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Risk factors for injury mortality in the Rufiji district, Tanzania

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Abstract

Background: Injuries rank high among the leading causes of death and disability annually, injuring over 50 million and killing over 5 million people globally. Approximately 90% of these deaths occur in developing countries. **Objectives:** To estimate and identify the risk factors for injury mortality in the Rufiji Health and Demographic Surveillance System (RHDSS) in Tanzania. **Methods**: Secondary data from the Rufiji Health and Demographic Surveillance System covering the period 2002 and 2007 was examined. Verbal Autopsy data was used to determine the causes of death based on the 10th revision of the International Classification of Diseases (ICD10). Trend and Poisson regression tests were used to investigate the associations between risk factors and injury mortality. **Results:** The overall crude injury mortality rate was 33.4 per 100,000 population. Injuries accounted for 4% of total deaths. Males were 3 times more likely to die from injuries compared with females [Adjusted IRR=3.04, P=0.001, 95% CI (2.22-4.17)]. The elderly (defined as 65^{+}) were 2.8 times more likely to die from injuries compared with children under 15 years of age [Adjusted IRR=2.83, P=0.048, 95% CI (1.01-7.93)]. The highest frequency of deaths resulted from road traffic crashes. **Conclusion:** Injury is becoming an important cause of mortality in the Rufiji district. Most injuries are preventable, policy makers need to institute measures to address the issue.

Key words: Injury, mortality, risk factor, Cause-specific

Introduction

Injuries have traditionally been regarded as 'unavoidable' accidents. In recent decades however, there is a shift in perspective and injuries are being recognized as preventable events, (1).

Injury mortality is a major global public health problem, accounting for 9% of mortality and 16% of all disabilities annually, (2). The global rate of unintentional injuries was 61 per 100,000 populations per year and road traffic injuries made up the largest proportion of unintentional injury deaths (33%). When standardized per 100,000 population, the death rate was almost double in Low and Middle Income Countries (LMIC) compared with high-income countries (65 versus 35 per 100,000), and the rate of disability-adjusted life-years is more than triple in LMIC (2,398 versus 774 per 100,000), (3).

In LMIC, injuries are growing in significance because of the demographic and socioeconomic transitions that have characterized their development in recent decades, (4). Of an estimated 5.4 million people worldwide who died from injuries in 2005, over 90% occurring in low and middle-income countries, (5).

Although non-communicable diseases were responsible for nearly 60% of deaths globally in 2001 compared with 9% due to injury mortality, the Years of Life Lost (YLL) proportional to injuries is much higher, at 12%, compared with 40% for chronic diseases, (6). According to the Global Burden of Disease 2000 data, over 5 million people (83.7 per 100,000 population) died worldwide from injuries in 2000, (7).

In many developing countries, injuries have a significant impact on the health of populations and are rapidly becoming increasingly recognized as a major cause of death and disability. Eight of the 15 leading causes of death for people aged 15 to 29 years were injury-related including both intentional and unintentional deaths, (8-9). For every death that results from injury, dozens of hospitalizations, hundreds of emergency department visits and thousands of doctors' appointments occur. It is projected that by 2020, injuries will compete with infectious diseases as a major source of mortality and morbidity in the developing world, (10).

Modernization has reportedly been associated with increased mortality from injury. A study in Tanzania reported that as populations grow and become more mobile, a large proportion of adults are at higher risk for injuries than in the past. Similarly, a 2002 survey of 7,035 rural and 8,188 urban households in Tanzania found that 22.5% and 4.3% persons reported injuries respectively. Although the overall incidence was higher in the rural area, the incidence of major injuries (> or = 30 disability days) was similar in both areas, (11-12). Males were mainly affected in a total of 342 burned children in Northwestern Tanzania and children aged two years and under were the majority, accounting for 45.9% of cases, (13).

The descriptive epidemiology of injury mortality in Africa and other low-income countries is poorly understood. As a result, accurate data on the vital statistics about injury mortality is not well documented, (12). To address this gap in knowledge, this study examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania.

Methodology

Study design and setting

The research design comprised a cross-sectional study of injury mortality amongst the population of residents in the Demographic Surveillance area of the RHDSS between 2002 and 2007.

The study was conducted in the Rufiji Health and Demographic Surveillance System (RHDSS) area, one of the Demographic Surveillance Centres in Tanzania. The INDEPTH Network's monograph on mortality defines a demographic surveillance system (DSS) as a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area.

The RHDSS area extends from 7.470 to 8.030 south latitude and 38.620 to 39.170 east longitude. The area is located in the Rufiji district, about 178 kilometres south of Dar es Salaam. The RHDSS operates in 6 contiguous wards and 31 villages (about 60 km long × 30 km wide) and covers an area of 1813 sq km. The total population under demographic surveillance is about 85,000. Females (52%) outnumber males (48%) in the Rufiji Demographic Surveillance Area (DSA). The average household size is about 4-8 persons.

According to The United Republic of Tanzania's 2002 Population and Housing Census General Report, the population of Rufiji district was approximately 203,102 (98,398 males and 104,704 females) with an annual growth rate of 2.3%. The mean household size for the whole district was approximately five persons, (14). The district is largely rural, though the population is clustered around Utete (District headquarters), Ikwiriri, Kibiti and Bungu townships. All the last three townships are within the Health and Demographic Surveillance System (HDSS) area. Islam is the dominant religion, followed by Christianity and then African traditional believers. Kiswahili is the main language spoken by the inhabitants.

Data source

The RDHSS cause-specific mortality data was the primary data source for this study. The RHDSS prospectively records longitudinal data on household demographics and is updated

every four months. The HDSS was established to provide sentinel data through continuous surveillance of households and members within households in cycles with the aim of gathering information on health and demographic data to inform health policy and planning and to evaluate/monitor the impact of health reforms.

Variables and definitions

Injury mortality was the outcome variable of interest. It included all deaths resulting from injuries, whether unintentional or intentional in the Rufiji surveillance area between 2002 and 2007. The causes of deaths in the DSA had already been determined by the physicians using the verbal autopsy data, (15-16), which is consistent with the International Classification of Diseases ICD-10, (17-18). The cause of death was usually based on both remote and immediate factors leading to death.

A death outcome was classified as injury death when it occurred due to any one or combination of the following: animal bites; drowning; falls; firearm; fire / burns; road transport crash; homicide; and suicide (poison, hanging). The outcome variable was classified as positive for all injury-related deaths and negative for individual alive in a particular year. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Case identification

Injury mortality data from the RHDSS database was used for the analysis.

Data collection

Data was extracted from the RHDSS for the period 2002 to 2007.

Data analysis

Principal Component Analysis (PCA) was used to construct a socio-economic index for each household, (19-20). Households were categorized into high, medium and low socio-economic status based on the average number of household assets owned by the study participants as well as the environmental and household characteristics. Some of the assets included in the construction of the PCA were ownership of goats, cattle, sheep, houses, cars, chicken and televisions. The person years of observation (PYO) was computed for all study participants from

the individual member information table and the migration table. This takes into consideration the movements of participants, the event file which records all the event history that have happened to individual members, and the interval file which is the start and end date of the study from which the person time of contribution is generated. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Univariate and multivariate Poisson regression analysis was performed using STATA 10 to assess the association between the risk factors and injury mortality. Not every study participant was observed for the same length of time and Poisson regression model allows for this through something called an offset whereby every individual contribution of time is account for in the analysis.

Chi-squared test for trend was used to examine trends and patterns in injury mortality. All tests for significant associations were based on p-values at 5% significance level.

The descriptive statistical analysis comprised an examination of trends and patterns in injury mortality by age, gender, socio-economic status, and the identification of other risk factors associated with injury mortality. The analytic component involved the measurement of the association between age, gender, socio-economic, education, occupation, marital status (for individuals aged 15 years only) and injury mortality. Poisson regression analysis was used because it takes into account each participant's contribution of time throughout the entire study duration.

Ethics

Anonymity and confidentiality was ensured by replacing any potential personal identification of the study participants with unique reference codes. Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. Ethics clearance was also obtained from the Ifakara Health Institute-Institutional Review Board for the primary study data collection.

Results

Description of the study population

Table I presents the socio-demographic characteristics of the study population. There were 119,271 residents contributing 592,324.03 PYO over the study period. There were slightly more females (52.9%) compared with males (47.1%). Children younger than 15 years of age constituted the largest group 50,515 (42.4%). Half of the study population [60,588 (50.8%)] had no formal education and over a third of the study participants (37.3%) were farmers. Household wealth profile using principal component analysis revealed that 18,971 (35.5%) were classified as low socio-economic status. In terms of conjugal status, 20,675 (18.6%) participants were not married while 40,554 (36.5%) ever married.

A total of 4,471 deaths were recorded over the study period, of which 198 were classified as injury deaths. Majority of the injury deaths were males 140 (71%) verse 58 (29%). Most of the injury deaths were unintentional (90%).

The overall injury mortality rate was 33.4 per 100,000 population. Injury mortality rate (49.7) was more than double in males compared to females (95% CI 42.1 - 58.6) compared to 18.7 (95% CI 14.4 – 24.2) p=0.001. The elderly (defined as any resident >65 years of age) experienced the highest injury mortality 128.7 (95% CI 98.9 – 167.7). Most important exposure variable(s) associated with injury mortality. It is of interest to note that tertiary education level participants constituted a small proportion of the population (n=757, number of deaths=3) compared with the other categories.

The injury deaths among retired workers was also higher (273 per 100,000 PYO), compared with casual workers (62 per 100,000 PYO), the unemployed (56 per 100,000 person years), and farmers (41 per 100,000 population). There was no evidence of a difference in injury mortality by SES though the individuals in the lowest SES category had the highest rates compared with the other groups. Those who ever married had mortality rate of 57 per 100,000 population, compared with 29 per 100,000 population among those who never married.

Table 1: Descriptive statistics of the study population by study variables

Exposure factor	Frequency	Percent	Person Time	Dead	Rate	95% Confidence Interval
Gender						
Female	63,042	52.9	310,556.33	58	18.7	14.4 - 24.2
Male	56,229	47.1	281,767.7	140	49.7	42.1 - 58.6
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Age Group						
1-14	50,515	42.4	254,938.5	40	15.7	11.5 - 21.4
15-34	41,195	34.5	192,014.21	55	28.6	22.0 - 37.3
35-64	19,480	16.3	102,645.01	48	46.8	35.2 - 62.1
65^{+}	8,081	6.8	42,726.31	55	128.7	98.8 - 167.7
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Education						
Primary	53,024	44.5	270,807.1	73	27.0	21.4 - 33.9
No-formal	60,588	50.8	293,677.2	118	40.2	33.6 - 48.1
Secondary	4,878	4.1	24,250.0	4	16.5	6.2 - 44.0
Tertiary	757	0.6	3,516.5	3	85.3	27.5 - 264.5
Total	**119,247**		**592250.83**	**198**	**33.4**	**29.08 - 38.4**
Occupation						
Student	4,026	4.2	151,544.4	12	8.0	4.5 - 13.9
Unemployed	27,435	28.9	17,878.2	10	55.9	30.1 - 104.0
Retired	4,399	4.6	12098.2	33	272.8	193.9 - 383.7
Casual	17,377	18.3	74459.5	46	61.8	46.3 - 82.5
Farming	35,505	37.3	181796.8	74	40.7	32.4 - 51.1
other	6,333	6.7	128472.2	23	17.9	11.9 – 26.9
Total	**95,076**		**566249.2**	**198**	**35.0**	**30.4 - 40.2**
Household SES						
High	15,989	30.0	78,611.6	23	29.3	19.4 - 44.0
Medium	18,418	34.5	91,127.64	38	41.7	30.3 - 57.3
Low	18,971	35.5	93,664.9	43	45.9	34.1 - 61.9
Total	**53,378**		**263,404.14**	**104**	**39.5**	**32.58 - 47.9**
Marital status						
Single (>15 years)	20,675	18.6	102,676.6	30	29.2	20.43 - 41.8
Ever Married	40,554	36.5	218,805.1	125	57.1	47.9 - 68.1
Single (<15 years)	49,950	44.9	261,6721.0	43	16.4	12.2 - 22.2
Total	**111,179**		**583,153.6**	**198**	**33.4**	**29.1 - 38.4**

Overview of mortality proportions in Rufiji DSA from 2002-2007

Figure 1 shows the distribution of causes of deaths during the study period. Injuries accounted for 4% of total deaths. The overall mortality was 754.8 per 100,000 PYO; Malaria (24%) and cardiovascular diseases (23%) contribution was similar and accounted for almost half of the total deaths. The other external cause category (15%) included maternal deaths, specified and

unspecified communicable diseases, specified and unspecified acute febrile illnesses, diarrhoeal diseases, meningitis, hepatitis, specified and unspecified acute respiratory infections, tetanus and measles. Acquired Immune Deficiency Syndrome and Pulmonary Tuberculosis (14%) was fourth largest contributor of burden of mortality.

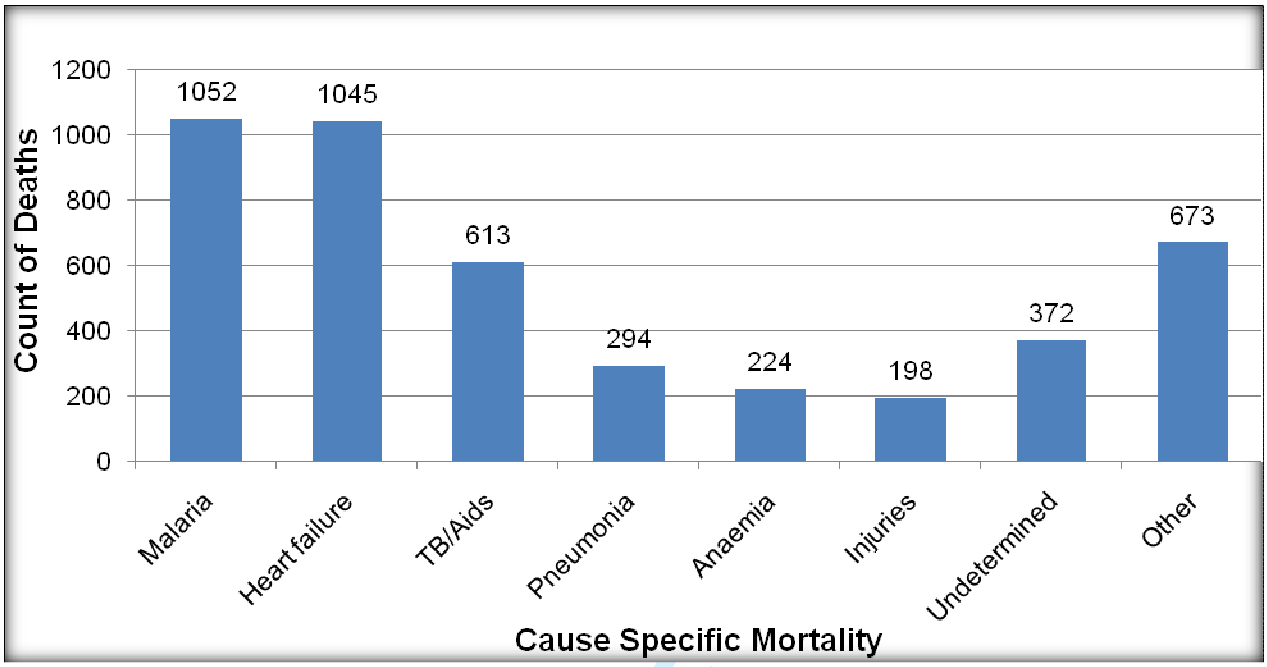

Figure 1: Major Causes of Mortality in RHDSS from 2002-2007

The distribution of cause-specific injury mortality in the Rufiji DSA

The types of injury mortality recorded in the study area during the period of analysis included road traffic accident, drowning, burns, homicidal injuries, accidental poisoning, animal bite/attack, falls, suicidal injuries and unspecified external injuries (deaths due to complications of medical and surgical care or being hit by external objects like trees and heavy loads). More than one quarter of the injury deaths were due to road traffic accidents 56 (28%), unspecified external injuries accounted for 40 (20%), drowning 32 (16%) and burns 18 (9%). The lowest injury deaths were attributed to suicide 4 (2%) or broadly referred here as intentional injuries.

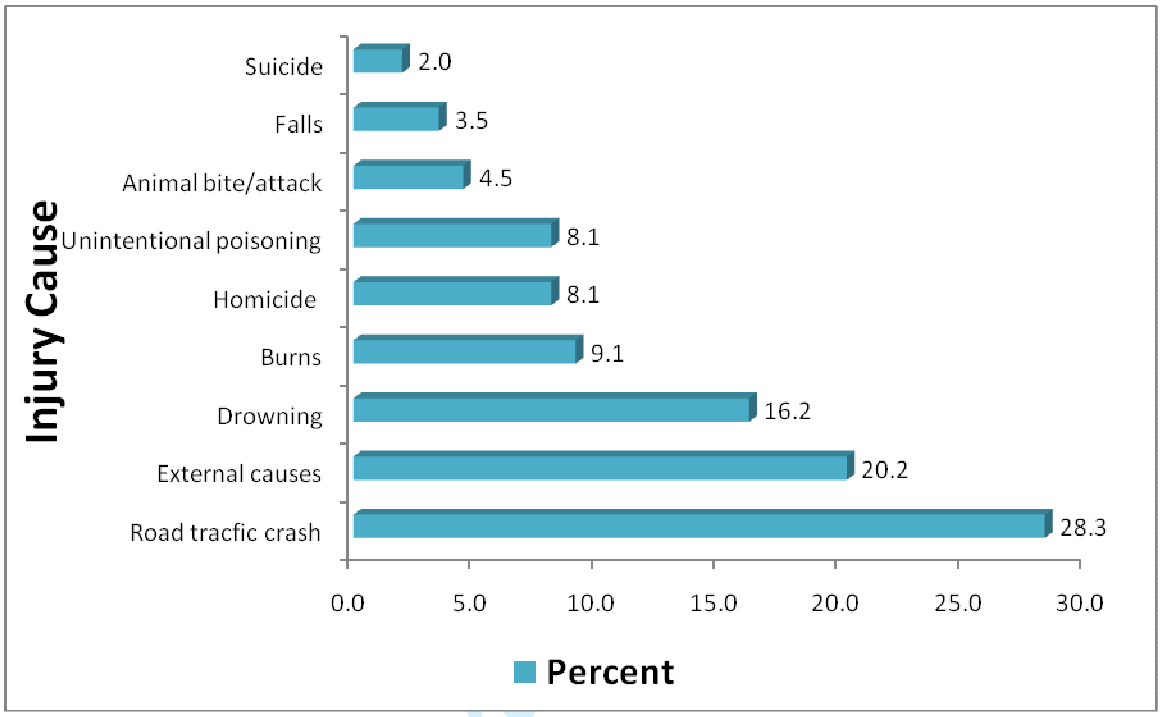

Figure 2: Distribution of Injury Cause-Specific Mortality in RHDSS

Estimating the yearly crude death rates (CDR) of injury from 2002-2007

There was a consistent yearly increase in the injury crude death rate (CDR) from 2002 to 2005. However, a slight decline was observed between 2005 and 2007 but we found no evidence of this drop in injury mortality. The Chi-Square for trends test showed no significant difference in proportions of injury deaths among the different years (P=0.288).

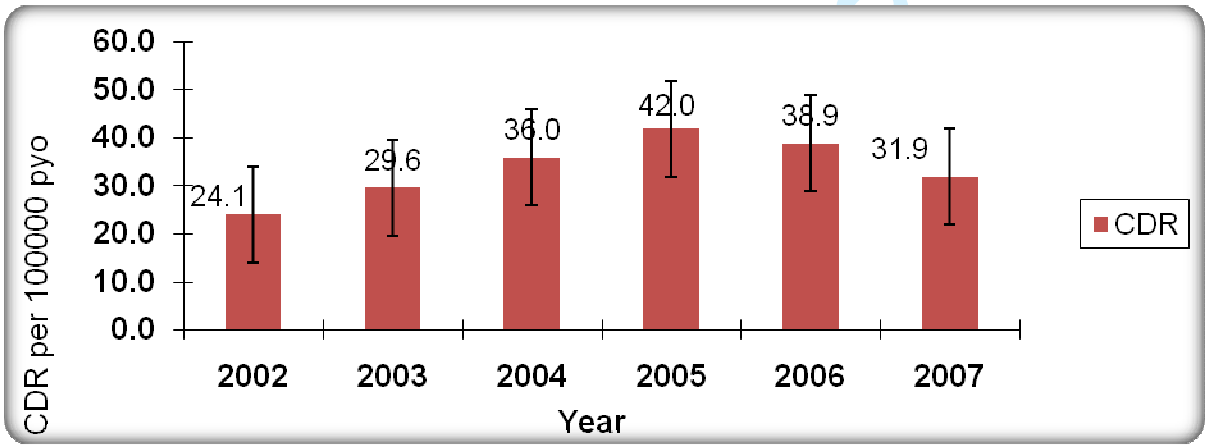

Figure 3: Trend of Injury Mortality from 2002-2007

Gender and Injury Mortality from 2002-2007

Injury mortality in males was significantly higher compared with females during the period. Injury mortality increased both in males and females from 2002-2005 and then dropped. Males were 2 to 4 times more likely to die of injuries compared with females. Males were more likely to die from RTAs, External causes and drowning compared to females. On the other hand females were more likely to die of burns and animal attacks.

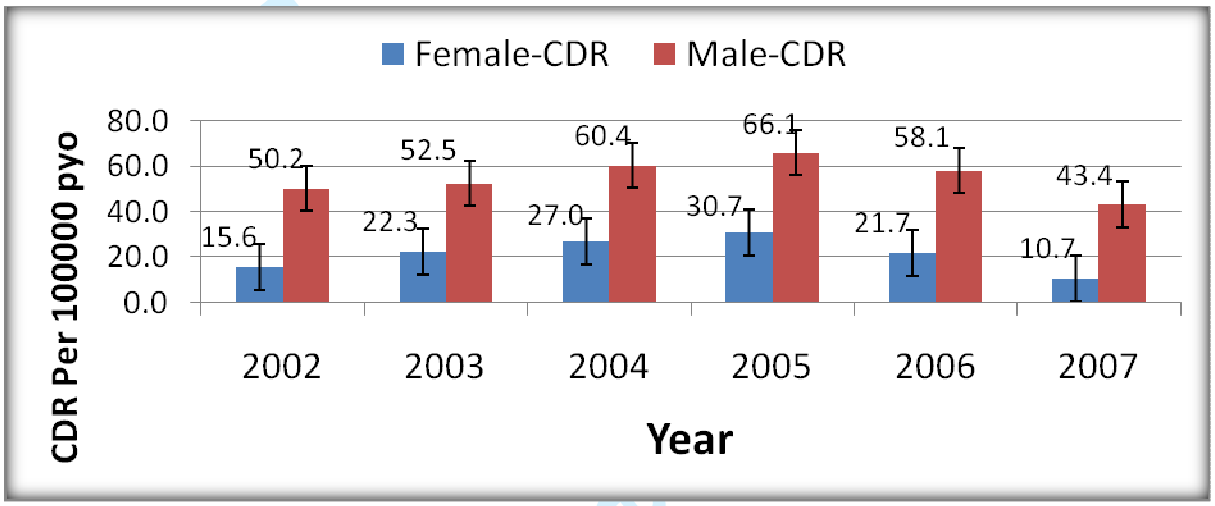

Figure 4: Trend of Injury Mortality by Gender from 2002-2007

Cause-Specific Injury Mortality by gender

Males were more likely to die in road traffic crashes, other external causes and drowning compared with females. On the other hand females were more likely to die of burns and animal attacks.

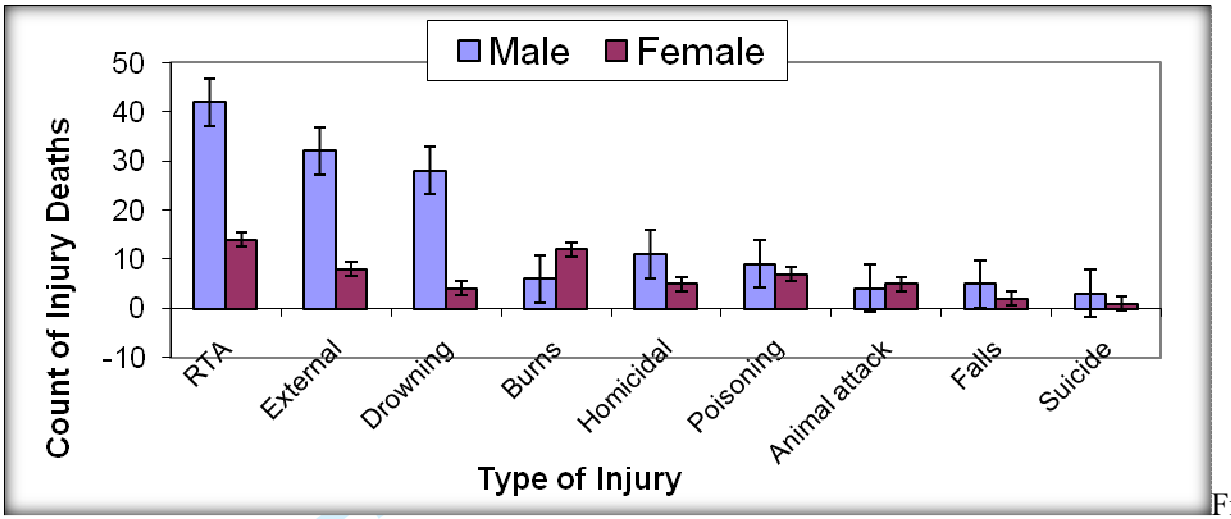

Figure 5: Cause-Specific Injury by Gender

Inferential Analysis

Univariate Poisson regression analysis of risk factors for injury mortality

Univariate and Multivariate Poisson regression analysis were carried out to demonstrate the associations between risks factors (gender, age, occupation, education, marital status, socio-economic status) and injury mortality. Incidence Risk Ratios (IRR) were used to measure the strength of the relationships and interpreted as Relative Risk. The results are presented in Table 2.

Table 2: Univariate and Multivariate Poisson regression analysis of injury mortality

Factor	Univariate Model (95% CI)			Multivariate Model (95% CI)		
	IRR	CI	P-Value	IRR	CI	P-Value
Gender						
Female	**1***			**1***		
Male	2.66	1.96 - 3.61	**<0.001**	3.04	2.22 - 4.17	**<0.001**
Age Groups						
1-14	**1***			**1***		
15-34	1.83	1.22 - 2.74	**0.004**	0.98	0.38 - 2.52	0.972
35-64	2.98	1.96 - 4.53	**<0.001**	1.34	0.48 - 3.75	0.582
65^{+}	8.20	5.46 - 12.33	**<0.001**	2.83	1.01 - 7.93	**0.048**
Occupation						
Student	**1***			**1***		
Farming	5.14	3.05 - 16.35	**<0.001**	4.13	1.81 - 9.42	**<0.001**
Casual	7.80	4.13 - 14.73	**<0.001**	7.36	3.25 - 16.66	**<0.001**
Unemployed	7.06	2.79 - 9.46	**<0.001**	8.57	3.26 - 22.48	**<0.001**
Retired	34.45	17.79 - 66.70	**<0.001**	28.26	12.53 - 63.71	**<0.001**
Marital status						
Single (>15 years)	**1***			**1***		
Ever Married	1.96	1.31 - 2.91	**<0.001**	1.08	0.64 - 1.83	0.776
Children (<15 years)	0.56	0.35 - 0.90	**0.016**	1.45	0.59 - 3.57	0.423

Education						
Primary	**1***			**1***		
No-formal	1.49	1.11 - 2.00	**0.007**	1.25	0.87 - 1.79	0.230
Secondary	0.61	0.22 - 1.67	0.339	0.59	0.21 - 1.62	0.306
Tertiary	3.16	1.00 - 10.04	**0.050**	1.19	0.37 - 3.86	0.769
Household SES						
High	**1***					
Medium	1.43	0.85 - 2.39	0.180			
Low	1.58	0.95 - 2.60	0.081			

1* *=Reference group*

In the univariate logistic regression analysis model, age, education, gender, marital status and occupation were all significant risk factors for injury mortality (Table 2).

In the multivariable logistic regression analysis model however, three variables were significant risk factors associated with injury mortality having adjusted for the variables in the univariate model. These are gender, age and occupation.

Adjusted for age, occupation, education and marital status, males (IRR=3.04; 95% CI: 2.22-4.17), the elderly (IRR=2.83; 95% CI: 1.01-9.93) and being unemployed (IRR=8.57; 95% CI: 3.26-22.48) were all found to be significant risk factors for someone developing active convulsive epilepsy (Table 2).

Discussion

Proportion of injury mortality

This study presented a population-based data on the proportion of injury-related deaths, the cause specific injuries as well as the risk factors for injury mortality from a predominantly rural area in Tanzania from 2002 to 2007.

Injuries remain a threat to human existence globally, especially in developing countries. Injury mortality accounted for 4% of total deaths during the study period. A study in South Africa reported that 8.9% of deaths were injury-related and homicide, road traffic crashes and suicide were the major causes of injury mortality. The study analyzed data on 133483 individuals with 717584.6 person-years of observation resulted in 11467 deaths, (21).

Risk factors for Injury mortality

The findings in this study are consistent with those found in other studies; generally males were more likely to experience injury mortality compared with females. Globally, injury mortality among males is twice of that among females and males in Africa and Europe have the highest injury-related mortality rates, (1). In South Africa, the male-female injury mortality ratio in 2008 was 3.3:1, (22). It also reflects the results from a study conducted by Moshiro et al.(2001) in Dar es Salaam, Hai, and Morogoro districts in Tanzania that documented injury mortality rates being approximately three times higher among men compared to women, (11, 23-24). The high male injury fatality rate in this rural setting might be explained by the gender specific roles where men are more likely to perform the risky jobs like fishing, manual farming and road traffic related activities like driving. There is a high need for targeted intervention for males in the district.

Age was also associated with injury mortality. The elderly were strongly associated with higher injury mortality rates compared with the younger age groups. This finding is similar to what was reported by Lopez et al. (2006) which attributed one-quarter of injuries deaths to those aged between 15 years and 59 years, (6). The assertion that injury mortality rates increased with age is similar to the findings by Moniruzzaman et al. (2008) which reported that in low and middle

income countries, there is a direct relationship between age and injury mortality such that as age increases, the risk for injury mortality increases, (25).

In this study, those who were in active employment had lower risk of injury mortality. This compares with the study by Garrib et al which found that full-time employment was significantly associated with lower mortality in South Africa, (21).

A couple of studies have demonstrated that increasing SES has a strong inverse association with the risk of fatal injuries; more than 80% of childhood burns have been reported to occur among low socio-economic groups, (26-29). This study did not find sufficient evidence to suggest that household wealth was a key risk factor for injury mortality. This could be attributed to the fact that socio-economic status information was not available for half of the households who were included in this analysis. Furthermore, Rufiji DSA is typically rural and almost homogeneous in terms of wealth index; there is very little variation in items possession, hence, no significant difference in SES between the high and low groups.

Types of injuries

Among the two broad types of injuries, 90% were unintentional The high unintentional injury deaths has been reported in studies in other parts of Tanzania, (11). The role of road traffic accident as the leading cause of injury mortality in this study is consistent with other injury deaths in other African Countries including Kenya and Ghana, (11, 30-31). Mortality rates because of road traffic crashes were again significantly higher in men than women in all age groups, for both pedestrians and vehicle occupant, (21).

Many other factors are known to be associated with risk of injury mortality. These include poverty, lack of education, unemployment, alcohol and substance abuse, interpersonal conflict, intimacy and power, (32-33).

Injuries related to burns from this analysis indicated that females were more likely to die compared with males. Other studies in Africa reported that males were more likely to die of burn fatalities and that young children and the elderly are the most vulnerable, (1, 29, 34-35). One possible explanation for the difference in findings may be due to the settings. Whereas those

studies were conducted in urban settlements, this study was conducted in a typically rural setting where cooking is seen as the birthright responsibility of females.

Drowning was among the main causes of injury mortality in this study. Studies have shown that Africa had the highest drowning mortality rate (13.1 per 100,000 PYO) and males had higher drowning mortality rates than females for all ages and in all regions and was more pronounced in children up to fourteen years, (7). In this study however, most of the drowning fatalities occurred in young (15-34) and middle-aged (35-54) adults. In the Rufiji Demographic Surveillance Area, most of the people are engaged in subsistence farming and fishing activities with the proximity of the Rufiji River as a possible influencing factor. For example most of the time males are the fishermen who at times engage in fishing without life jackets. There are no enforced laws on fishing. Fishing activities need to be regulated to save lives. In some developed countries however, there are laws regulating recreational swimmers and fishermen which proves a safety measure against drowning, (36-37).

We documented more male deaths from unintentional poisoning compared with females, reflecting those reported in other studies which indicate that the highest poisoning mortality rates were among the male populations in the low and middle-income countries; over 60% of the global mortality due to poisoning occurs among adolescents and adults aged between 15–59 years, (38).

Middle-aged men reported to have died more of homicidal injuries compared to females is consistent with global report which shows that more than three-quarters (77%) of homicide deaths in 2000 were among males with the highest levels of homicide occurring among males 15 to 29 years of age and closely followed by those 30 to 44 years old, (38). Results from the South African National Injury Mortality Surveillance System (NIMSS) in 2000 also indicate that homicidal injuries contributed 36% of all injury deaths, (39) and that homicide continues to be the leading cause of premature death among South African males (40). In another study higher mortality rates were reported for homicide deaths among men in all age groups especially young adults aged 30 – 39 years, (21).

In related studies, young adult men are at highest risk of injury-related mortality and comprised the majority of perpetrators as well as victims of violent incidents, (33, 41).

Suicide was the lowest rate of external cause of death in this community even though suicide was most common cause of injury death and was more pronounced in men compared with women in a South African study, (21).

In many Western countries, suicide is commonly the leading cause of death. Suicide rates have increased during the last four decades despite prevention efforts and there is marked geographic variability in suicide rates, with the highest rates being found in Eastern Europe and the lowest in Muslim and Latin American countries. This unevenness in suicide rates has not been adequately established. Majority of studies in the psychiatric literature have approached the analysis of risk factors and correlates of suicidal behaviours from a clinical perspective in developed countries where clinical studies have established that psychiatric disorders are the most important contributing factor to suicide, (42-44).

Trends of Injury Mortality

What is of greatest concern is the increasing trend in injury mortality over time in the studied area. The increase could be attributed to the bad road network. According to the U.S. State Department, many rural roads in Tanzania are virtually impassable, as seasonal washouts are commonplace, (45). It is encouraging however that a gradual decreasing trend was observed getting to the tail end of the studied period. The reversal trend could be attributed to the reconstruction of the Dar es Salaam Rufiji road which got completed in 2005. It is recommended that further analysis be carried out on the data collected from 2008 to ascertain whether the current deaths attributed to road traffic crashes is generally on the increase or decrease.

Conclusion and Recommendation

In Rufiji Demographic Surveillance Area, injuries remain an important cause of death but the extent of variation by age-group in the overall level of risk as well as risk from individual causes suggest that interventions tailored more to age-group and gender-specific would maximize prevention efforts.

In particular, the threats from road traffic accidents in the middle-aged adults and the elderly, drowning in young adults and children, burns as well as animal attack in children, homicide in young adults, suicide in middle adults, and accidental poisoning in all age groups need urgent attention and consideration. Also, burns as well as animal attack in females, and road traffic injuries, drowning, falls, homicidal or assault, accidental poisoning in males needs targeted interventions. This study has revealed that in the Rufiji Demographic Surveillance Area, there are significant disparities in injury mortality rates by gender, age-group and occupation. The leading cause of injury mortality has been noted as RTAs. Males continue to have higher injury mortality rates than females across all age groups.

With the demonstrated increasing trend of injury mortalities in most developing countries, an injury prevention curriculum has to be introduced in the education portfolio and this should be across the various levels of the educational levels for awareness creation. The Health Sector needs to include road safety in their health promotion and disease prevention activities. Road safety education has been noted as one of the key tools used to successfully reduce fatalities on the roads. There is the need for educational campaigns at various levels to create public awareness of the need for safety and precautionary measures to minimize or prevent injuries.

Two of the three factors (age and gender) associated with injury mortality are frequently found in other disease processes and are largely thought to be non-modifiable. However, intervention tailored to these groups can improve and maximize prevention policies.

Weakness of the HDSS

Some of the risk factor variables for injury mortality in this study had relatively small number of deaths for each injury aetiology. Examples are injury from burns, poisoning, and homicide. This makes the discussions not very conclusive. Also, the classification of cause-of-death as the assignment of ICD-10 coding can be quite complex, particularly for poisoning. SES as a risk factor for injury mortality had missing data for half of the study participants and could have a

potential impact on the findings. Nevertheless, SES was not the main interest of this study. Another possible limitation of verbal autopsy data recall bias and miss or under reporting of some vital events

Despite rigorous training and thorough fieldwork operations and quality control measures, it is difficult to comprehensively evaluate the completeness and accuracy of HDSS data given the absence of a gold standard against which to measure findings, (46).

Strengths of the HDSS

The sample size was a true representation of the study area and was large enough to give the study a statistical power. We used person years of observation method which is a more accurate measure of time-to-event compared to mid-year population estimates. The study used longitudinal data collected and updated periodically and thus able to monitor demographic change. Unlike clinical studies in which the individual alone is investigated, health and demographic surveillance also has the community as object of study, which it follows prospectively, (47). This fundamental concept gives rise to far-reaching strengths: generation of research questions that derive directly from empirical data, cost-effective support for a diversity of study designs to address these questions, and the capacity to track population change and the impact of interventions over time.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AK conceived of and developed the proposal under the supervision of RK. AK performed the statistical analysis under the supervision of HM. AK drafted the manuscript which was reviewed by OA. All authors read and approved the final manuscript.

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Data Sharing

The data remains the property of the Rufiji Health and Demographic Surveillance System.

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Dear Reviewer, Thank you for your comments, which we found useful in improving our paper. We have now revised the manuscript and the table below provides a detailed account of actions taken in response to each comment.	
Reviewers Comments	**Action Taken/Response**
Reviewer: 1 Comments to the Author Injury has become an important burden of disease in developing countries. Examining the nature, demographic characteristics, and extent of the problem is the first step in a public health approach to its prevention. This study could be a useful paper to provide some data on injuries mortality in Africa. The introduction needs to review existed studies in Africa in more detail, highlighting the result gaps. The aim of the study that examined the burden of injuries is not fully achieved (see comments in "introduction"). Data quality should be assessed. The discussion and recommendations should be more specific based on the unique pattern of injury mortality and risk factors in Tanzania. A few specific comments as to how this paper could be improved are presented under the headings below.	The current manuscript is structured in this format
1. Abstract: 1.1 Method: Why only include the cases above one year of age? 1.2 Results: "Injury contributed 4% to total mortality burden", the statement is not accurate enough. Actually, injury mortality accounted for 4% of total deaths. "Most injury deaths were due to road traffic crashes and unspecific external injuries". I just wonder whether "unspecific external injuries" is a real etiology of injury. 1.3 Conclusion: The conclusion that "most injuries can be prevented by life saving interventions such …." is a bit sloppy and lack of evidence base.	1.1 We anticipated complications surrounding the cause of death for less than 1 year old but in the analysis we did not come across these. So the entire population was included 1.2 This is true and the changes are made. We used this term in our study to classify a group of injuries (deaths due to complications of medical and surgical care or being hit by external objects like trees and heavy loads) 1.3 The conclusion has been modified to reflect the findings of the study
2. Introduction: Page 3 line 41-42: "A study in Tanzania…..in the past" no reference. Page 3 line 55: "As a result….is not well document" no causal relationship between this sentence and the previous statement. Page 4 line 1: "The aim of….investigate the burden of injuries". This aim is not fully achieved in the study. The study describes the proportion of injury deaths, trend, and the age-sex-mortality rate. However, some indicators may be included to assess the burden of injury mortality (e.g. Years of Life Lost, YLL). Otherwise, the aim may be modified	Reference has been provided for this statement and the sentence restructured in page 4. Page 4 line 1: I agreed. The aim was actually to estimate the proportion of injury deaths. The data was not comprehensive enough to run the detail analysis for burden
3. Methodology This part can be more concise. It may use subtitle "data" to summarize the context of "Rufiji Health and Demographic Surveillance System", "Primary Data Source", and "Study design and population". The authors should evaluate the data quality in terms of completeness of death data and validity of cause-of-death. It is noted that the proportion of heart failure is very high, which may be an indicator that the validity of cause-of-death is not very satisfactory. Also, the proportion of unspecific external injury is high (20%). Page 6 line 26-34: the method of classifying socioeconomic status is not quite clear. And the missing data of the socioeconomic status is 55% (see page 11 line 50). I just wonder whether the missing data are random or not. If not, it may lead to a bias. It is recommended to discuss the issue.	The structure is reorganized per the suggestion The cause-of-death data have been validated and this is discussed in page 6 of the manuscript The missing socioeconomic status data was random and this posed a limitation of the finding which have been discussed in the strengths and weakness section of this manuscript.
4. Results This part is tedious. And some contexts, tables, and figures may be deleted or merged. For example, Table I and Table II can be merged. Figure 3 and Figure 4 may be deleted. Page 9: As mentioned earlier, the subtitle "An overview of mortality burden in Rufiji	Table I and Table II are now merged and Figure 3 and Figure 4 have been dropped

DSA from 2002-2007" and "the burden of injury mortality in the Rufiji DSA" are not very accurate. These two parts describe the proportion of injury mortality and the pattern of injury mortality by sex, age, education, occupation and etc. Page 10, Table II: I hesitate for the classification of the education. Only 3 injury deaths in high tertiary education groups, but the rates of injury mortality were extremely high among the high education population. The education group for secondary and tertiary may be merged. Page 10, line 26: There are 104 cases with household socioeconomic status compared with total 198 injury deaths. The proportion of missing value is very high. Page 11, line 1-line27: may be deleted. As mortality is highly related to population age structure, the value of crude death rate is limited. Page 12, Figure 6: the data regarding to some types of injury (e.g. suicide, falls) are not informative due to small number of deaths. Page 12, Table III: The higher risk of injury among retired population may be caused by age effect. Thus, the interaction effect between occupation and age may be considered. Again, the higher risk of tertiary education population may be problematic.	The heading is now "overview of mortality proportions in Rufiji DSA from 2002-2007" Yes the missing socio-economic data is almost half but our main objective for this study was just to describe the proportion of injury deaths as well as trends. We discussed this in the study limitation. Interaction of the age and the other factors were investigated in the regression models and found none.
5. Discussion The unique risk factors based on the social, cultural context in the study area may be further discussed. Page 14, line-24-29: "The elderly were strongly….. This finding is similar to …….15 years and 59 years". The conclusion based on Lopez et al.(2006) did not talk about the same thing as authors' statement that "elderly have higher injury mortality rate" Page 15: I am hesitant to suggest that the discussion of risk factors for injury from burns, poisoning, and homicide is not conclusive, as the relatively small number of deaths for each etiology of injury.	We have now included the unique risk factors based on the social cultural context in the discussion section Page 14, line-24-29: "The statement have been properly structured to reflect what Lopez et al.(2006) found in page 15 of the manuscript We have done more discussion on injury from burns, poisoning, and homicide
6. Conclusion and Recommendation Some of the countermeasures which the authors think may have special relevance based on cultural and social contexts in Tanzania could be selected and discussed. The measurements' feasibility and effectiveness may be highlighted.	We have discussed some of the counter measures but these are mere speculative since our was not an intervention and therefore, we do not have evidence to support any of these claims
Reviewer: 2 Comments to the Author GENERAL Comment 1. This is an interesting paper that has valuable content to an international audience with an interest in injury mortality and methods of fatal injury surveillance in developing countries. The order of some of this content makes some of the messages unclear. The paper could be strengthened and reach a standard acceptable for publication if this is addressed. To assist the authors to address this, I have re-ordered the content of the paper and inserted other word changes. I hope the authors find these suggested amendments constructive and helpful.	
ABSTRACT Comment 2. Much of the content is fine. A few word changes have been made (see revised version below). Background: Injuries rank high among the leading causes of death and disability annually, injuring over 50 million and killing over 5 million people globally. Approximately 90% of these deaths occur in developing countries. Aim: To identify the risk factors for injury mortality in the Rufiji Health and Demographic Surveillance System (RHDSS) in Tanzania. Methodology: Mortality data from Rufiji HDSS for the period 2002 to 2007 was examined. All persons aged one year and over were included in the analysis. Verbal Autopsy data was used to determine the cause of death in	Re-ordered accepted in good faith.

accordance with the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10). Trend and Poisson regression tests were used to examine the association between socio-demographic risk factors and injury mortality. Results: The overall crude injury mortality rate was 33.4 per 100,000 person years of observation. Injuries contributed to 4% of the total mortality burden. Males were three times more likely to die from injuries compared with females [Adjusted IRR=3.04, p=0.001, 95% CI (2.22-4.17)]. Persons aged 65 years and over were 2.8 times more likely to die from injuries compared to children under 15 years of age [Adjusted IRR=2.83, p=0.048, 95% CI (1.01- 7.93)]. The highest frequency of deaths resulted from Most injury deaths were due to road transport crashes and other external causes. Conclusion: Injury is becoming an important cause of mortality in the Rufiji HDSS Area. Most injuries can be prevented by life saving interventions such as road safety education, regular road maintenance and use of life jackets for fishermen and recreational swimmers. Key words: Injury, mortality, burden, risk factor, Cause-specific	I have accepted the minor changes in the abstract
INTRODUCTION Comment 3. The first two sentences are known by the target audience and are not needed. There is other content in the first paragraph that is much stronger and makes some interesting points. Suggested refinement and re-order of content is shown below.	
Comment 4. The word “disabilities” is spelt incorrectly.	Accepted
Comment 5. The referencing is not in accordance with the authorship guidelines. The number comes after the full stop and should not be in brackets. Check the authorship guidelines and / or look at a recently published paper for guidance.	This have been done in the reference section
Comment 6. The two sentences comparing injury to chronic disease (see below) is interesting, however it was difficult to follow. If the authors wish to include this in the introductory paragraph to the paper, it needs to be more clearly articulated. “Injury remains a very important, but neglected cause of non communicable diseases (NCD) in the world. Although non-communicable diseases were responsible for nearly 60% of deaths globally in 2001 compared with 9% due to injury mortality, the Years of Life Lost (YLL) proportional to injuries is much higher, at 12%, compared with 40% for chronic diseases,(4).”	We have revised this sentence as “Although non-communicable diseases were responsible for nearly 60% of deaths globally in 2001 compared with 9% due to injury mortality, the Years of Life Lost (YLL) proportional to injuries is much higher, at 12%, compared with 40% for chronic diseases, (6)**” in page 3**
Comment 7. What is missing from this introduction is a paragraph on the death reporting and registration process in Tanzania. For instance, is there any medico-legal death investigation process or other formal registration or certification of death required by law. Who and how is the cause of the death determined and how is it recorded? The reader needs to understand this as it has implications for the method. For example, see below for how this process operates in Victoria, Australia: “In Australia, death investigation is administered under a death registration process that involves treating medical practitioners issuing death certificates, supported by a coroner’s system which comes into play in special circumstances of death. The coroner’s investigation is a true medico-legal process led by legally trained practitioners assisted by medically trained practitioners. There are approximately 35,000 deaths in the State of Victoria per year, the majority of which are registered following the issue of a death certificate by the treating medical practitioner. Approximately 4,500 of these are reported to the State Coroner’s Office for investigation. Of these deaths, approximately 1,500 are found, following post-mortem procedures, to result from natural causes. Investigation into these deaths is often limited. In contrast, deaths resulting from external causes often receive more extensive investigation. Such deaths include deaths from unintentional injury (eg motor vehicle	In Tanzania, apart from deaths that occur in the hospitals, only few people report deaths at the births and deaths registry for certification.

collisions, falls, poisonings and drowning), intentional self-harm and interpersonal violence." RE-ORDERED INTRODUCTION Injury mortality is a major global public health problem, accounting for 9% of mortality and 16% of all disabilities annually.3 In low and middle-income countries, injuries are growing in significance because of the demographic and socioeconomic transitions that have characterized their development in recent decades.2 Of an estimated 5.4 million people worldwide who died from injuries in 2005, over 90% occurring in low and middle-income countries.6 In many developing countries, injuries have a significant impact on the health of populations and are rapidly becoming increasingly recognised as a major cause of death and disability. Eight of the 15 leading causes of death for people aged 15 to 29 years were injury-related including both intentional and unintentional deaths.8;9 For every death that results from injury, dozens of hospitalizations, hundreds of emergency department visits and thousands of doctors' appointments occur. It is projected that by 2020, injuries will compete with infectious diseases as a major source of mortality and morbidity in the developing world.7 Modernisation has reportedly been associated with increased mortality from injury. A study in Tanzania reported that as populations grow and become more mobile, a large proportion of adults are at higher risk for injuries than in the past. Similarly, a 2002 survey of 7,035 rural and 8,188 urban households in Tanzania found that 22.5% and 4.3% persons reported injuries respectively. Although the overall incidence was higher in the rural area, the incidence of major injuries (> or = 30 disability days) was similar in both areas.10; 11 Males were mainly affected in a total of 342 burned children in Northwestern Tanzania and children aged two years and under were the majority, accounting for 45.9% of cases.12 The descriptive epidemiology of injury mortality in Africa and other low-income countries is poorly understood. As a result, accurate data on the vital statistics about injury mortality is not well documented.11 To address this gap in knowledge, this study examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania.	We have accepted the re-ordering of the Introduction in pages 1 and 2
METHOD Comment 8. Need to set out the method as follows: Study design and setting; Data source; Variables and definitions; Case identification; Data collection; Data analysis; Ethics.	Suggestion accepted in the current manuscript
Comment 9. Some of the content is included under the incorrect sub-heading. See below for suggested re-ordering of method.	
Comment 10. The word "accident / accidental" should be replaced with unintentional.	
Comment 11. More information is needed to explain the case identification. Who identified the deaths, explain whether the data was extracted as a unit record and what if any data cleaning was needed.	
Comment 12. Also need some information on how the data was collected and prepared for analysis following extraction from the surveillance system.	
Comment 13. When you say "diagnosis" do you mean "cause of death"?	In this manuscript diagnosis was also used to mean cause of death assigned by the physician but we

	have replaced it with 'cause of death'
Comment 14. As stated in comments made on the Introduction, some explanation of how and who determinations cause of death and an explanation of what a verbal autopsy comprises. RE-ORDERED METHOD Study design and setting The research design comprised a cross-sectional study of injury mortality amongst the population of residents in the Demographic Surveillance area of the RHDSS between 2002 and 2007. The study was conducted in the Rufiji Health and Demographic Surveillance System (RHDSS) area, one of the Demographic Surveillance Centres in Tanzania. The INDEPTH Network's monograph on mortality defines a demographic surveillance system (DSS) as a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area. The RHDSS area extends from 7.470 to 8.030 south latitude and 38.620 to 39.170 east longitude. The area is located in the Rufiji district, about 178 kilometres south of Dar es Salaam. The RHDSS operates in 6 contiguous wards and 31 villages (about 60 km long × 30 km wide) and covers an area of 1813 sq km. The total population under demographic surveillance is about 85,000. Females (52%) outnumber males (48%) in the Rufiji DSA. The average household size is about 4-8 persons. According to The United Republic of Tanzania's 2002 Population and Housing Census General Report, the population of Rufiji district was approximately 203,102 (98,398 males and 104,704 females) with an annual growth rate of 2.3%.13 The mean household size for the whole district was approximately five persons.13 The district is largely rural, though the population is clustered around Utete (District headquarters), Ikwiriri, Kibiti and Bungu townships. All the last three townships are within the HDSS area. Islam is the dominant religion, followed by Christianity and then African traditional believers. Kiswahili is the main language spoken by the inhabitants. Data source The Rufiji Health and Demographic Surveillance System's (RDHSS) cause-specific mortality data was the primary data source for this study. The RHDSS prospectively records longitudinal data on household demographics and is updated every four months. The HDSS was established to provide sentinel data through continuous surveillance of households and members within households in cycles with the aim of gathering information on health and demographic data to inform health policy and planning and to evaluate/monitor the impact of health reforms. Variables and definitions Injury mortality was the outcome variable of interest. It included all deaths resulting from injuries, whether unintentional or intentional in the Rufiji surveillance area between 2002 and 2007. The causes of deaths in the DSA had already been determined by the physicians using the verbal autopsy data.14;15. Verbal Autopsy (VA) interviews were performed on all deaths occurring in the study area using a standardized questionnaire to determine the probable cause of death which was based on ICD-10.16; 17 The cause of death was usually based on both remote and immediate factors leading to death. A death outcome was classified as injury death when it occurred due to any one or combination of the following: animal bites; drowning; falls; firearm; fire / burns; road	Re-ordering of the method section accepted in current manuscript

transport crash; homicide; and suicide (poison, hanging). The outcome variable was classified as positive for all injury mortality and negative for individual alive in a particular year. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007. Case identification Injury mortality data from was from the database for the analysis. Data collection Data was extracted from the Rufiji Health and Demographic Surveillance System (HDSS) for the period 2002 to 2007. Data analysis Principal Component Analysis (PCA) was used to construct a socio-economic index for each household.18;19 Households were categorized into high, medium and low socio-economic status based on the average number of household assets owned by the study participants as well as the environmental and household characteristics. Some of the assets included in the construction of the PCA were ownership of goats, cattle, sheep, houses, cars, chicken and televisions. The person years of observation (PYO) was computed for all study participants from the individual member information table and the migration table. This takes into consideration the movements of participants, the event file which records all the event history that have happened to individual members, and the interval file which is the start and end date of the study from which the person time of contribution is generated. Bivariate and multivariate Poisson regression analysis was performed using STATA 10 to assess the association between the risk factors and injury mortality. Chi-squared test for trend was used to examine trends and patterns in injury mortality. All tests for significant associations were based on p-values at 5% significance level. The descriptive statistical analysis comprised an examination of trends and patterns in injury mortality by age, gender, socio-economic status, and the identification of other risk factors associated with injury mortality. The analytic component involved the measurement of the association between age, gender, socio-economic, education, occupation, marital status (for individuals aged 15 years only) and injury mortality. Poisson regression analysis was used because it takes into account each participant's contribution of time throughout the entire study duration. Ethics Anonymity and confidentiality was ensured by replacing any potential personal identification of the study participants with unique reference codes. Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. Ethics clearance was also obtained from the Ifakara Health Institute-Institutional Review Board for the primary study data collection.	
RESULTS Comment 15. Paragraph 1 - Replace "over the six year period" with "over the study period".	Suggestion accepted in good faith
Comment 16. Paragraph 1 - The sentence "The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007" belongs in the method.	This was moved to the method section
Comment 17. Paragraph 1 – Replace "significant number of the study participants" with "over a third".	Suggestion accepted

Comment 18. Paragraph 1 – Replace "belonged to the" with "were classified as".	Done
Comment 19. Paragraph 1 – Last sentence beginning "A total of 4,471 …" belongs in the next section.	Done
Comment 20. Paragraph 1 – Replace the word "versus" with "compared to" and add the word "female" after the (29%).	Done
Comment 21. Table I should be Table 1 and formatted in accordance with the authorship guidelines.	Done
Comment 22. Paragraph 2 – Move the last sentence "Injuries contributed to 4% of the mortality burden" to be the first sentence as that is the subject of interest in this paper.	Done
Comment 23. Paragraph 2 – "other", should it be "other external causes"?	Done
Comment 24. Paragraph 3 – You have already reported a mortality rate of 4% and it does not need to be repeated. Comment 24. Paragraph 3 – I don't think homicide and suicide should be reported together as one figure.	Accepted These are not reported separately
DISCUSSION Comment 25. Paragraph 1 – In the second last sentence you say "… perform the risky jobs like fishing, manual farming and road traffic related injuries". Do you mean driving for the purposes of work? If so, this needs to be clarified.	Yes. I have revised the sentence to read "The high male injury fatality rate in this rural setting might be explained by the gender specific roles where men are more likely to perform the risky jobs like fishing, manual farming and road traffic related activities like driving"
Comment 26. Paragraph 5 – In the second sentence you make reference to the "bad road network", what evidence is there that road infrastructure is poor and a contributory factor to road transport deaths. If this evidence is anecdotal, a description of the characteristics that increase the risk of such crashes would be useful. Later in this paragraph use introduce the term RTA, which I think is the first time you use it. Be consistent throughout that paper in your use of the term.	There was no anecdotal evidence to support this.
Comment 27. Paragraph 6 – In the last sentence you refer to cooking as a possible explanation for the high frequency of burns amongst females. Did you have data on activity undertaken at the time the fatal injury occurred to substantiate this, or are just postulating?	Here we were just postulating since women do most of the cooking in this part of the world
Comment 28. Paragraph 7 – There is some evidence that laws requiring the carriage of safety equipment on water vessels reduces the risk of drowning. To strengthen your conclusion, this body of literature should be referenced. In particular, life jackets are a promising drowning prevention intervention that provides an opportunity for a rescue to occur.	We have included evidence of life jackets as a safety measure of preventing drowning
Comment 29. It would be interesting to have some commentary on suicide as the lowest rate of external cause death in this community. In many Western countries, suicide is commonly the leading cause and readers may be interested in your explanation for this finding.	We have included a commentary on suicide as the lowest rate of external cause death page17 and 18
Comment 30. A section on the strengths and limitations of this study is needed. Of particular interest is any limitations you identified in the classification of cause of death as the assignment of ICD-10 coding can be quite complex, particularly for poisoning.	We now have a section on the strengths and limitations of the study in pages 19 and 20
Comment 31. Figure 1 should be formatted in the same way as Figure 2.	This is done in the current manuscript

Comment 32. Figure 2 - replace "suicidal injuries" with "suicide", replace "accidental" with "unintentional", replace "homicidal injuries" with "homicide" or "assault", does "external causes" mean "other external causes". Replace "percentage" with "percent" on the x axis.	This is done in the current manuscript
Reviewer: 3 Comments to the Author The authors present work on the risk factors that contribute to injury mortality in the southern area of Tanzania. They use surveillance data from 2002 to 2007 to determine the cause of mortality for injuries based on verbal autopsies. Though crude analysis found an association between patient characteristics and mortality, adjusted analysis only showed an association between age, gender, and occupation to mortality. Despite the interesting and much needed work on the topic of injury and mortality in developing countries, there are numerous areas in the manuscript that warrant substantial modification. The authors are encourage to thoroughly review the publishing guidelines for Injury Prevention, such as incorporating word count on the title page, proper formatting of citations within the text, and the use appropriate styles for sections headings (BOLD CAPS, bold lower case, Plain text, Italics). The labeling and format of tables should also be changed as described in the submission guidelines. The authors are also encouraged to thoroughly vet their citations to conform to the Vancouver style. The numbering of the citations is incorrect, the authors are frequently formatted incorrectly, none of the journal titles are italicized, and none of the volume numbers for journals are bolded. With regard to the text itself, abbreviations should be defined at their first use and then applied consistently for the rest of the text. For instance, the Rufiji Health and Demographic Surveillance System is both abbreviated as RHDSS and Rufiji HDSS as well as defined multiple times (both the Introduction and Methodology sections). Some abbreviations are never defined, such as DALY on page 3 line 31 or DSA on line 25 of page 2. There are also numerous grammatical and punctuation errors throughout the manuscript. In short, there are significant formatting issues that require substantial revision and attention to detail.	
Introduction This section begins by describing the global burden of disease caused by injuries. However, the comparison between injury, non-communicable diseases, and chronic diseases is awkwardly phrased and needs revision (lines 14-15, pg 1). Some statements should also have citations for support (lines 30-32 on pg 1 and lines 41-46 on pg 1).	The introduction have been re-organized and some of the statement referenced appropriately
Methodology The description of the Rufiji district as well as the area under surveillance was helpful, but there are some questions regarding the methodology 1) Poisson regression is certainly appropriate for data that approximates a Poisson distribution. Does the mortality data follow a Poisson distribution? 2) Please comment on the appropriateness of Poisson (as opposed to a proportional hazards model for instance) to account for a "participant's contribution of time throughout the entire study population." 3) SES is obviously very difficult to capture and model, and the authors are applauded for utilizing principal component analysis (PCA). It would be helpful, however, to give further detail on its construction, especially since 55% of the subjects were apparently missing SES data. Also, it would be appropriate to report eigenvalues to ascertain how much of the variability was accounted for by each of the factors.	1. Yes the data followed a Poisson distribution. In the regression analysis, we tested this and finally settled on the Poisson model 2. These two methods are good at accounting for individual contribution of time throughout the study period. We chose Poisson for this analysis 3. Since we were just investigating the possible factors that might predict injury deaths, were not really interested in the details of the SES even though we known that missing data in the SES construction was a major weakness in the

Furthermore, were the factors standardized in any way to account for obvious differences between assets (owning a car is presumably much more significant than owning a chicken)? 4) The methodology should include which statistical tests were used to determine statistical difference. Chi-squared? T-test?	study. In the construction of the PCA, the factors were standardized to assign more weight for assts like a car which carries more value compare with bicycles and chicken. 4. We have now included in the methodology the statistical tests that were used in this study
Results 1) Because the investigation focuses on trauma mortality, Figure 1 might be better incorporated as a supplemental figure and not part of the full manuscript. 2) Please include the units for "Rate" in Table 2. 3) Interpretive comments regarding data, such as line 34 on page 9, should be addressed in the discussion and not the results section. 4) It appears that 104 of 198 of the deaths had SES data (per Table I). Please comment on the appropriateness of PCA based on SES if nearly half of the population with the primary outcome (mortality) was missing SES data. 5) Because the number of individuals in Low SES is substantially higher than those found in the SES, comparing deaths across SES should be reported as a percentage or rate. Furthermore the corresponding results section (lines 48-55 on page 11) should provide quantitative and qualitative data. 6) Would it be more appropriate to use ages 15-34 as your baseline reference group for the bivariate analysis? Please comment. 7) Given the low statistical significance of marital status in the multivariate model, is there a compelling reason for its conclusion? 8) In the text for the bivariate discussion, please report either p values or 95% confidence intervals but not both. 9) It is statistically impossible for a p-value to equal 0.000. Please report as <0.001 if that is the case. 10) As stated in the submission guidelines, tables "…should not duplicate information in the text of the paper." Please modify the text for the bivariate and multivariate analysis accordingly (ie shorten and mention only highly relevant data points/trends).	1. Suggestion accepted in good faith 2. These are incidence risk ratios 3. This comment have been moved to the discussion section **4.** This was a weakness of the study but we were just investigating possible risk factors for injury fatalities 5. This suggestion has been acted on and the results reported accordingly 6. We tried using all the age group as reference age but finally settled on the 1-14 years age group. We can reverse this if so necessary. 7. Not at al 8. This is noted and acted upon. Only the CI have now been reported 9. Well noted and acted upon 10. This has been revised accordingly
Discussion 1) The analysis of mortality across years might not fit within the stated scope of the project, which was to assess the risk factors associated with injury mortality. Furthermore, it appears that there is no statistical difference across years (based on the error bars in the figures since no confidence intervals were given). If the authors wish to do a trend analysis, this needs to be explicitly stated and addressed in the introduction and methods section. An alternative would be to a trend analysis project in and of itself provided the data had compelling results. 2) The authors suggest that the high adjusted mortality rate for males in the study may be due to their occupation, yet the study controls for occupation suggesting that gender is an independent predictor of mortality. Please comment/explain. 3) No quantitative data is provided on the mechanism of injury (burns, RTAs) and gender. Please provide. The same applies to mechanism by age. 4) Please comment on the fidelity of the dataset. Is there any sense or metric that would demonstrate how accurate data capture is within the RDHSS? Are there deaths not captured in the RDHSS? Is it possible for people within the surveillance area to not be captured within the RDHSS? 5) Two of the three factors (age and gender) associated with injury mortality are frequently found in other disease processes and are largely thought to be non-modifiable. Please comment on the policy implications if any. 6) Please include a discussion of any weaknesses of the study within the discussion section	1. The trend analysis was just an additional finding that was interesting in this study. However, the trend observed was not statistically significant across the years. 2. The sentence has been rephrased to the effect that gender was an independent risk factor for injury mortality. 3. We do not have data on the mechanism of injury 4. We have now included a section about the HDSS and all these have been discussed under the strengths and weakness section. The HDSS have been validated and reported to capture above 96% of all the information that they set out to collect. 5. This is true but I personally think we still need to do something as preventive measure 6. this has been included
Figures 1) Abbreviations in the figures should be defined within figure legends (ie Figure 3 should define what CDR is an abbreviation for) 2) The formatting of the figures needs polishing. The authors are encouraged to look	1. This is now defined as crude death rate 2. Suggestion accepted

at the current issue of Injury Prevention and emulate the formatting for figures seen there. 3) The error bars for Figure 3 appear to be the same for each year. Is that correct? What exactly are the error bars are referring to? 95% confidence intervals? This should be clearly labeled in the figure text. The same issue pertains to Figure 4. 4) It is not clear that a year-by-year display (Figure 3-5) is pertinent to the stated goals of the investigation. These (and their corresponding text) are probably left excluded or at best included in a the online supplemental section. 5) Figure 6 should include 95% confidence intervals or some way of determine statistical difference between Low, Medium, and High SES groups. For instance, was the difference between RTA (which needs to be defined in figure text) for High and Low SES statistically different?	3. We wanted to see whether these error bars will not overlap to show an indication of statistical significance across the various years but they tend to overlap meaning the deaths were not different in the various years. 4. We have deleted these figures 5. We have also deleted this figure since it has no direct study aim implication
Reviewer: 4 Comments to the Author This paper describes trends in injury mortality from morality surveillance system for the studied population. More data on cause-specific injury mortality would be useful addition. Considerable repetition of the findings in text could be avoided. Detailed comments follow.	
Introduction 1. Page 3, paragraph 1 – Please shorten this paragraph considerably as these generic details regarding injuries are well established/known. 2. Page 3, paragraph 2 – Please provide Africa-specific data in this paragraph as context for the readers. 3. Page 4 – Please provide reference for the demographic surveillance system area.	1. The paragraph has been rephrased in page 2 2. This is also done in page 2 and 3 **3.** Reference has been provided
Methodology 4. Page 5, lines 3-12 – Description of Rufiji district can be shortened.	4. We have shorten the description of the Rufiji area
Results 5. General comment – There is a significant repetition in text of the results presented in tables and figures. Please summarize/highlight the findings from tables and results and not describe everything presented in the tables/figures. 6. Data on household socioeconomic status (SES) was missing for 55% of the population. This variable should not be included for analysis as inference based on such data can be erroneous. 7. Data on occupation are also missing for 20% of the population. Since occupation was found to be significantly associated with injury mortality in this paper, please present data showing for whom the occupation is missing, and if that can have any impact on the results. 8. Figures 3 and 4 - Possible reasons (including methodology, implementation or intervention) should be highlighted for the drop in injury mortality between 2005 and 2007. Is the decreasing trend continuing? 9. Page 11, lines 21-24 – Perhaps, a figure showing details of cause-specific mortality by gender would be useful. 10. Figure 5 – Crude death rates by age groups do not add much to the analysis as the higher burden of mortality in older age group is clearly documented in Tables 2	5. We have removed the paragraphs and sentences that were deemed repetitive 6. This is true but we discussed this in the limitation section 7. We 8. We need data for 2008 and 2009 to assess whether the decrease is continuing but which were not readily available. 9. We initially included this but were advised to delete it but if it is so crucial we can easily include it again. 10. We have deleted this figure

and 3. Please delete. 11. Cause-specific mortality by age group would be very useful, in particular because 65+ age group had the highest injury mortality from 2002 to 2007. 12. Figure 6 should be deleted (please see point 6 above). 13. Trend over years can be presented for cause-specific injury mortality. This can help with planning of interventions based on increase/decrease over time for certain causes. Discussion	11. We have described it briefly in the text but in a figure presentation 12. We have deleted figure 6 13. We did this but the number of figures was more than the required number specified by the journal. We excluded it.
14. General comments a. At various places, data from this study are referred to (or presented) in this section but these are not presented in results. For example – cause-specific injury mortality by age and gender. The need for such data to be presented is suggested in a few of the points above in this review. b. This section is mainly repetition of results with comparison with other reported data. Intervention needs in this population are referred to (page 16) but data are not presented in a manner that can fully justify these intervention needs.	14. A. We agreed fully with this view B. We have eliminated all the text that were repetitive in this manuscript and the results adequately presented and discussed
15. Possible limitations of verbal autopsy data should be mentioned. Within the social context of the studied population, are there reasons for some causes to be under-reported, in particular the intentional injuries?	15. the limitation of the verbal autopsy data have been discussed in the discussion section
Reviewer: 5 Comments to the Author The study sought to generate population-based data on risk factors for injury deaths in the study area, based on data extracted from Rufiji DSS in Tanzania. The study has the potential of generating data on specific risk factors for injury deaths in the area, and adding to existing knowledge on the subject.	
Specific comments: 1. Abstract - The stated aim is different from the aim indicated in Introduction (p.4 line 1-3) – to investigate the burden of injuries, determine gender-age-specific trends …see last paragraph on p.4. - Injury mortality rate should be correctly reported per 100,000 population, and not PYO (per years of observation). - Key results on specific risk factors identified should be included.	We have reconciled the differences in the aims stated in both the abstract and the introduction as examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania. Injury rates have now been consistently reported in 100,000 population and key results included in the abstract
2. Introduction - This section needs to emphasize the need for this study and the gaps in existing literature on injury mortality in Tanzania that need further investigation. Most of the information presented refer to global injury burden and not risk factors. Note that the cited injury mortality rate is correctly indicated as per 100,000 population, and not PYO. - As observed above, the stated aim of the study here is much broader and includes measuring injury burden – not captured in the title of the study. All the sentences from line 3 to the end (line 12) should be deleted or moved to appropriate section in the Methodology.	The introduction have now been restructured (see page 2 and 3) and more literature on the risk factors have been added The stated aim have been be revised to reflect what is captured in the title

3. Methodology - If the cause-specific mortality data were extracted from the DSS database, then what was the purpose of verbal autopsy? Who were the respondents for VA ? Who conducted the interviews and what questions were asked? - The use of ICD-10 codes should be more clearly described, including the exact categories of codes assigned to each injury death. - It is not clear why the investigators chose to examine socio-economic status of households as a risk factor of injuries and not other documented risk factors (place, activity, etc) - Computation of person-years of observation is inappropriate, since the 'cohort' population was not observed for exposure to specific risk factors for injury mortality. --Analysis of annual injury deaths would be a better approach to showing trends. - The relevant variables for measuring injury burden should be clearly described. - The rationale for using Poisson, Bivariate and Multivariate analysis techniques should be explained here, including selection of variables for the different analysis.	It is true that the cause-specific mortality data was extracted from the DSS database, but then we needed to let eh reader know the cause of death came about. We have just now mentioned it as a process leading to the classification of the cause of death. We were exploring possible risk factors associated with injury mortality and as we know socio-economic status of an individual may lead h/her to engage in some activities of a sort that might result in injuries. We have now added detailed information on the method section
4. Results - The key results for injury mortality burden, trends, risk factors, etc need to be systematically presented. As already noted, injury mortality rates should be computed per 100,000 population – the use mid-year population to calculate the annual rate is recommended, in order to allow for appropriate cross-comparisons with the rates in published literature. - It would be useful to present the cause-specific injury mortality data by the ICD-10 categories –see Methodology (p.6, line 21). Example: ICD-10: V89, Y85.0 - unspecified road injury; ICD-10: X59 – unspecified unintentional injury, etc. - Analysis of injury mortality distribution by residence (urban vs rural), place of occurrence (road, school, home, farm, etc), month, time of the day, etc would be more informative in identifying risk factors than socio-economic status. - Most of the narrative text on p.13 repeats data already presented in Tables II & III. From the MLR analysis, it would be more informative to state the most important exposure factor(s) associated with injury mortality.	Only the key findings have now been presented and the results reported in per 100,000 persons. Because this was a secondary analysis from the HDSS, some of the information was not available for analysis eg. Where accident occurred? road, school, home, farm, etc), month, time of the day etc. Only the salient findings were mentioned under each table
5. Discussion - The discussion can be improved by focusing on the key results for each study aim (burden of injury mortality, trends, risk factors) - Efforts should be made to cite only relevant studies with a similar design to the current study (a retrospective cohort using DSS database). - What is the new take home message from this study?	The discussion have been reorganized under various heading and detailed discussion made on them in juxtaposition with other related studies

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Risk factors for injury mortality in rural Tanzania: a secondary data analysis

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Abstract

Background: Injuries rank high among the leading causes of death and disability annually, injuring over 50 million and killing over 5 million people globally. Approximately 90% of these deaths occur in developing countries. **Objectives:** To estimate and identify the risk factors for injury mortality in the Rufiji Health and Demographic Surveillance System (RHDSS) in Tanzania. **Methods**: Secondary data from the Rufiji Health and Demographic Surveillance System covering the period 2002 and 2007 was examined. Verbal Autopsy data was used to determine the causes of death based on the 10th revision of the International Classification of Diseases (ICD10). Trend and Poisson regression tests were used to investigate the associations between risk factors and injury mortality. **Results:** The overall crude injury mortality rate was 33.4 per 100,000 population. Injuries accounted for 4% of total deaths. Males were 3 times more likely to die from injuries compared with females [Adjusted IRR=3.04, P=0.001, 95% CI (2.22-4.17)]. The elderly (defined as 65^{+}) were 2.8 times more likely to die from injuries compared with children under 15 years of age [Adjusted IRR=2.83, P=0.048, 95% CI (1.01-7.93)]. The highest frequency of deaths resulted from road traffic crashes. **Conclusion:** Injury is becoming an important cause of mortality in the Rufiji district. Injury mortality varied by age and gender in this area. Most injuries are preventable, policy makers need to institute measures to address the issue.

Key words: Injury, mortality, risk factor, Cause-specific, Tanzania

Introduction

Injuries have traditionally been regarded as 'unavoidable' accidents. In recent decades however, there is a shift in perspective and injuries are being recognized as preventable events, (1).

Injury mortality is a major global public health problem, accounting for 9% of mortality and 16% of all disabilities annually, (2). The global rate of unintentional injuries was 61 per 100,000 populations per year and road traffic injuries made up the largest proportion of unintentional injury deaths (33%). When standardized per 100,000 population, the death rate was almost double in Low and Middle Income Countries (LMIC) compared with high-income countries (65 versus 35 per 100,000), and the rate of disability-adjusted life-years is more than triple in LMIC (2,398 versus 774 per 100,000), (3).

In LMIC, injuries are growing in significance because of the demographic and socioeconomic transitions that have characterized their development in recent decades, (4). Of an estimated 5.4 million people worldwide who died from injuries in 2005, over 90% occurring in low and middle-income countries, (5).

Although non-communicable diseases were responsible for nearly 60% of deaths globally in 2001 compared with 9% due to injury mortality, the Years of Life Lost (YLL) proportional to injuries is much higher, at 12%, compared with 40% for chronic diseases, (6). According to the Global Burden of Disease 2000 data, over 5 million people (83.7 per 100,000 population) died worldwide from injuries in 2000, (7).

In many developing countries, injuries have a significant impact on the health of populations and are rapidly becoming increasingly recognized as a major cause of death and disability. Eight of the 15 leading causes of death for people aged 15 to 29 years were injury-related including both intentional and unintentional deaths, (8-9). For every death that results from injury, dozens of hospitalizations, hundreds of emergency department visits and thousands of doctors' appointments occur. It is projected that by 2020, injuries will compete with infectious diseases as a major source of mortality and morbidity in the developing world, (10).

Modernization has reportedly been associated with increased mortality from injury. A study in Tanzania reported that as populations grow and become more mobile, a large proportion of

adults are at higher risk for injuries than in the past. Similarly, a 2002 survey of 7,035 rural and 8,188 urban households in Tanzania found that 22.5% and 4.3% persons reported injuries respectively. Although the overall incidence was higher in the rural area, the incidence of major injuries (> or = 30 disability days) was similar in both areas, (11-12). Males were mainly affected in a total of 342 burned children in Northwestern Tanzania and children aged two years and under were the majority, accounting for 45.9% of cases, (13).

The descriptive epidemiology of injury mortality in Africa and other low-income countries is poorly understood. As a result, accurate data on the vital statistics about injury mortality is not well documented, (12).

To add to knowledge on injury mortality in the Africa, this study examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania.

Methodology

Study design and setting

The research design comprised a cross-sectional study of injury mortality amongst the population of residents in the Demographic Surveillance area of the RHDSS between 2002 and 2007.

The study was conducted in the Rufiji Health and Demographic Surveillance System (RHDSS) area, one of the Demographic Surveillance Centres in Tanzania. The INDEPTH Network's monograph on mortality defines a demographic surveillance system (DSS) as a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area.

The RHDSS area extends from 7.470 to 8.030 south latitude and 38.620 to 39.170 east longitude. The area is located in the Rufiji district, about 178 kilometres south of Dar es Salaam. The RHDSS operates in 6 contiguous wards and 31 villages (about 60 km long × 30 km wide) and covers an area of 1813 sq km. The total population under demographic surveillance is about 85,000. Females (52%) outnumber males (48%) in the Rufiji Demographic Surveillance Area (DSA). The average household size is about 4-8 persons.

According to The United Republic of Tanzania's 2002 Population and Housing Census General Report, the population of Rufiji district was approximately 203,102 (98,398 males and 104,704 females) with an annual growth rate of 2.3%. The mean household size for the whole district was approximately five persons, (14). The district is largely rural, though the population is clustered around Utete (District headquarters), Ikwiriri, Kibiti and Bungu townships. All the last three townships are within the Health and Demographic Surveillance System (HDSS) area. Islam is the dominant religion, followed by Christianity and then African traditional believers. Kiswahili is the main language spoken by the inhabitants.

Data source

The RDHSS cause-specific mortality data was the primary data source for this study. The RHDSS prospectively records longitudinal data on household demographics and is updated

every four months. The variables contained in the RHDSS injury mortality database includes basic demographic information such as date of birth, personal identification number, gender, occupation, marital status, socoi-economic status, migration, injury specific cause of death, date of death, place of death and year of death.

The HDSS was established to provide sentinel data through continuous surveillance of households and members within households in cycles with the aim of gathering information on health and demographic data to inform health policy and planning and to evaluate/monitor the impact of health reforms.

Variables and definitions

Injury mortality was the outcome variable of interest. It included all deaths resulting from injuries, whether unintentional or intentional in the Rufiji surveillance area between 2002 and 2007. The causes of deaths in the DSA had already been determined by the physicians using the verbal autopsy data, in line with the International Classification of Diseases ICD-10, (15-16). Using the verbal autopsy data to diagnose cause of death have been validated, (17-18). The cause of death was usually based on both remote and immediate factors leading to death.

A death outcome was classified as injury death when it occurred due to any one or combination of the following: animal bites; drowning; falls; firearm; fire / burns; road transport crash; homicide; and suicide (poison, hanging). The outcome variable was classified as positive for all injury-related deaths and negative for individual alive in a particular year. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Case identification

Injury mortality data from the RHDSS database was used for the analysis.

Data collection

Data was extracted from the RHDSS for the period 2002 to 2007.

Data analysis

Principal Component Analysis (PCA) was used to construct a socio-economic index for each household, (19-20). Households were categorized into high, medium and low socio-economic status based on the average number of household assets owned by the study participants as well as the environmental and household characteristics. Some of the assets included in the construction of the PCA were ownership of goats, cattle, sheep, houses, cars, chicken and televisions. The person years of observation (PYO) was computed for all study participants from the individual member information table and the migration table. This takes into consideration the movements of participants, the event file which records all the event history that have happened to individual members, and the interval file which is the start and end date of the study from which the person time of contribution is generated. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Univariate and multivariate Poisson regression analysis was performed using STATA 10 to assess the association between the risk factors and injury mortality. Not every study participant was observed for the same length of time and Poisson regression model allows for this through something called an offset whereby every individual contribution of time is account for in the analysis.

Chi-squared test for trend was used to examine trends and patterns in injury mortality. All tests for significant associations were based on p-values at 5% significance level.

The descriptive statistical analysis comprised an examination of trends and patterns in injury mortality by age, gender, socio-economic status, and the identification of other risk factors associated with injury mortality. The analytic component involved the measurement of the association between age, gender, socio-economic, education, occupation, marital status (for individuals aged 15 years only) and injury mortality. Poisson regression analysis was used because it takes into account each participant's contribution of time throughout the entire study duration.

Ethics

Anonymity and confidentiality was ensured by replacing any potential personal identification of the study participants with unique reference codes. Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. Ethics

clearance was also obtained from the Ifakara Health Institute-Institutional Review Board for the primary study data collection.

Results

Description of the study population

Table I presents the socio-demographic characteristics of the study population. There were 119,271 residents contributing 592,324.03 PYO over the study period. There were slightly more females (52.9%) compared with males (47.1%). Children younger than 15 years of age constituted the largest group 50,515 (42.4%). Half of the study population [60,588 (50.8%)] had no formal education and over a third of the study participants (37.3%) were farmers. Household wealth profile using principal component analysis revealed that 18,971 (35.5%) were classified as low socio-economic status. In terms of conjugal status, 20,675 (18.6%) participants were not married while 40,554 (36.5%) ever married.

A total of 4,471 deaths were recorded over the study period, of which 198 were classified as injury deaths. Majority of the injury deaths were males 140 (71%) verse 58 (29%). Most of the injury deaths were unintentional (90%).

The overall injury mortality rate was 33.4 per 100,000 population. Injury mortality rate (49.7) was more than double in males (95% CI 42.1 - 58.6) compared to females, 18.7 (95% CI 14.4 – 24.2) p=0.001. The elderly (defined as any resident >65 years of age) experienced the highest injury mortality 128.7 (95% CI 98.9 – 167.7). Most important exposure variable(s) were associated with injury mortality. It is of interest to note that tertiary education level participants constituted a small proportion of the population (n=757, number of deaths=3) compared with the other categories.

The injury deaths among retired workers was also higher (273 per 100,000 PYO), compared with casual workers (62 per 100,000 PYO), the unemployed (56 per 100,000 person years), and farmers (41 per 100,000 population). There was no evidence of a difference in injury mortality by SES though the individuals in the lowest SES category had the highest rates compared with the other groups. Those who ever married had mortality rate of 57 per 100,000 population, compared with 29 per 100,000 population among those who never married.

Table 1: Descriptive statistics of the study population by study variables

Exposure factor	Frequency	Percent	Person Time	Dead	Rate	95% Confidence Interval
Gender						
Female	63,042	52.9	310,556.33	58	18.7	14.4 - 24.2
Male	56,229	47.1	281,767.7	140	49.7	42.1 - 58.6
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Age Group						
1-14	50,515	42.4	254,938.5	40	15.7	11.5 - 21.4
15-34	41,195	34.5	192,014.21	55	28.6	22.0 - 37.3
35-64	19,480	16.3	102,645.01	48	46.8	35.2 - 62.1
65^{+}	8,081	6.8	42,726.31	55	128.7	98.8 - 167.7
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Education						
Primary	53,024	44.5	270,807.1	73	27.0	21.4 - 33.9
No-formal	60,588	50.8	293,677.2	118	40.2	33.6 - 48.1
Secondary	4,878	4.1	24,250.0	4	16.5	6.2 - 44.0
Tertiary	757	0.6	3,516.5	3	85.3	27.5 - 264.5
Total	**119,247**		**592250.83**	**198**	**33.4**	**29.08 - 38.4**
Occupation						
Student	4,026	4.2	151,544.4	12	8.0	4.5 - 13.9
Unemployed	27,435	28.9	17,878.2	10	55.9	30.1 - 104.0
Retired	4,399	4.6	12098.2	33	272.8	193.9 - 383.7
Casual	17,377	18.3	74459.5	46	61.8	46.3 - 82.5
Farming	35,505	37.3	181796.8	74	40.7	32.4 - 51.1
other	6,333	6.7	128472.2	23	17.9	11.9 – 26.9
Total	**95,076**		**566249.2**	**198**	**35.0**	**30.4 - 40.2**
Household SES						
High	15,989	30.0	78,611.6	23	29.3	19.4 - 44.0
Medium	18,418	34.5	91,127.64	38	41.7	30.3 - 57.3
Low	18,971	35.5	93,664.9	43	45.9	34.1 - 61.9
Total	**53,378**		**263,404.14**	**104**	**39.5**	**32.58 - 47.9**
Marital status						
Single (>15 years)	20,675	18.6	102,676.6	30	29.2	20.43 - 41.8
Ever Married	40,554	36.5	218,805.1	125	57.1	47.9 - 68.1
Single (<15 years)	49,950	44.9	261,6721.0	43	16.4	12.2 - 22.2
Total	**111,179**		**583,153.6**	**198**	**33.4**	**29.1 - 38.4**

Overview of mortality proportions in Rufiji DSA from 2002-2007

Figure 1 shows the distribution of causes of deaths during the study period. Injuries accounted for 4% of total deaths. The overall mortality was 754.8 per 100,000 PYO; Malaria (24%) and cardiovascular diseases (23%) contribution was similar and accounted for almost half of the total deaths. The other external cause category (15%) included maternal deaths, specified and unspecified communicable diseases, specified and unspecified acute febrile illnesses, diarrhoeal diseases, meningitis, hepatitis, specified and unspecified acute respiratory infections, tetanus and

measles. Acquired Immune Deficiency Syndrome and Pulmonary Tuberculosis (14%) was fourth largest contributor of burden of mortality.

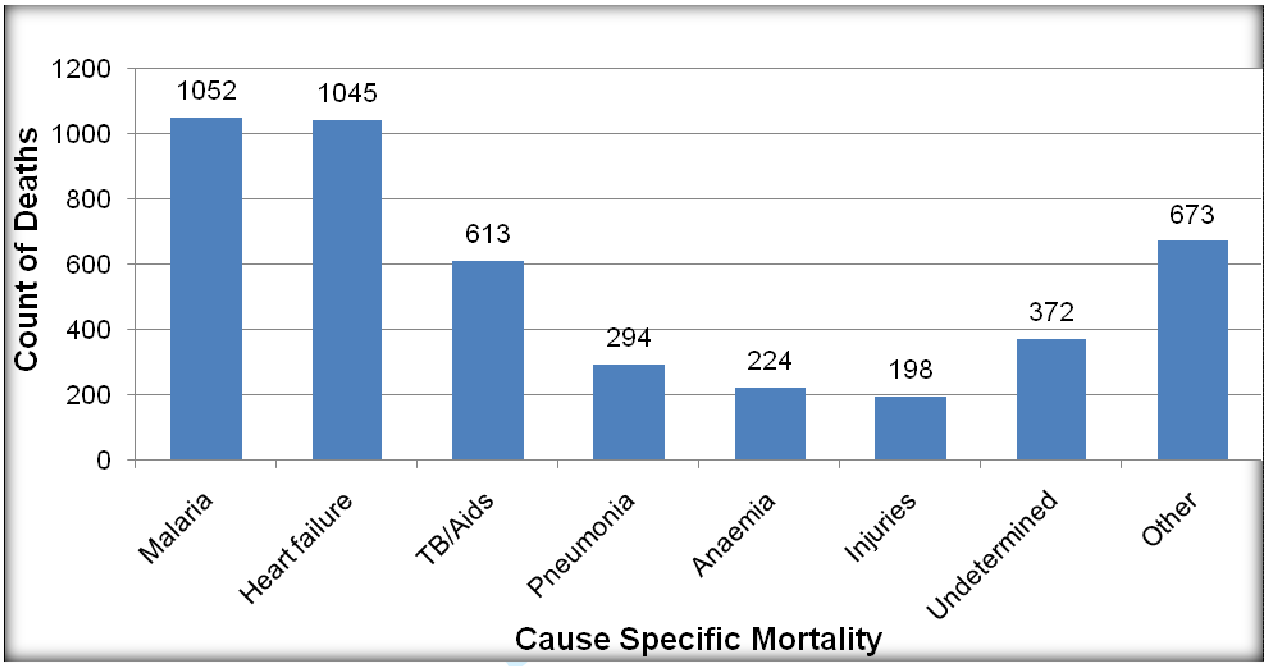

Figure 1: Major Causes of Mortality in RHDSS from 2002-2007

The distribution of cause-specific injury mortality in the Rufiji DSA

The types of injury mortality recorded in the study area during the period of analysis included road traffic accident, drowning, burns, homicidal injuries, accidental poisoning, animal bite/attack, falls, suicidal injuries and unspecified external injuries (deaths due to complications of medical and surgical care or being hit by external objects like trees and heavy loads). More than one quarter of the injury deaths were due to road traffic accidents 56 (28%), unspecified external injuries accounted for 40 (20%), drowning 32 (16%) and burns 18 (9%). The lowest injury deaths were attributed to suicide 4 (2%) or broadly referred here as intentional injuries.

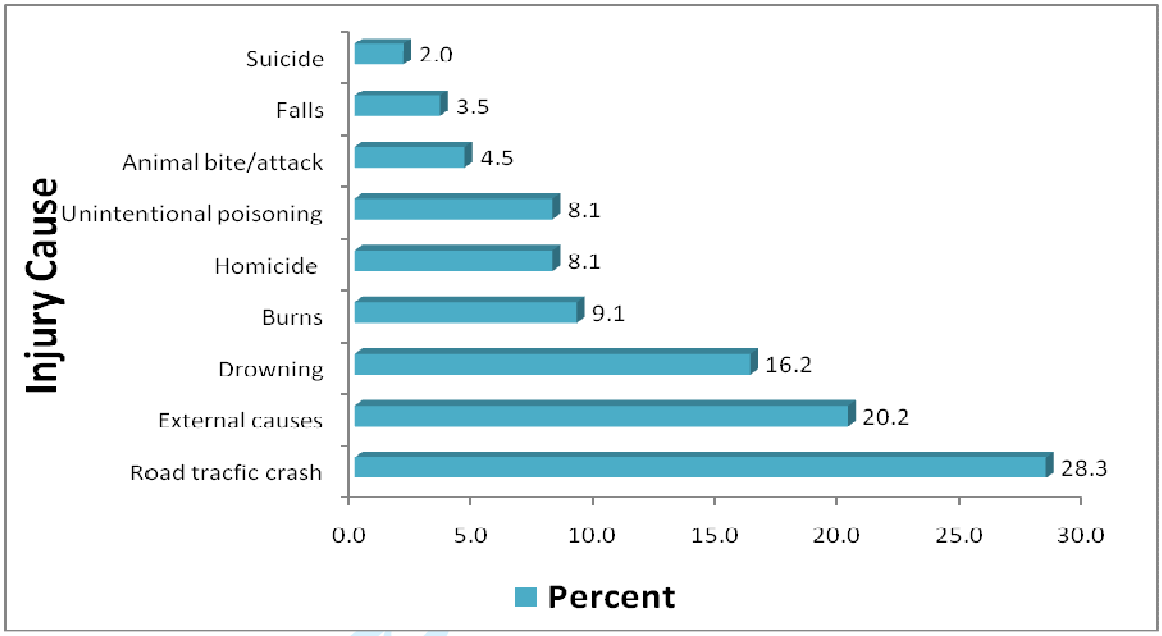

Figure 2: Distribution of Injury Cause-Specific Mortality in RHDSS

Estimating the yearly crude death rates (CDR) of injury from 2002-2007

There was a consistent yearly increase in the injury crude death rate (CDR) from 2002 to 2005. However, a slight decline was observed between 2005 and 2007 but we found no evidence of this drop in injury mortality. The Chi-Square for trends test showed no significant difference in proportions of injury deaths among the different years (P=0.288).

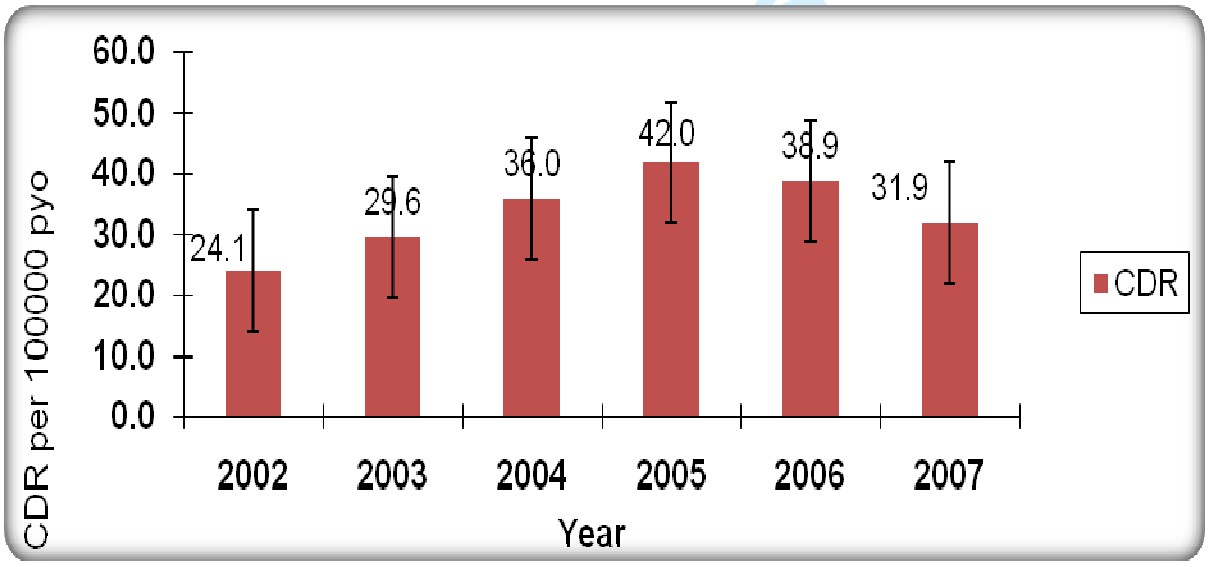

Figure 3: Trend of Injury Mortality from 2002-2007

Gender and Injury Mortality from 2002-2007

Injury mortality in males was significantly higher compared with females during the period. Injury mortality increased both in males and females from 2002-2005 and then dropped. Males were 2 to 4 times more likely to die of injuries compared with females. Males were more likely to die from RTAs, External causes and drowning compared to females. On the other hand females were more likely to die of burns and animal attacks.

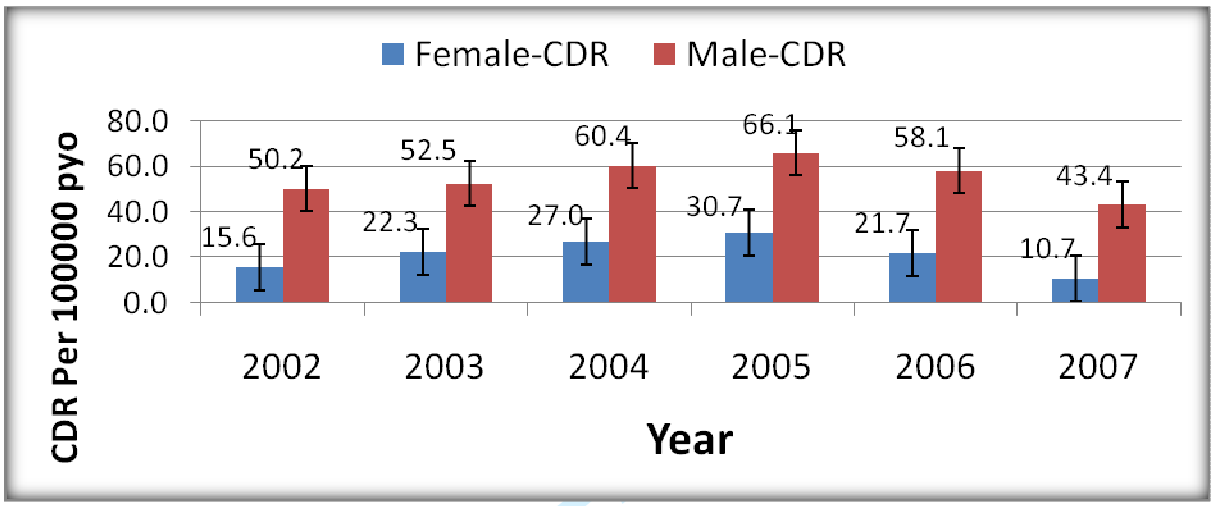

Figure 4: Trend of Injury Mortality by Gender from 2002-2007

Cause-Specific Injury Mortality by gender

Males were more likely to die in road traffic crashes, other external causes and drowning compared with females. On the other hand females were more likely to die of burns and animal attacks.

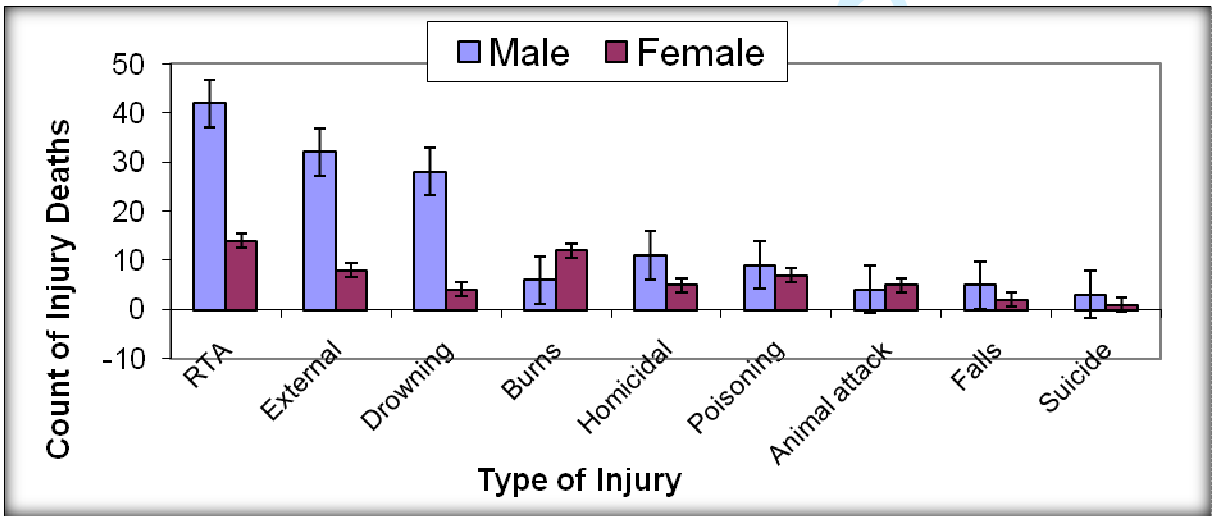

Figure 5: Cause-Specific Injury by Gender

Inferential Analysis

Univariate Poisson regression analysis of risk factors for injury mortality

Univariate and Multivariate Poisson regression analysis were carried out to demonstrate the associations between risks factors (gender, age, occupation, education, marital status, socio-economic status) and injury mortality. Incidence Risk Ratios (IRR) were used to measure the strength of the relationships and interpreted as Relative Risk. The results are presented in Table 2.

Table 2: Univariate and Multivariate Poisson regression analysis of injury mortality

Factor	Univariate Model (95% CI)			Multivariate Model (95% CI)		
	IRR	CI	P-Value	IRR	CI	P-Value
Gender						
Female	**1***			**1***		
Male	2.66	1.96 - 3.61	**<0.001**	3.04	2.22 - 4.17	**<0.001**
Age Groups						
1-14	**1***			**1***		
15-34	1.83	1.22 - 2.74	**0.004**	0.98	0.38 - 2.52	0.972
35-64	2.98	1.96 - 4.53	**<0.001**	1.34	0.48 - 3.75	0.582
65^{+}	8.20	5.46 - 12.33	**<0.001**	2.83	1.01 - 7.93	**0.048**
Occupation						
Student	**1***			**1***		
Farming	5.14	3.05 - 16.35	**<0.001**	4.13	1.81 - 9.42	**<0.001**
Casual	7.80	4.13 - 14.73	**<0.001**	7.36	3.25 - 16.66	**<0.001**
Unemployed	7.06	2.79 - 9.46	**<0.001**	8.57	3.26 - 22.48	**<0.001**
Retired	34.45	17.79 - 66.70	**<0.001**	28.26	12.53 - 63.71	**<0.001**
Marital status						
Single (>15 years)	**1***			**1***		
Ever Married	1.96	1.31 - 2.91	**<0.001**	1.08	0.64 - 1.83	0.776
Children (<15 years)	0.56	0.35 - 0.90	**0.016**	1.45	0.59 - 3.57	0.423
Education						
Primary	**1***			**1***		
No-formal	1.49	1.11 - 2.00	**0.007**	1.25	0.87 - 1.79	0.230
Secondary	0.61	0.22 - 1.67	0.339	0.59	0.21 - 1.62	0.306
Tertiary	3.16	1.00 - 10.04	**0.050**	1.19	0.37 - 3.86	0.769
Household SES						
High	**1***					
Medium	1.43	0.85 - 2.39	0.180			
Low	1.58	0.95 - 2.60	0.081			

1*=*Reference group*

In the univariate logistic regression analysis model, age, education, gender, marital status and occupation were all significant risk factors for injury mortality (Table 2).

In the multivariable logistic regression analysis model however, three variables were significant risk factors associated with injury mortality having adjusted for the variables in the univariate model. These are gender, age and occupation.

Adjusted for age, occupation, education and marital status, males (IRR=3.04; 95% CI: 2.22-4.17), the elderly (IRR=2.83; 95% CI: 1.01-9.93) and being unemployed (IRR=8.57; 95% CI: 3.26-22.48) were all found to be significant risk factors for injury mortality (Table 2).

Discussion

Proportion of injury mortality

This study presented a population-based data on the proportion of injury-related deaths, the cause specific injuries as well as the risk factors for injury mortality from a predominantly rural area in Tanzania from 2002 to 2007.

Injuries remain a threat to human existence globally, especially in developing countries. Injury mortality accounted for 4% of total deaths during the study period. A study in South Africa reported that 8.9% of deaths were injury-related and homicide, road traffic crashes and suicide were the major causes of injury mortality. The study analyzed data on 133483 individuals with 717584.6 person-years of observation resulted in 11467 deaths, (21).

Risk factors for Injury mortality

The findings in this study are consistent with those found in other studies; generally males were more likely to experience injury mortality compared with females. Globally, injury mortality among males is twice of that among females and males in Africa and Europe have the highest injury-related mortality rates, (1). In South Africa, the male-female injury mortality ratio in 2008 was 3.3:1, (22). It also reflects the results from a study conducted by Moshiro et al.(2001) in Dar es Salaam, Hai, and Morogoro districts in Tanzania that documented injury mortality rates being approximately three times higher among men compared to women, (11, 23-24). The high male injury fatality rate in this rural setting might be explained by the gender specific roles where men are more likely to perform the risky jobs like fishing, manual farming and road traffic related activities like driving.

Age was also associated with injury mortality. The elderly were strongly associated with higher injury mortality rates compared with the younger age groups. This finding is similar to what was reported by Lopez et al. (2006) which attributed one-quarter of injuries deaths to those aged between 15 years and 59 years, (6). The assertion that injury mortality rates increased with age is similar to the findings by Moniruzzaman et al. (2008) which reported that in low and middle

income countries, there is a direct relationship between age and injury mortality such that as age increases, the risk for injury mortality increases, (25).

In this study, those who were in active employment had lower risk of injury mortality. This compares with the study by Garrib et al which found that full-time employment was significantly associated with lower mortality in South Africa, (21).

A couple of studies have demonstrated that increasing SES has a strong inverse association with the risk of fatal injuries; more than 80% of childhood burns have been reported to occur among low socio-economic groups, (26-29). This study did not find sufficient evidence to suggest that household wealth was a key risk factor for injury mortality. This could be attributed to the fact that socio-economic status information was not available for half of the households who were included in this analysis. Furthermore, Rufiji DSA is typically rural and almost homogeneous in terms of wealth index; there is very little variation in items possession, hence, no significant difference in SES between the high and low groups.

Types of injuries

Among the two broad types of injuries, 90% were unintentional The high unintentional injury deaths has been reported in studies in other parts of Tanzania, (11). The role of road traffic accident as the leading cause of injury mortality in this study is consistent with other injury deaths in other African Countries including Kenya and Ghana, (11, 30-31). Mortality rates because of road traffic crashes were again significantly higher in men than women in all age groups, for both pedestrians and vehicle occupant, (21).

Many other factors are known to be associated with risk of injury mortality. These include poverty, lack of education, unemployment, alcohol and substance abuse, interpersonal conflict, intimacy and power, (32-33).

Injuries related to burns from this analysis indicated that females were more likely to die compared with males. Other studies in Africa reported that males were more likely to die of burn fatalities and that young children and the elderly are the most vulnerable, (1, 29, 34-35). One possible explanation for the difference in findings may be due to the settings. Whereas those

studies were conducted in urban settlements, this study was conducted in a typically rural setting where cooking is seen as the birthright responsibility of females.

Drowning was among the main causes of injury mortality in this study. Studies have shown that Africa had the highest drowning mortality rate (13.1 per 100,000 PYO) and males had higher drowning mortality rates than females for all ages and in all regions and was more pronounced in children up to fourteen years, (7). In this study however, most of the drowning fatalities occurred in young (15-34) and middle-aged (35-54) adults. In the Rufiji Demographic Surveillance Area, most of the people are engaged in subsistence farming and fishing activities with the proximity of the Rufiji River as a possible influencing factor. For example most of the time males are the fishermen who at times engage in fishing without life jackets. There are no enforced laws on fishing. Fishing activities need to be regulated to save lives. In some developed countries however, there are laws regulating recreational swimmers and fishermen which proves a safety measure against drowning, (36-37).

We documented more male deaths from unintentional poisoning compared with females, reflecting those reported in other studies which indicate that the highest poisoning mortality rates were among the male populations in the low and middle-income countries; over 60% of the global mortality due to poisoning occurs among adolescents and adults aged between 15–59 years, (38).

Middle-aged men reported to have died more of homicidal injuries compared to females is consistent with global report which shows that more than three-quarters (77%) of homicide deaths in 2000 were among males with the highest levels of homicide occurring among males 15 to 29 years of age and closely followed by those 30 to 44 years old, (38). Results from the South African National Injury Mortality Surveillance System (NIMSS) in 2000 also indicate that homicidal injuries contributed 36% of all injury deaths, (39) and that homicide continues to be the leading cause of premature death among South African males (40). In another study higher mortality rates were reported for homicide deaths among men in all age groups especially young adults aged 30 – 39 years, (21).

In related studies, young adult men are at highest risk of injury-related mortality and comprised the majority of perpetrators as well as victims of interpersonal violence, (33, 41).

Suicide was the lowest rate of external cause of death in this community even though suicide was most common cause of injury death and was more pronounced in men compared with women in a South African study, (21).

In many Western countries, suicide is commonly the leading cause of death. Suicide rates have increased during the last four decades despite prevention efforts and there is marked geographic variability in suicide rates, with the highest rates being found in Eastern Europe and the lowest in Muslim and Latin American countries. This unevenness in suicide rates has not been adequately established. Majority of studies in the psychiatric literature have approached the analysis of risk factors and correlates of suicidal behaviours from a clinical perspective in developed countries where clinical studies have established that psychiatric disorders are the most important contributing factor to suicide, (42-44).

Trends of Injury Mortality

What is of greatest concern is the increasing trend in injury mortality over time in the studied area. The increase could be attributed to the bad road network. According to the U.S. State Department, many rural roads in Tanzania are virtually impassable, as seasonal washouts are commonplace, (45). It is encouraging however that a gradual decreasing trend was observed getting to the tail end of the studied period. The reversal trend could be attributed to the reconstruction of the Dar es Salaam Rufiji road which got completed in 2005. It is recommended that further analysis be carried out on the data collected from 2008 to ascertain whether the current deaths attributed to road traffic crashes is generally on the increase or decrease.

Conclusion and Recommendation

In Rufiji Demographic Surveillance Area, injuries remain an important cause of death but the extent of variation by age-group in the overall level of risk as well as risk from individual causes suggest that interventions tailored more to age-group and gender-specific would maximize prevention efforts.

In particular, the threats from road traffic accidents in the middle-aged adults and the elderly, drowning in young adults and children, burns as well as animal attack in children, homicide in young adults, suicide in middle adults, and accidental poisoning in all age groups need urgent attention and consideration. Also, burns as well as animal attack in females, and road traffic injuries, drowning, falls, homicidal or assault, accidental poisoning in males needs targeted interventions. This study has revealed that in the Rufiji Demographic Surveillance Area, there are significant disparities in injury mortality rates by gender, age-group and occupation. The leading cause of injury mortality has been noted as RTAs. Males continue to have higher injury mortality rates than females across all age groups. There is a high need for targeted intervention for males in the district.

With the demonstrated increasing trend of injury mortalities in most developing countries, an injury prevention curriculum has to be introduced in the education portfolio and this should be across the various levels of the educational levels for awareness creation. The Health Sector needs to include road safety in their health promotion and disease prevention activities. Road safety education has been noted as one of the key tools used to successfully reduce fatalities on the roads. There is the need for educational campaigns at various levels to create public awareness of the need for safety and precautionary measures to minimize or prevent injuries.

Two of the three factors (age and gender) associated with injury mortality are frequently found in other disease processes and are largely thought to be non-modifiable. However, intervention tailored to these groups can improve and maximize prevention policies.

Weakness of the HDSS

Some of the exposure variables for injury mortality in this study had relatively small number of deaths for each injury aetiology. Examples are injury from burns, poisoning, and homicide. This makes the discussions not very conclusive. Therefore the existing RHDSS data does not contain sufficient information to accurately and adequately estimate the risk factors for injury mortality. Also, the classification of cause-of-death as the assignment of ICD-10 coding can be quite

complex, particularly for poisoning. SES as a risk factor for injury mortality had missing data for half of the study participants and could have a potential impact on the findings. Nevertheless, SES was not the main interest of this study. Another possible limitation of verbal autopsy data recall bias and miss or under reporting of some vital events

Despite rigorous training and thorough fieldwork operations and quality control measures, it is difficult to comprehensively evaluate the completeness and accuracy of HDSS data given the absence of a gold standard against which to measure findings, (46).

Strengths of the HDSS

The sample size was a true representation of the study area and was large enough to give the study a statistical power. We used person years of observation method which is a more accurate measure of time-to-event compared to mid-year population estimates. The study used longitudinal data collected and updated periodically and thus able to monitor demographic change. Unlike clinical studies in which the individual alone is investigated, health and demographic surveillance also has the community as object of study, which it follows prospectively, (47). This fundamental concept gives rise to far-reaching strengths: generation of research questions that derive directly from empirical data, cost-effective support for a diversity of study designs to address these questions, and the capacity to track population change and the impact of interventions over time.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AK conceived of and developed the proposal under the supervision of RK. AK performed the statistical analysis under the supervision of HM. AK drafted the manuscript which was reviewed by OA. All authors read and approved the final manuscript.

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Data Sharing

The data remains the property of the Rufiji Health and Demographic Surveillance System.

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Risk factors for injury mortality in rural ~~the Rufiji district,~~ Tanzania: a secondary data analysis

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Abstract

Background: Injuries rank high among the leading causes of death and disability annually, injuring over 50 million and killing over 5 million people globally. Approximately 90% of these deaths occur in developing countries. **Objectives:** To estimate and identify the risk factors for injury mortality in the Rufiji Health and Demographic Surveillance System (RHDSS) in Tanzania. **Methods**: Secondary data from the Rufiji Health and Demographic Surveillance System covering the period 2002 and 2007 was examined. Verbal Autopsy data was used to determine the causes of death based on the 10th revision of the International Classification of Diseases (ICD10). Trend and Poisson regression tests were used to investigate the associations between risk factors and injury mortality. **Results:** The overall crude injury mortality rate was 33.4 per 100,000 population. Injuries accounted for 4% of total deaths. Males were 3 times more likely to die from injuries compared with females [Adjusted IRR=3.04, P=0.001, 95% CI (2.22-4.17)]. The elderly (defined as 65^{+}) were 2.8 times more likely to die from injuries compared with children under 15 years of age [Adjusted IRR=2.83, P=0.048, 95% CI (1.01-7.93)]. The highest frequency of deaths resulted from road traffic crashes. **Conclusion:** Injury is becoming an important cause of mortality in the Rufiji district. Injury mortality varied by age and gender in this area. Most injuries are preventable, policy makers need to institute measures to address the issue.

Key words: Injury, mortality, risk factor, Cause-specific, Tanzania

Introduction

Injuries have traditionally been regarded as 'unavoidable' accidents. In recent decades however, there is a shift in perspective and injuries are being recognized as preventable events, (1).

Injury mortality is a major global public health problem, accounting for 9% of mortality and 16% of all disabilities annually, (2). The global rate of unintentional injuries was 61 per 100,000 populations per year and road traffic injuries made up the largest proportion of unintentional injury deaths (33%). When standardized per 100,000 population, the death rate was almost double in Low and Middle Income Countries (LMIC) compared with high-income countries (65 versus 35 per 100,000), and the rate of disability-adjusted life-years is more than triple in LMIC (2,398 versus 774 per 100,000), (3).

In LMIC, injuries are growing in significance because of the demographic and socioeconomic transitions that have characterized their development in recent decades, (4). Of an estimated 5.4 million people worldwide who died from injuries in 2005, over 90% occurring in low and middle-income countries, (5).

Although non-communicable diseases were responsible for nearly 60% of deaths globally in 2001 compared with 9% due to injury mortality, the Years of Life Lost (YLL) proportional to injuries is much higher, at 12%, compared with 40% for chronic diseases, (6). According to the Global Burden of Disease 2000 data, over 5 million people (83.7 per 100,000 population) died worldwide from injuries in 2000, (7).

In many developing countries, injuries have a significant impact on the health of populations and are rapidly becoming increasingly recognized as a major cause of death and disability. Eight of the 15 leading causes of death for people aged 15 to 29 years were injury-related including both intentional and unintentional deaths, (8-9). For every death that results from injury, dozens of hospitalizations, hundreds of emergency department visits and thousands of doctors' appointments occur. It is projected that by 2020, injuries will compete with infectious diseases as a major source of mortality and morbidity in the developing world, (10).

Modernization has reportedly been associated with increased mortality from injury. A study in Tanzania reported that as populations grow and become more mobile, a large proportion of

adults are at higher risk for injuries than in the past. Similarly, a 2002 survey of 7,035 rural and 8,188 urban households in Tanzania found that 22.5% and 4.3% persons reported injuries respectively. Although the overall incidence was higher in the rural area, the incidence of major injuries (> or = 30 disability days) was similar in both areas, (11-12). Males were mainly affected in a total of 342 burned children in Northwestern Tanzania and children aged two years and under were the majority, accounting for 45.9% of cases, (13).

The descriptive epidemiology of injury mortality in Africa and other low-income countries is poorly understood. As a result, accurate data on the vital statistics about injury mortality is not well documented, (12).

To add to knowledge on injury mortality in the Africaddress this gap in knowledge, this study examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania.

Methodology

Study design and setting

The research design comprised a cross-sectional study of injury mortality amongst the population of residents in the Demographic Surveillance area of the RHDSS between 2002 and 2007.

The study was conducted in the Rufiji Health and Demographic Surveillance System (RHDSS) area, one of the Demographic Surveillance Centres in Tanzania. The INDEPTH Network's monograph on mortality defines a demographic surveillance system (DSS) as a set of field and computing operations to handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area.

The RHDSS area extends from 7.470 to 8.030 south latitude and 38.620 to 39.170 east longitude. The area is located in the Rufiji district, about 178 kilometres south of Dar es Salaam. The RHDSS operates in 6 contiguous wards and 31 villages (about 60 km long × 30 km wide) and covers an area of 1813 sq km. The total population under demographic surveillance is about 85,000. Females (52%) outnumber males (48%) in the Rufiji Demographic Surveillance Area (DSA). The average household size is about 4-8 persons.

According to The United Republic of Tanzania's 2002 Population and Housing Census General Report, the population of Rufiji district was approximately 203,102 (98,398 males and 104,704 females) with an annual growth rate of 2.3%. The mean household size for the whole district was approximately five persons, (14). The district is largely rural, though the population is clustered around Utete (District headquarters), Ikwiriri, Kibiti and Bungu townships. All the last three townships are within the Health and Demographic Surveillance System (HDSS) area. Islam is the dominant religion, followed by Christianity and then African traditional believers. Kiswahili is the main language spoken by the inhabitants.

Data source

The RDHSS cause-specific mortality data was the primary data source for this study. The RHDSS prospectively records longitudinal data on household demographics and is updated

every four months. The variables contained in the RHDSS injury mortality database includes basic demographic information such as date of birth, personal identification number, gender, occupation, marital status, socoi-economic status, migration, injury specific cause of death, date of death, place of death and year of death.

The HDSS was established to provide sentinel data through continuous surveillance of households and members within households in cycles with the aim of gathering information on health and demographic data to inform health policy and planning and to evaluate/monitor the impact of health reforms.

Variables and definitions

Injury mortality was the outcome variable of interest. It included all deaths resulting from injuries, whether unintentional or intentional in the Rufiji surveillance area between 2002 and 2007. The causes of deaths in the DSA had already been determined by the physicians using the verbal autopsy data, in line with the International Classification of Diseases ICD-10, (15-16). ~~,~~ Using the verbal autopsy data to diagnose cause of death have been validated, ~~which is consistent with the International Classification of Diseases ICD-10,~~ (17-18). The cause of death was usually based on both remote and immediate factors leading to death.

A death outcome was classified as injury death when it occurred due to any one or combination of the following: animal bites; drowning; falls; firearm; fire / burns; road transport crash; homicide; and suicide (poison, hanging). The outcome variable was classified as positive for all injury-related deaths and negative for individual alive in a particular year. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Case identification

Injury mortality data from the RHDSS database was used for the analysis.

Data collection

Data was extracted from the RHDSS for the period 2002 to 2007.

Data analysis

Principal Component Analysis (PCA) was used to construct a socio-economic index for each household, (19-20). Households were categorized into high, medium and low socio-economic status based on the average number of household assets owned by the study participants as well as the environmental and household characteristics. Some of the assets included in the construction of the PCA were ownership of goats, cattle, sheep, houses, cars, chicken and televisions. The person years of observation (PYO) was computed for all study participants from the individual member information table and the migration table. This takes into consideration the movements of participants, the event file which records all the event history that have happened to individual members, and the interval file which is the start and end date of the study from which the person time of contribution is generated. The total person years observed was the summation of all the individual time at risk of injury mortality from 2002 to 2007.

Univariate and multivariate Poisson regression analysis was performed using STATA 10 to assess the association between the risk factors and injury mortality. Not every study participant was observed for the same length of time and Poisson regression model allows for this through something called an offset whereby every individual contribution of time is account for in the analysis.

Chi-squared test for trend was used to examine trends and patterns in injury mortality. All tests for significant associations were based on p-values at 5% significance level.

The descriptive statistical analysis comprised an examination of trends and patterns in injury mortality by age, gender, socio-economic status, and the identification of other risk factors associated with injury mortality. The analytic component involved the measurement of the association between age, gender, socio-economic, education, occupation, marital status (for individuals aged 15 years only) and injury mortality. Poisson regression analysis was used because it takes into account each participant's contribution of time throughout the entire study duration.

Ethics

Anonymity and confidentiality was ensured by replacing any potential personal identification of the study participants with unique reference codes. Ethical approval was obtained from the

Human Research Ethics Committee (Medical) of the University of the Witwatersrand. Ethics clearance was also obtained from the Ifakara Health Institute-Institutional Review Board for the primary study data collection.

Results

Description of the study population

Table I presents the socio-demographic characteristics of the study population. There were 119,271 residents contributing 592,324.03 PYO over the study period. There were slightly more females (52.9%) compared with males (47.1%). Children younger than 15 years of age constituted the largest group 50,515 (42.4%). Half of the study population [60,588 (50.8%)] had no formal education and over a third of the study participants (37.3%) were farmers. Household wealth profile using principal component analysis revealed that 18,971 (35.5%) were classified as low socio-economic status. In terms of conjugal status, 20,675 (18.6%) participants were not married while 40,554 (36.5%) ever married.

A total of 4,471 deaths were recorded over the study period, of which 198 were classified as injury deaths. Majority of the injury deaths were males 140 (71%) verse 58 (29%). Most of the injury deaths were unintentional (90%).

The overall injury mortality rate was 33.4 per 100,000 population. Injury mortality rate (49.7) was more than double in males ~~compared to females~~ (95% CI 42.1 - 58.6) compared to females, 18.7 (95% CI 14.4 – 24.2) p=0.001. The elderly (defined as any resident >65 years of age) experienced the highest injury mortality 128.7 (95% CI 98.9 – 167.7). Most important exposure variable(s) were associated with injury mortality. It is of interest to note that tertiary education level participants constituted a small proportion of the population (n=757, number of deaths=3) compared with the other categories.

The injury deaths among retired workers was also higher (273 per 100,000 PYO), compared with casual workers (62 per 100,000 PYO), the unemployed (56 per 100,000 person years), and farmers (41 per 100,000 population). There was no evidence of a difference in injury mortality by SES though the individuals in the lowest SES category had the highest rates compared with the other groups. Those who ever married had mortality rate of 57 per 100,000 population, compared with 29 per 100,000 population among those who never married.

Table 1: Descriptive statistics of the study population by study variables

Exposure factor	Frequency	Percent	Person Time	Dead	Rate	95% Confidence Interval
Gender						
Female	63,042	52.9	310,556.33	58	18.7	14.4 - 24.2
Male	56,229	47.1	281,767.7	140	49.7	42.1 - 58.6
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Age Group						
1-14	50,515	42.4	254,938.5	40	15.7	11.5 - 21.4
15-34	41,195	34.5	192,014.21	55	28.6	22.0 - 37.3
35-64	19,480	16.3	102,645.01	48	46.8	35.2 - 62.1
65^{+}	8,081	6.8	42,726.31	55	128.7	98.8 - 167.7
Total	**119,271**		**592,324.03**	**198**	**33.4**	**29.1 - 38.4**
Education						
Primary	53,024	44.5	270,807.1	73	27.0	21.4 - 33.9
No-formal	60,588	50.8	293,677.2	118	40.2	33.6 - 48.1
Secondary	4,878	4.1	24,250.0	4	16.5	6.2 - 44.0
Tertiary	757	0.6	3,516.5	3	85.3	27.5 - 264.5
Total	**119,247**		**592250.83**	**198**	**33.4**	**29.08 - 38.4**
Occupation						
Student	4,026	4.2	151,544.4	12	8.0	4.5 - 13.9
Unemployed	27,435	28.9	17,878.2	10	55.9	30.1 - 104.0
Retired	4,399	4.6	12098.2	33	272.8	193.9 - 383.7
Casual	17,377	18.3	74459.5	46	61.8	46.3 - 82.5
Farming	35,505	37.3	181796.8	74	40.7	32.4 - 51.1
other	6,333	6.7	128472.2	23	17.9	11.9 – 26.9
Total	**95,076**		**566249.2**	**198**	**35.0**	**30.4 - 40.2**
Household SES						
High	15,989	30.0	78,611.6	23	29.3	19.4 - 44.0
Medium	18,418	34.5	91,127.64	38	41.7	30.3 - 57.3
Low	18,971	35.5	93,664.9	43	45.9	34.1 - 61.9
Total	**53,378**		**263,404.14**	**104**	**39.5**	**32.58 - 47.9**
Marital status						
Single (>15 years)	20,675	18.6	102,676.6	30	29.2	20.43 - 41.8
Ever Married	40,554	36.5	218,805.1	125	57.1	47.9 - 68.1
Single (<15 years)	49,950	44.9	261,6721.0	43	16.4	12.2 - 22.2
Total	**111,179**		**583,153.6**	**198**	**33.4**	**29.1 - 38.4**

Overview of mortality proportions in Rufiji DSA from 2002-2007

Figure 1 shows the distribution of causes of deaths during the study period. Injuries accounted for 4% of total deaths. The overall mortality was 754.8 per 100,000 PYO; Malaria (24%) and cardiovascular diseases (23%) contribution was similar and accounted for almost half of the total deaths. The other external cause category (15%) included maternal deaths, specified and unspecified communicable diseases, specified and unspecified acute febrile illnesses, diarrhoeal diseases, meningitis, hepatitis, specified and unspecified acute respiratory infections, tetanus and

measles. Acquired Immune Deficiency Syndrome and Pulmonary Tuberculosis (14%) was fourth largest contributor of burden of mortality.

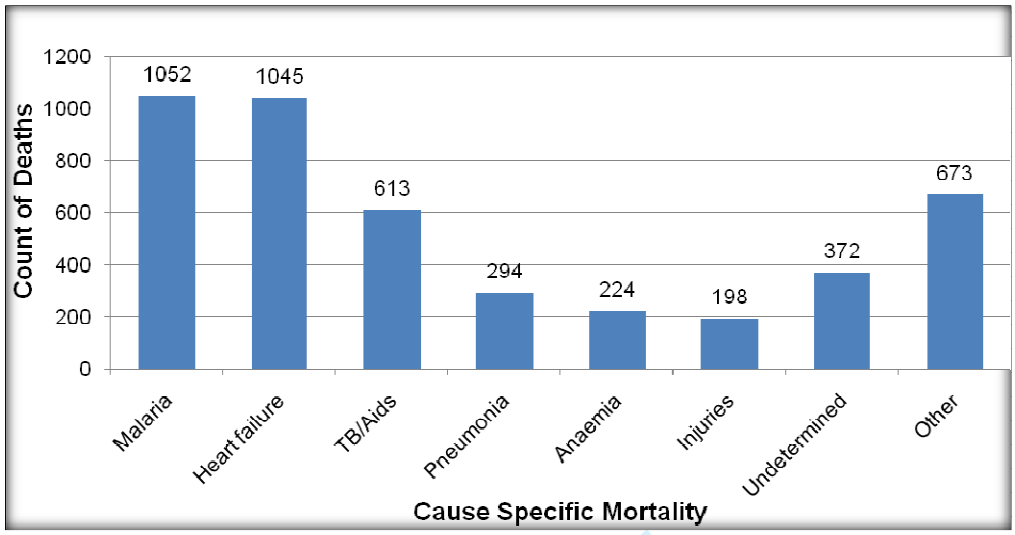

Figure 11: Major Causes of Mortality in RHDSS from 2002-2007

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The distribution of cause-specific injury mortality in the Rufiji DSA

The types of injury mortality recorded in the study area during the period of analysis included road traffic accident, drowning, burns, homicidal injuries, accidental poisoning, animal bite/attack, falls, suicidal injuries and unspecified external injuries (deaths due to complications of medical and surgical care or being hit by external objects like trees and heavy loads). More than one quarter of the injury deaths were due to road traffic accidents 56 (28%), unspecified external injuries accounted for 40 (20%), drowning 32 (16%) and burns 18 (9%). The lowest injury deaths were attributed to suicide 4 (2%) or broadly referred here as intentional injuries.

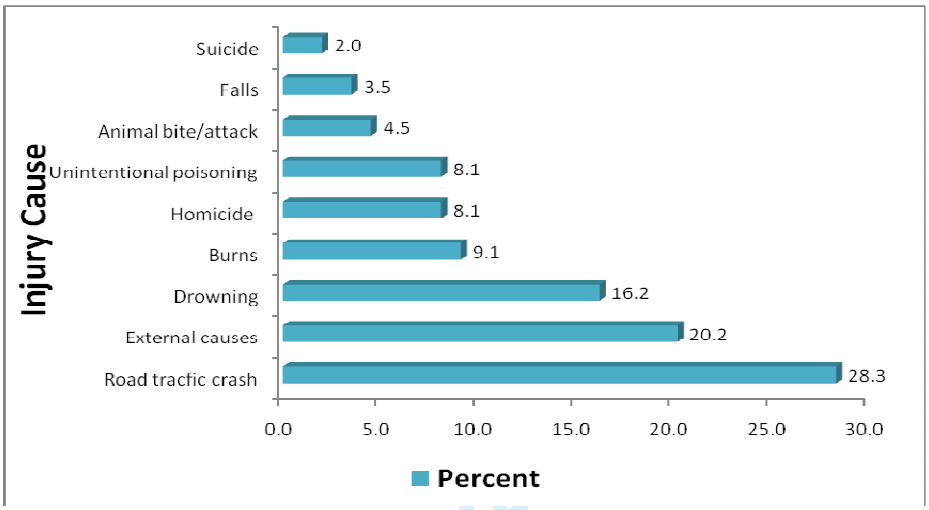

Figure 2: Distribution of Injury Cause-Specific Mortality in RHDSS

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Estimating the yearly crude death rates (CDR) of injury from 2002-2007

There was a consistent yearly increase in the injury crude death rate (CDR) from 2002 to 2005. However, a slight decline was observed between 2005 and 2007 but we found no evidence of this drop in injury mortality. The Chi-Square for trends test showed no significant difference in proportions of injury deaths among the different years (P=0.288).

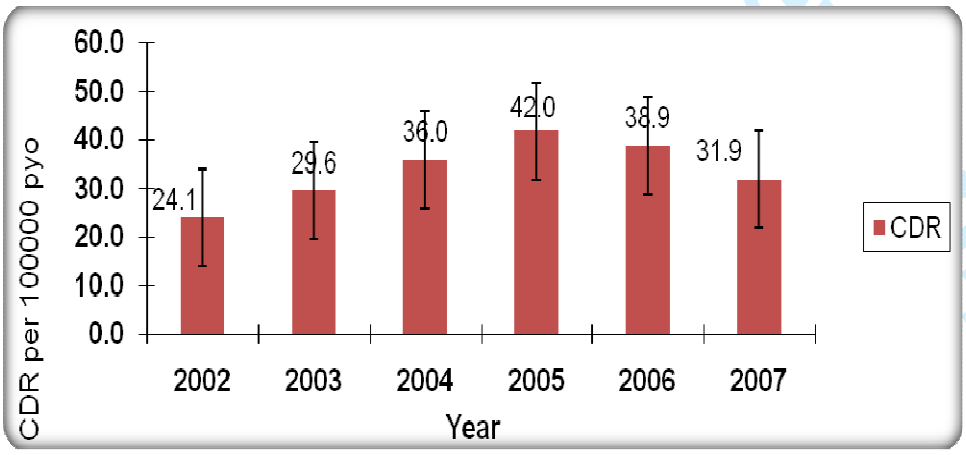

Figure 3: Trend of Injury Mortality from 2002-2007

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Gender and Injury Mortality from 2002-2007

Injury mortality in males was significantly higher compared with females during the period. Injury mortality increased both in males and females from 2002-2005 and then dropped. Males were 2 to 4 times more likely to die of injuries compared with females. Males were more likely to die from RTAs, External causes and drowning compared to females. On the other hand females were more likely to die of burns and animal attacks.

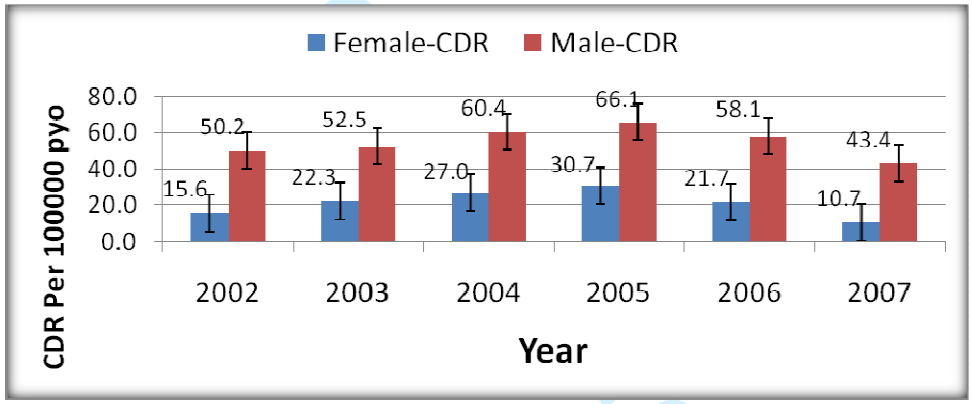

Figure 4: Trend of Injury Mortality by Gender from 2002-2007

Cause-Specific Injury Mortality by gender

Males were more likely to die in road traffic crashes, other external causes and drowning compared with females. On the other hand females were more likely to die of burns and animal attacks.

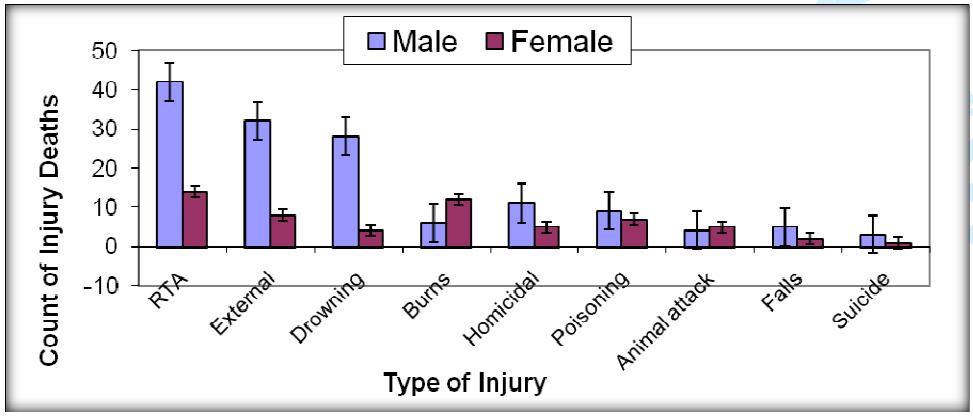

Figure 5: Cause-Specific Injury by Gender

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Inferential Analysis

Univariate Poisson regression analysis of risk factors for injury mortality

Univariate and Multivariate Poisson regression analysis were carried out to demonstrate the associations between risks factors (gender, age, occupation, education, marital status, socio-economic status) and injury mortality. Incidence Risk Ratios (IRR) were used to measure the strength of the relationships and interpreted as Relative Risk. The results are presented in Table 2.

Table 2: Univariate and Multivariate Poisson regression analysis of injury mortality

Factor	Univariate Model (95% CI)			Multivariate Model (95% CI)		
	IRR	CI	P-Value	IRR	CI	P-Value
Gender						
Female	**1***			**1***		
Male	2.66	1.96 - 3.61	**<0.001**	3.04	2.22 - 4.17	**<0.001**
Age Groups						
1-14	**1***			**1***		
15-34	1.83	1.22 - 2.74	**0.004**	0.98	0.38 - 2.52	0.972
35-64	2.98	1.96 - 4.53	**<0.001**	1.34	0.48 - 3.75	0.582
65^{+}	8.20	5.46 - 12.33	**<0.001**	2.83	1.01 - 7.93	**0.048**
Occupation						
Student	**1***			**1***		
Farming	5.14	3.05 - 16.35	**<0.001**	4.13	1.81 - 9.42	**<0.001**
Casual	7.80	4.13 - 14.73	**<0.001**	7.36	3.25 - 16.66	**<0.001**
Unemployed	7.06	2.79 - 9.46	**<0.001**	8.57	3.26 - 22.48	**<0.001**
Retired	34.45	17.79 - 66.70	**<0.001**	28.26	12.53 - 63.71	**<0.001**
Marital status						
Single (>15 years)	**1***			**1***		
Ever Married	1.96	1.31 - 2.91	**<0.001**	1.08	0.64 - 1.83	0.776
Children (<15 years)	0.56	0.35 - 0.90	**0.016**	1.45	0.59 - 3.57	0.423
Education						
Primary	**1***			**1***		
No-formal	1.49	1.11 - 2.00	**0.007**	1.25	0.87 - 1.79	0.230
Secondary	0.61	0.22 - 1.67	0.339	0.59	0.21 - 1.62	0.306
Tertiary	3.16	1.00 - 10.04	**0.050**	1.19	0.37 - 3.86	0.769
Household SES						
High	**1***					
Medium	1.43	0.85 - 2.39	0.180			
Low	1.58	0.95 - 2.60	0.081			

1*=*Reference group*

In the univariate logistic regression analysis model, age, education, gender, marital status and occupation were all significant risk factors for injury mortality (Table 2).

In the multivariable logistic regression analysis model however, three variables were significant risk factors associated with injury mortality having adjusted for the variables in the univariate model. These are gender, age and occupation.

Adjusted for age, occupation, education and marital status, males (IRR=3.04; 95% CI: 2.22-4.17), the elderly (IRR=2.83; 95% CI: 1.01-9.93) and being unemployed (IRR=8.57; 95% CI: 3.26-22.48) were all found to be significant risk factors for injury mortality~~someone developing active convulsive epilepsy~~ (Table 2).

Discussion

Proportion of injury mortality

This study presented a population-based data on the proportion of injury-related deaths, the cause specific injuries as well as the risk factors for injury mortality from a predominantly rural area in Tanzania from 2002 to 2007.

Injuries remain a threat to human existence globally, especially in developing countries. Injury mortality accounted for 4% of total deaths during the study period. A study in South Africa reported that 8.9% of deaths were injury-related and homicide, road traffic crashes and suicide were the major causes of injury mortality. The study analyzed data on 133483 individuals with 717584.6 person-years of observation resulted in 11467 deaths, (21).

Risk factors for Injury mortality

The findings in this study are consistent with those found in other studies; generally males were more likely to experience injury mortality compared with females. Globally, injury mortality among males is twice of that among females and males in Africa and Europe have the highest injury-related mortality rates, (1). In South Africa, the male-female injury mortality ratio in 2008 was 3.3:1, (22). It also reflects the results from a study conducted by Moshiro et al.(2001) in Dar es Salaam, Hai, and Morogoro districts in Tanzania that documented injury mortality rates being approximately three times higher among men compared to women, (11, 23-24). The high male injury fatality rate in this rural setting might be explained by the gender specific roles where men are more likely to perform the risky jobs like fishing, manual farming and road traffic related activities like driving. ~~There is a high need for targeted intervention for males in the district.~~

Age was also associated with injury mortality. The elderly were strongly associated with higher injury mortality rates compared with the younger age groups. This finding is similar to what was reported by Lopez et al. (2006) which attributed one-quarter of injuries deaths to those aged between 15 years and 59 years, (6). The assertion that injury mortality rates increased with age is similar to the findings by Moniruzzaman et al. (2008) which reported that in low and middle

income countries, there is a direct relationship between age and injury mortality such that as age increases, the risk for injury mortality increases, (25).

In this study, those who were in active employment had lower risk of injury mortality. This compares with the study by Garrib et al which found that full-time employment was significantly associated with lower mortality in South Africa, (21).

A couple of studies have demonstrated that increasing SES has a strong inverse association with the risk of fatal injuries; more than 80% of childhood burns have been reported to occur among low socio-economic groups, (26-29). This study did not find sufficient evidence to suggest that household wealth was a key risk factor for injury mortality. This could be attributed to the fact that socio-economic status information was not available for half of the households who were included in this analysis. Furthermore, Rufiji DSA is typically rural and almost homogeneous in terms of wealth index; there is very little variation in items possession, hence, no significant difference in SES between the high and low groups.

Types of injuries

Among the two broad types of injuries, 90% were unintentional The high unintentional injury deaths has been reported in studies in other parts of Tanzania, (11). The role of road traffic accident as the leading cause of injury mortality in this study is consistent with other injury deaths in other African Countries including Kenya and Ghana, (11, 30-31). Mortality rates because of road traffic crashes were again significantly higher in men than women in all age groups, for both pedestrians and vehicle occupant, (21).

Many other factors are known to be associated with risk of injury mortality. These include poverty, lack of education, unemployment, alcohol and substance abuse, interpersonal conflict, intimacy and power, (32-33).

Injuries related to burns from this analysis indicated that females were more likely to die compared with males. Other studies in Africa reported that males were more likely to die of burn fatalities and that young children and the elderly are the most vulnerable, (1, 29, 34-35). One possible explanation for the difference in findings may be due to the settings. Whereas those

studies were conducted in urban settlements, this study was conducted in a typically rural setting where cooking is seen as the birthright responsibility of females.

Drowning was among the main causes of injury mortality in this study. Studies have shown that Africa had the highest drowning mortality rate (13.1 per 100,000 PYO) and males had higher drowning mortality rates than females for all ages and in all regions and was more pronounced in children up to fourteen years, (7). In this study however, most of the drowning fatalities occurred in young (15-34) and middle-aged (35-54) adults. In the Rufiji Demographic Surveillance Area, most of the people are engaged in subsistence farming and fishing activities with the proximity of the Rufiji River as a possible influencing factor. For example most of the time males are the fishermen who at times engage in fishing without life jackets. There are no enforced laws on fishing. Fishing activities need to be regulated to save lives. In some developed countries however, there are laws regulating recreational swimmers and fishermen which proves a safety measure against drowning, (36-37).

We documented more male deaths from unintentional poisoning compared with females, reflecting those reported in other studies which indicate that the highest poisoning mortality rates were among the male populations in the low and middle-income countries; over 60% of the global mortality due to poisoning occurs among adolescents and adults aged between 15–59 years, (38).

Middle-aged men reported to have died more of homicidal injuries compared to females is consistent with global report which shows that more than three-quarters (77%) of homicide deaths in 2000 were among males with the highest levels of homicide occurring among males 15 to 29 years of age and closely followed by those 30 to 44 years old, (38). Results from the South African National Injury Mortality Surveillance System (NIMSS) in 2000 also indicate that homicidal injuries contributed 36% of all injury deaths, (39) and that homicide continues to be the leading cause of premature death among South African males (40). In another study higher mortality rates were reported for homicide deaths among men in all age groups especially young adults aged 30 – 39 years, (21).

In related studies, young adult men are at highest risk of injury-related mortality and comprised the majority of perpetrators as well as victims of interpersonal violence~~t incidents~~, (33, 41).

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Suicide was the lowest rate of external cause of death in this community even though suicide was most common cause of injury death and was more pronounced in men compared with women in a South African study, (21).

In many Western countries, suicide is commonly the leading cause of death. Suicide rates have increased during the last four decades despite prevention efforts and there is marked geographic variability in suicide rates, with the highest rates being found in Eastern Europe and the lowest in Muslim and Latin American countries. This unevenness in suicide rates has not been adequately established. Majority of studies in the psychiatric literature have approached the analysis of risk factors and correlates of suicidal behaviours from a clinical perspective in developed countries where clinical studies have established that psychiatric disorders are the most important contributing factor to suicide, (42-44).

Trends of Injury Mortality

What is of greatest concern is the increasing trend in injury mortality over time in the studied area. The increase could be attributed to the bad road network. According to the U.S. State Department, many rural roads in Tanzania are virtually impassable, as seasonal washouts are commonplace, (45). It is encouraging however that a gradual decreasing trend was observed getting to the tail end of the studied period. The reversal trend could be attributed to the reconstruction of the Dar es Salaam Rufiji road which got completed in 2005. It is recommended that further analysis be carried out on the data collected from 2008 to ascertain whether the current deaths attributed to road traffic crashes is generally on the increase or decrease.

Conclusion and Recommendation

In Rufiji Demographic Surveillance Area, injuries remain an important cause of death but the extent of variation by age-group in the overall level of risk as well as risk from individual causes suggest that interventions tailored more to age-group and gender-specific would maximize prevention efforts.

In particular, the threats from road traffic accidents in the middle-aged adults and the elderly, drowning in young adults and children, burns as well as animal attack in children, homicide in young adults, suicide in middle adults, and accidental poisoning in all age groups need urgent attention and consideration. Also, burns as well as animal attack in females, and road traffic injuries, drowning, falls, homicidal or assault, accidental poisoning in males needs targeted interventions. This study has revealed that in the Rufiji Demographic Surveillance Area, there are significant disparities in injury mortality rates by gender, age-group and occupation. The leading cause of injury mortality has been noted as RTAs. Males continue to have higher injury mortality rates than females across all age groups. There is a high need for targeted intervention for males in the district.

With the demonstrated increasing trend of injury mortalities in most developing countries, an injury prevention curriculum has to be introduced in the education portfolio and this should be across the various levels of the educational levels for awareness creation. The Health Sector needs to include road safety in their health promotion and disease prevention activities. Road safety education has been noted as one of the key tools used to successfully reduce fatalities on the roads. There is the need for educational campaigns at various levels to create public awareness of the need for safety and precautionary measures to minimize or prevent injuries.

Two of the three factors (age and gender) associated with injury mortality are frequently found in other disease processes and are largely thought to be non-modifiable. However, intervention tailored to these groups can improve and maximize prevention policies.

Weakness of the HDSS

Some of the exposure ~~risk factor~~ variables for injury mortality in this study had relatively small number of deaths for each injury aetiology. Examples are injury from burns, poisoning, and homicide. This makes the discussions not very conclusive. Therefore the existing RHDSS data does not contain sufficient information to accurately and adequately estimate the risk factors for injury mortality. Also, the classification of cause-of-death as the assignment of ICD-10 coding

can be quite complex, particularly for poisoning. SES as a risk factor for injury mortality had missing data for half of the study participants and could have a potential impact on the findings. Nevertheless, SES was not the main interest of this study. Another possible limitation of verbal autopsy data recall bias and miss or under reporting of some vital events

Despite rigorous training and thorough fieldwork operations and quality control measures, it is difficult to comprehensively evaluate the completeness and accuracy of HDSS data given the absence of a gold standard against which to measure findings, (46).

Strengths of the HDSS

The sample size was a true representation of the study area and was large enough to give the study a statistical power. We used person years of observation method which is a more accurate measure of time-to-event compared to mid-year population estimates. The study used longitudinal data collected and updated periodically and thus able to monitor demographic change. Unlike clinical studies in which the individual alone is investigated, health and demographic surveillance also has the community as object of study, which it follows prospectively, (47). This fundamental concept gives rise to far-reaching strengths: generation of research questions that derive directly from empirical data, cost-effective support for a diversity of study designs to address these questions, and the capacity to track population change and the impact of interventions over time.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AK conceived of and developed the proposal under the supervision of RK. AK performed the statistical analysis under the supervision of HM. AK drafted the manuscript which was reviewed by OA. All authors read and approved the final manuscript.

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Data Sharing

The data remains the property of the Rufiji Health and Demographic Surveillance System.

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Dear Reviewers,
Thank you for your comments, which we found useful in improving our paper. We have revised the manuscript and the table below provides a detailed account of actions taken in response to each comment.

Reviewers Comments	**Action Taken/Response**
From the managing editor Please include the study design in the title	The title have been modified as "*Risk factors for injury mortality in rural Tanzania: a secondary data analysis*"
Reviewer: Wilson Odero MD, PhD Professor of Public Health Maseno University, Kenya	
1. Abstract - The stated conclusions should relate to the objective of the study, i.e., risk factors of injury mortality.	The conclusion is now revised as "*Injury is becoming an important cause of mortality in the Rufiji district. Injury mortality varied by age and gender in this area. Most injuries are preventable, policy makers need to institute measures to address the issue*
2. Introduction - p 4, last paragraph (line 33-37), implies that the study was motivated by poor documentation and lack of accurate of data on injury mortality in Africa. This statement should be deleted since the study did not examine the quality/accuracy of injury mortality data captured in the RHDSS.	This is now revised in a separate paragraph which reads "*To add to knowledge on injury mortality in the Africa, this study examined the distribution of injury deaths, gender- and age-specific trends and other risk factors associated with injury mortality in rural Tanzania".*
3. Methods - A brief description of the purpose and structure of RHDSS including the variables contained in the database is needed, this will help in evaluating whether the database is populated with sufficient variables for estimating risk factors for injury deaths; cite appropriate reference(s).	The variables contained in the RHDSS injury mortality database includes basic demographic information such as date of birth, personal identification number, gender, occupation, marital status, socoi-economic status, migration, injury specific cause of death, date of death, place of death and year of death.
- It is still not clear whether RHDSS cause of death diagnoses are ICD-10 coded, and whether the codes were used to extract cause-specific mortality.	The RHDSS cause of death diagnoses are ICD-10 coded, and these codes were used to extract the cause-specific mortality data.
Note that refs #17-18 do not support the statement that causes of injury deaths as determined by verbal autopsy are consistent with ICD-10 codes.	The sentence is restated "*The causes of deaths in the DSA had already been determined by the physicians using the verbal autopsy data, in line with the International Classification of Diseases ICD-10,(15-16). Using the verbal autopsy data to diagnose cause of death have been validated, (17-18).*"
4. Results - p8, 2nd paragraph (line 37-39) – the sentence on exposure variables is incomplete and not supported by the data presented.	This sentence have now been stated appropriately in the main document
- Other than demographics, what were the other important exposure factor(s) for injury mortality?	We didn't have other important exposure factors available for the analysis which was a limitation of the study
- p.14, last paragraph, surprisingly suggests that the identified risk factors were for development of active convulsive epilepsy, yet epilepsy was not the outcome variable for this study (see p.6, on variables and definitions); delete.	This was a mistake but have now been corrected to read risk factors for injury mortality
5. Discussion - p.15, 2nd paragraph, last sentence (line 47) is a recommendation; delete/ incorporate in the recommendations on p.19. - p.17, line 51-52 – the cited studies are specific to injuries from interpersonal violence (#33, 41) are not appropriate, and not deaths from all injuries.	This is done. This is restated to capture only interpersonal violence
- Conclusions should highlight the key risk factors and trend of injury deaths.	The conclusion have been restated to highlight the key findings in the 1st and 2nd paragraph
Note that the recommended road safety education as an intervention to reduce road deaths is not based on the risk factors identified from the study.	This is true but was just speculative. Could easily be deleted from the main document.
- Based on the stated limitations, the main take home message should be that the existing RHDSS does not contain sufficient data that can be used to provide an accurate estimate of risk factors for cause-specific injury deaths.	Agree completely with you and this is incorporated into the main document