the focus of the survey on consequential injuries. However, a review of injury reports by month indicated that 44% of injuries were reported in the most recent 6 months and the rest in the next half of the 12-month period, reflecting that there was no sharp fall in monthly recall within the time period. Whereas ~60% of the Nigerian population lives in rural areas, the reverse is represented in this survey population—an artefact of the sampling technique used in the study and an over-representation of the urban population. This may have resulted in the bulk of significant difference between rural and urban RTI rates. It may have also affected the distribution of education and marital status (table 1) in the sample used in this study.

Initially, a fatality was defined as a death within 30 days of an RTI, but respondents in certain parts of the surveyed areas were very sensitive to a discussion of death in this time period during pilot testing. As a result, the definition had to be revised to death on the scene or in the hospital, and this may have resulted in under-reporting of deaths in the survey. The study also provides limited classification of injury severity and treatment consequences for injury. Although designed to capture information from a representation of Nigeria's diverse geopolitical zones, this survey is not nationally representative. Although the sample size allows estimation of RTI incidence rates, the study was not powered to look at disaggregated analysis by gender, age and educational status.

This survey suggests that the morbidity and mortality caused by RTIs in Nigeria may be much higher than previously appreciated. Given the number of Nigerian lives that are potentially affected and lost by RTIs on an annual basis, improved prevention measures, prioritisation of policy measures, and further exploration of accurate methods of injury surveillance are strongly warranted.

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Contributors: ML was responsible for the study design, survey development, data collection and outline of paper. CJ analysed data and wrote the first draft of the paper. OCK assisted with the study design and data collection. AAH guided the study design, data analysis, edited all drafts, and approved the final manuscript.

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