

# BMJ Open Demographic, occupational and societal risk exposures to physical injuries in a rural community in Western Kenya: a 12-week longitudinal study

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## ABSTRACT

**Objective** We studied factors associated with the weekly occurrence of physical injuries in a rural setting to determine injury-related burden and risk exposures.

**Design** Prospective cohort study.

**Setting** Suna-West subcounty, Migori County, Western Kenya.

**Participants** 390 study participants (subjects) cluster sampled from 92 households, recruited and followed up for 12 weeks, between August and October 2019.

**Methods** We collected data weekly on occurrence of injuries, individual-level and household-level independent variables using a standard interviewer-administered questionnaire adapted from the WHO survey tool for injuries. Analyses related occurrence of injuries and independent variables using a multilevel Poisson regression model, adjusting for age and sex.

**Outcome measures** Quantifying injury-related burden and patterns by demographic, occupational and societal risk exposures.

**Results** We documented 44 injuries, coming from 38 subjects dwelling in 30 of the 92 study households. On average, each study subject and household experienced 1.2 and 1.5 episodes of injuries across the 12 study weeks. Open wounds and bruises were the most frequent injuries commonly reported among middle-aged (18–54 years) and young (5–17 years) subjects at 32.2 and 7.6 episodes per 1000-person week, respectively. The common cause of injuries among young, middle-aged and old subjects (>54 years) were falls, road accidents and person-related assault or being hit by an object, each at 15.2, 18.9, and 11.4 episodes per 1000-person week, respectively. Subjects not domesticating animals (incidence rate ratio (IRR)=7.6, 95% CI 1.4 to 41.7) and those making a visit outside the local subcounty of residence (IRR=2.2, 95% CI 1.5 to 3.1) were at higher risk of reporting injuries.

**Conclusion** We provide evidence of a higher burden of physical injuries associated with demographic, occupational and societal risk exposures with the most injuries resulting from falls. Further studies could better define granular characteristics constituting these factors.

## INTRODUCTION

Globally, injuries impose an enormous public health burden and are projected to increase

## Strengths and limitations of this study

- We evaluated temporal risks of injuries by demographic, occupational and societal exposures.
- We analytically controlled for the correlation of injury responses across time, between subjects and households.
- Self-reports of injuries are prone to bias but yielded reliable findings when collected within 7 days, with the weekly decrease suggesting response fatigue.
- Our multilevel analytical approach overcame the effect of loss to follow-up.
- Injuries may vary by time of year/season; however, the short study period meant a possibility of a fairly small number of injuries and not capturing all cases.

by 28% by 2030.<sup>1</sup> Most injuries resulting from occupational risk exposures attributable to road traffic injury, violence or self-inflicted injury, and falls are among the leading causes of disease burden in sub-Saharan Africa.<sup>1–3</sup> Although injury patterns remain to be well defined across different occupational settings, mobility-related injuries significantly increase disability-adjusted life years among individuals aged between 15 and 49 years calling for urgent interventions particularly in low-income countries.<sup>4</sup>

In most low-income countries, data on injuries are frequently obtained from hospital records.<sup>1 3</sup> However, these records are collected under inadequate record-management systems; they are not population-wide representative in absence of injury-led surveillance systems and are widely inaccessible, contributing to underestimation of subnational injury-related burden.<sup>5</sup> To address these gaps, self-reported data on injuries could be obtained to estimate the associated burden.<sup>5</sup> Moreover, longitudinally collected self-reported data on injuries could causally identify and quantify risk exposures, as well as answer questions on the patterns



and dynamics of acquiring injuries to better inform public health interventions.<sup>3,5</sup>

Past studies have identified demographic, occupational and societal risk exposures of injuries in Kenya. For instance, demographic changes have contributed to rural–urban migration, therefore increasing movements associated with rising road accidents,<sup>6</sup> affecting persons of all age groups.<sup>7</sup> However, resulting injuries from occupational exposures including road accidents and falls, among others, could cause disabilities that affect economically productive persons, leading to loss of wages and productivity, or impact education among adolescents.<sup>8</sup> Additionally, societal risk exposures, including unsafe environments, poor enforcement of road safety regulations, inadequate road networks and poor access to quality healthcare interventions, contribute to the increasing number of injuries in rural settings.<sup>7,9</sup> However, the current understanding of injury burden in Kenya is still limited by inadequate epidemiological data and surveillance systems.<sup>9,10</sup> An alternative to address this challenge could be to longitudinally collect data on the occurrence of injuries in rural settings,<sup>10</sup> quantify the burden, and assess patterns of injury by demographic, occupational and societal risk exposures.<sup>11</sup>

Here, we conducted a longitudinal study for 12 weeks aiming to achieve two linked aims: (1) to determine the longitudinal patterns of injuries and (2) to determine independent variables associated with physical injuries adjusting for study participants' age and sex.

## MATERIALS AND METHODS

### Sample size determination

The present study is part of a broader study looking into influenza-like, gastrointestinal illnesses and injuries in a rural setting.<sup>12,13</sup> In brief, 390 study subjects were cluster sampled from 92 households determined using a formula adapted from *Multiple Indicator Cluster Survey Manual, 2005*,<sup>14</sup> as follows:

$$\frac{4 (0.5)(0.5)(1.5)(1.1)}{[(0.12 \times 0.5)^2 \times 5]} = 92 \text{ households}$$

In the numerator, 4 denoted a factor to achieve the 95% level of confidence; (0.5)(0.5) denoted the binomial distribution in occurrence of injuries that would give a maximum variability in the target population<sup>15</sup>; 1.5 denoted the design effect estimated as 1+(average household size–1)×intra-cluster correlation coefficients (ICC). We used an ICC of 0.125 to correspond with the ICC calculated for cluster sizes ranging between 2 and 50.<sup>16</sup> A factor that raised the sample size by 10% to account for non-response was 1.1. In the denominator, 0.12×0.5 denoted the margin of error tolerated at the 95% confidence level, and 5 denoted the average household size in the study site.

### Study site and selection of households

The study site and selection of the households are mentioned elsewhere.<sup>12</sup> In brief, the study area was in

Suna-West subcounty in Migori County, Western Kenya, with Wasweta II ward, one of the four administrative wards within the Suna-West subcounty randomly selected as the study site. The estimated population size in the study site is 42 244, with a population density of about 450 persons/km<sup>2</sup>.<sup>17</sup> Additionally, the main economic activities in the area included agriculture and some commercial activities, including running small shops, mechanics, furniture works and tailoring, among others. To select representative households, we generated 92 random geographical points using QGIS V.3.6.1, each with Global Positioning System coordinates that we used to identify the study households.<sup>12</sup> These coordinates were collected using the ODK Collect application<sup>18</sup> on a smartphone. We tracked each of these points on the ground to identify the nearest household to each of these points and approached them for recruitment. Subsequently, we requested the household heads of these households on whether they could allow members of their households to participate in the study before obtaining written informed consent. A map of the household points was generated using R V.3.6.2<sup>19</sup> to visualise their spatial distribution and to easily identify the households during follow-up household visits. The Average Nearest-Neighbour Index determined the extent of the random distribution of the sampled households.<sup>20,21</sup> This study was conducted between August and October 2019, where August marked the end of cold season, September a hot and dry season, and October the beginning of short rains.

### Study design, enrolment and longitudinal follow-up of subjects

This study adopted a prospective cohort study design. A total of 390 subjects from the 92 randomly sampled households were recruited and followed up weekly for 12 weeks, excluding those aged below 5 years due to the unreliable reporting of their injuries. Subjects aged above 18 years provided their consent to participate in the study, while parental consent and subject assent were sought for those aged between 5 and 17 years. On every Friday of each week of follow-up, the household heads received a phone call from the principal author to inquire about any report of an injury within the study week. A report of an injury in a household member triggered a household visit to characterise the injury to the specific person injured using a standard questionnaire structured in a closed format by a trained research assistant. Injuries among subjects aged below the age of 18 years were characterised in presence of their parents or guardians. We conducted the questionnaire survey in the local 'Dholuo' language to ensure reliability and consistency of responses.

### Longitudinal data collection

We had already obtained information on time-invariant factors relevant to sociodemographic, socioeconomic and household-level variables during the baseline survey.<sup>12</sup> Briefly, these included independent variables considered as demographic, occupational, societal risks

**Table 1** Description of the time-invariant variables collected during the recruitment of study subjects

Factors	Variable group level	Factor levels
Demographic	Individual level	Age in years, gender
	Household level	Household sample size, income of the household head, active medical insurance, house floor type, house roof type, house wall type, source of drinking water, mode of water treatment, human waste destination, defecation location, trash disposal
Occupational	Individual level	Employment type, education level
	Household level	Domesticated animals including cattle, sheep, goats, poultry, dogs and cats

broadly grouped at the individual and household levels. Demographic factors at the individual level included sex grouped into male and female subjects, and age categorised into those aged 5–17 years, 18–54 years, and >54 years hereinafter denoted simply as young, middle-aged and old subjects, respectively (table 1). Three regions arbitrarily defined the study area into the top, bottom left and bottom right according to their geographical positions (online supplemental figure 1S).

The weekly follow-up survey collected time-variant data consisting of the occurrence of injuries, causes, nature and severity, based on the WHO survey tool for injuries<sup>22</sup> (table 2). Time-variant risk factors include, among others, societal risks including the presence of visible stagnant water within household compounds due to rain and domesticating animals. In each week of study, we linked time-variant data to the time-invariant data collected at baseline for each subject. When a response was not obtained from any of the household heads during the follow-up weeks, a visit was made to the households to obtain the specific data within the week and to also motivate participant retention.

### Estimating the association between injuries and independent variables

Adjusting for correlation of responses at the subject and household levels, we fitted generalised mixed effect models (GLMMs) with a Poisson error distribution and a log link function to examine the effect of the independent variables on injuries in two steps. First, we conducted a multilevel univariable analysis using a less-restrictive level of significance of  $p < 0.1$  to identify single

significant risk factors. Second, we conducted a multilevel multivariable analysis to identify significant independent variables associated with injuries. All GLMMs adopted a maximum likelihood approach using Laplace approximation with flat covariance priors and normal fixed priors, with the household group and individual group IDs included as the random effects. To account for model uncertainty, the GLMMs were implemented in a Bayesian setting using the `bgfmer` function in R software.<sup>19 23</sup> We examined time-invariant and time-variant risk factors described in tables 1 and 2, respectively, and included them as fixed effects in the model. In the multivariable analyses step, we forced age and gender in the models to account for their confounding characteristics. The final model was selected using the backward-stepwise selection process, whereby variables not contributing significantly to predicting the occurrence of injuries were eliminated based on low values of Akaike information criterion and Bayesian information criterion, signifying a better-fitted model.

We fitted a multilevel Poisson model based on our three-multilevel data structure organised as level 3: households, level 2: individual household member and level 1: repeated weekly measures. All analyses in this study were conducted using R V.3.6.2.<sup>19</sup>

### Patient and public involvement

Patients and the public were not involved in the design, conduct of the study and determination of the outcome measures. Additionally, patients and the public were not involved in deciding the reporting tools, analysis and dissemination of study findings.

## RESULTS

### Subject-level characteristics

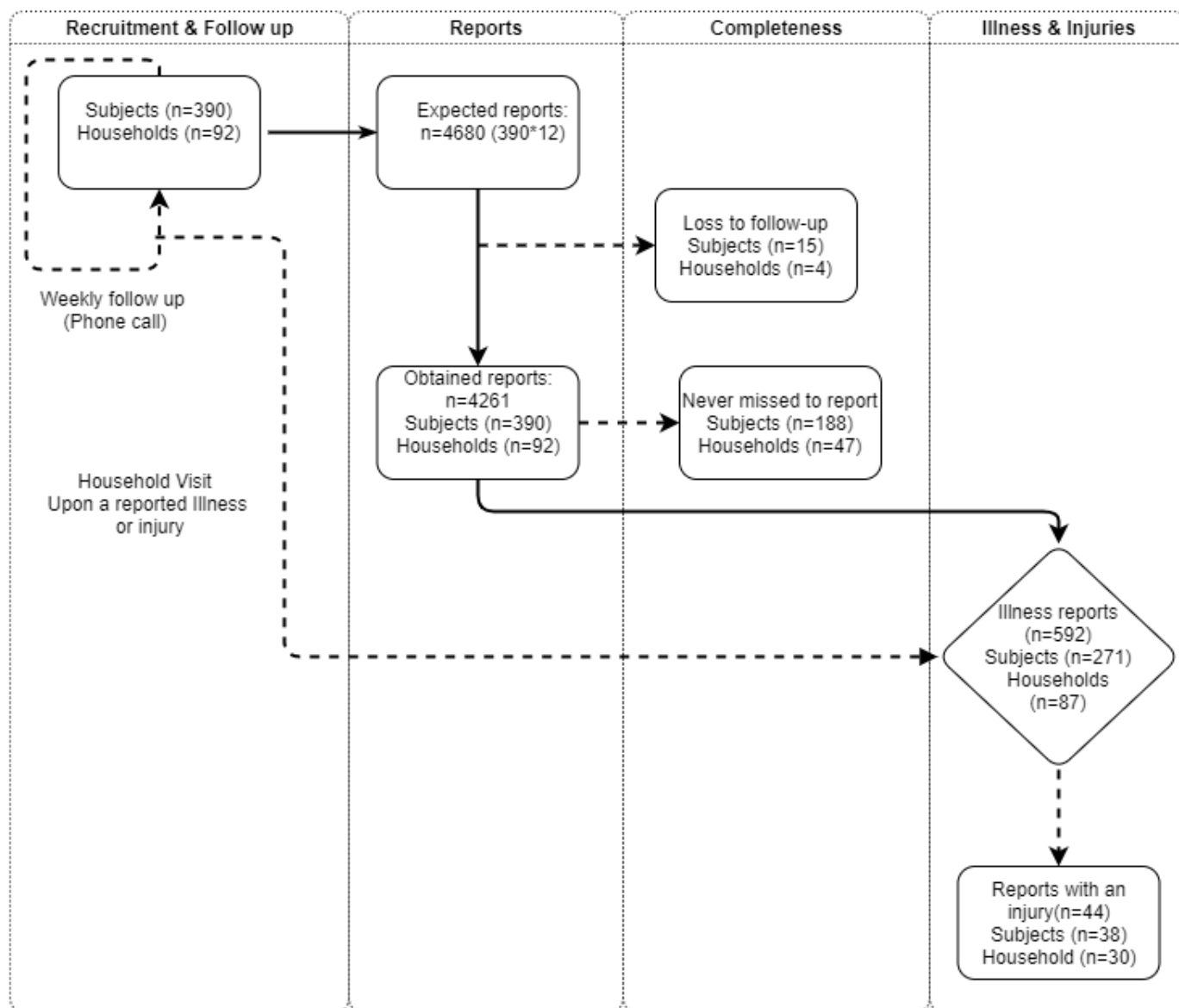
Descriptive characteristics of study subjects collected at recruitment are reported elsewhere.<sup>12</sup> Briefly, of the 390 study subjects, 55% were female. The average age and SD of study subjects were 26.5 and 19.6 years, respectively, ranging from 5 to 83 years. About 53% were still schooling, while 84% had attained some primary education. Of the 47% non-schooling subjects, 46% and 1% engaged in informal and formal occupations, respectively.

### Enrolment and retention of subjects

The enrolment and retention of the study subjects across the study weeks is reported elsewhere.<sup>12 13</sup> Briefly, we

**Table 2** Description of the time-variant variables collected weekly (n=12)

Variable group level	Variable
Household factors	Household size, domestic animals, source of drinking water, mode of water treatment, human waste destination, defecation location, trash disposal
Individual factors	Visit outside the local subcounty, injuries by severity, mechanisms, nature and intent
Environmental factors	Presence of stagnant water due to rain



**Figure 1** Schematic diagram showing the flow of the profile of the descriptive findings.

followed up 390 study subjects across the recruited 92 households weekly for 12 weeks. In total, we obtained 4261 reports covering August–October 2019 against the expected 4680 reports, yielding a response rate of 91% (figure 1). We consistently obtained reports in each week of follow-up without missing data from 188 (48%) of the 390 study subjects (figure 1). These 188 study subjects were members of 47 (51%) of the 92 study households. Only 15 study subjects distributed across four households were lost to follow-up due to other reasons including opting out of the study; however, they did not differ from those who remained in the study (figure 1).

The findings profile is summarised in a schematic diagram (figure 1).

#### Longitudinal distribution of subjects reporting an injury

Of the 4261 reports obtained, 592 (14%) described an illness eligible to be investigated for injuries of which

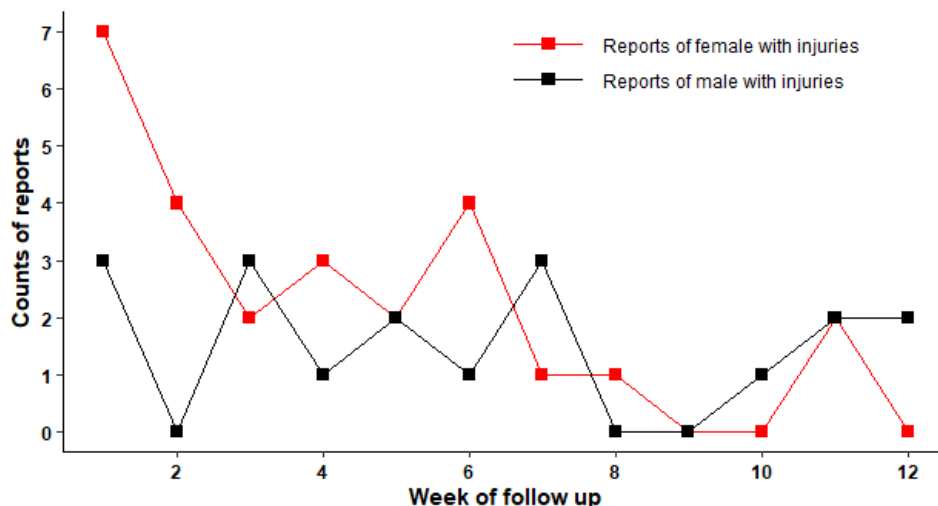
44 (7.4%) documented an injury. Across time, injury frequencies overlapped between male and female subjects (figure 2).

In the 12 weeks of follow-up, the 44 reports came from 38 subjects constituting 10% of the entire 390 study subjects (figure 1). Of these 38 subjects, 55% were female. Additionally, of these 38 subjects, 34% belonged to the young age category, while 50% and 16% belonged to the middle and old age categories. Each of the 38 study subjects had, on average, 1.2 episodes of injuries across the 12 weeks of follow-up, yielding a mean of 17 injuries per 100 weeks (approximately 2 years).

#### Demographic factors and nature of injuries

The nature of injuries tallied in the 44 injury reports was 64% cuts and open wounds, 20% bruises and superficial injuries, 7% dislocations and 5% animal bites, while we tallied burns and fractures in 2.3% of the reports,





**Figure 2** Longitudinal distribution of reports describing injuries.

respectively. Of the 44 reports, women (59%) frequently reported injuries than men ( $p>0.05$ ). On the other hand, the distribution of the 44 reports was 34%, 52% and 14% among young, middle-aged, and older subjects, respectively.

Table 3 shows the distribution of demographic factors and the nature of the injuries. While cuts and wounds were the most often reported among the middle-aged subjects, bruises were the most often reported among the young subjects (table 3).

### Cause of injuries and occupational factors

Irrespective of age and gender, 30%, 25% and 23% of the 44 reports resulted from falls ( $n=13$ ), person-related assault or being hit by an object ( $n=11$ ), and road accidents arising from vehicles or motorcycles ( $n=10$ ), respectively. The remaining 10 injuries were due to cuts from sharp objects, animal bites and fire burns (table 4).

Of the 44 reports of injuries, 18 (41%) and 26 (59%) reports came from school-going and non-school-going subjects, respectively. When classified by the most frequently reported injuries, falls ( $n=13$ ) were more likely (62%) to be reported by school-going subjects. Person-related assault or being hit by an object ( $n=11$ ) and road

accidents ( $n=10$ ) were 64% and 80% more likely to be reported by non-school-going subjects, respectively.

### Multilevel univariable analyses of injuries

We used a multilevel univariable Poisson regression analysis factoring in the correlation of responses at individual and household levels. The analysis assessed the relationship between dichotomised reporting of an injury (yes vs no) and independent variables, returning three factors at  $p<0.1$ . Of these three factors, visits outside the local subcounty of residence was the only factor at the subject level ( $p<0.001$ ). The household-level factor included the keeping of a domestic animal ( $p=0.0081$ ). Additionally, time in weeks treated as a risk factor predicted the occurrence of injuries ( $p<0.001$ ), while the area-level variable did not predict the occurrence (online supplemental table 1S).

### Multilevel multivariate Poisson regression model

Adjusting for age and sex, the multilevel multivariate Poisson regression model factoring individual and household random effects returned three factors. These included making visits outside the local subcounty ( $p=0.007$ ), domesticating an animal ( $p=0.020$ ) and the

**Table 3** Distribution of demographic factors and nature of the injury

Nature of injury	Age group (years)	Female (%)	Male (%)	Injury/1000 subjects/week	95% CI
Cuts, open wound	5–17	4 (14)	5 (18)	17.0	16.4 to 49.3
	18–54	11 (39)	6 (21)	32.2	31.3 to 93.6
	>54	1 (4)	1 (4)	3.8	3.6 to 10.9
Bruises, superficial injury	5–17	1 (11)	3 (33)	7.6	7.3 to 21.8
	18–54	2 (22)	1 (11)	5.7	5.4 to 16.4
	>54	2 (22)	0 (0)	3.8	3.6 to 10.9

Other nature of injuries included dislocation, animal bites, fractures and burns, each having  $\leq 3$  occurrences across age and gender.

**Table 4** Distribution and causes of injury by sex and age

Cause of injury	Age group (years)	Female (%)	Male (%)	Injury/1000 subjects/ week	95% CI
Falls	5–17	4 (31)	4 (31)	15.2	14.6 to 43.8
	18–54	2 (15)	1 (8)	5.7	5.4 to 16.4
	>54	2 (15)	0 (0)	3.8	3.6 to 10.9
Person-related assault or hit by an object	5–17	0 (0)	3 (27)	5.7	5.4 to 16.4
	18–54	2 (18)	4 (36)	11.4	10.9 to 32.8
	>54	2 (18)	0 (0)	3.8	3.6 to 10.9
Road accidents	5–17	0 (0)	0 (0)	0.0	0.0 to 0.0
	18–54	6 (60)	4 (40)	18.9	18.3 to 54.8
	>54	0 (0)	0 (0)	0.0	0.0 to 0.0

Other causes of injuries included cuts from sharp objects, animal bites, and fire burns each having  $\leq 3$  occurrences across age and gender.

study week ( $p=0.038$ ). The risk of reporting an injury decreased by 10% weekly. Subjects who made a visit outside the local subcounty were twofold higher at risk of reporting a physical injury at any study week compared with those who did not make a visit. Subjects not domesticating animals were eight times higher at risk of reporting injuries at any study week compared with those domesticating animals (table 5).

## DISCUSSION

This study aimed to investigate factors associated with the weekly occurrence of physical injuries in a rural setting in Western Kenya. We determined the unique differences in nature, source and risks resulting from occupational, societal and demographic exposures associated with injuries. Injuries were more frequently reported by female subjects than male subjects, though the difference was non-significant. Moreover, the common causes of injuries

among young, middle-aged and older subjects were falls, road accidents and person-related assault or being hit by an object, respectively. We classified these causes into occupational and societal risk exposures resulting from making visits outside the local subcounty and not owning a domestic animal that independently predicted the occurrence of injuries.

Injuries were more often reported by middle-aged subjects relative to other age groups, suggesting age-related differential exposures. Previous studies disproportionately link high injury frequencies among adults and communities with low education and poverty levels similar to our setting.<sup>24 25</sup> Indeed, the majority (70%) of the middle-aged subjects reporting injuries had primary or no education, earning a low monthly income of >10 000 Kenya shillings (~US\$100). The more frequent reports from female subjects that we found contrasted with findings from a cross-sectional study conducted

**Table 5** Random-intercept Poisson regression model analysis for injuries

Variable	Levels	IRR	IRR (95% CI)	P value
Week		0.90	0.82 to 0.99	0.038
Visits outside	Yes	2.16	1.54 to 3.11	0.007
	No	Reference	–	
Domesticate animals	Yes	Reference	–	
	No	7.59	1.38 to 41.7	0.020
Gender	Male	0.87	0.37 to 2.04	0.748
	Female	Reference.	–	
Age		1.00	0.99 to 1.03	0.454
Random parameter				
Variance	Household (level 3)	0.63		
	Study participant (level 2)	4.05		
	Residual (level 1)	8.28		

Akaike information criterion 464.9, Bayesian information criterion 515.8, log likelihood –224.5, deviance 448.9. IRR, incident rate ratio.

elsewhere in Kenya,<sup>26</sup> perhaps due to more women taking up more strenuous roles in male-dominated sectors.<sup>27</sup> This finding suggested varied risk exposures between gender and their physical or social environments. People with low levels of education especially in rural settings are more likely to engage in occupations with elevated risks for injuries. Hence, there is a need for targeted public health interventions to promote home and occupational safety in rural areas.<sup>25</sup>

We documented a fairly small number of 0.21 injuries weekly from 34% of the 87 study households that reported an illness, with the majority (61%) of such injuries resulting from falls and person-related assault or being hit by an object. While injuries due to person-related assault could have resulted from violence or abuse, among other causes that this study did not focus on, those from falls resulted from essential daily activities including household chores, farming and schooling among others, which could have potentially advanced the risk of physical injuries. Indeed, although earlier studies associate the essential daily activities and occupations with the occurrence of unintentional injuries and physical violence or abuse with intentional injuries across all age groups, gaps still exist in their documentation and subsequent social or economic impacts in rural settings.<sup>28</sup> Nonetheless, preventable injuries could be overcome by investing in home or occupational safety in rural areas.<sup>29</sup>

Subjects not domesticating animals were eight times at higher risk of reporting injuries compared with those domesticating animals. Indeed, those domesticating animals were likely to use them, particularly cattle, for draught power compared with those not domesticating and therefore likely to use risky hand tools or outdated machinery during farming or in any other activities. Such tools and machines increased the likelihood of injuries, as also identified in cross-sectional studies conducted in Nepal and Ethiopia.<sup>30 31</sup> On the other hand, the reduced risk (1/8) of reporting injuries among subjects domesticating animals signals the minimal exposure to injury-prone inanimate machines or tools in livestock farming or transportation. Nevertheless, there is still a need to create awareness on occupational safe handling of domestic animals.<sup>32 33</sup>

Under the societal exposure of injuries, subjects making visits outside the subcounty of residence were at twofold higher risk of reporting injuries perhaps due to increased use of motorcycles as a mode of transport.<sup>34 35</sup> Motorcycles are beginning to be a frequent cause of injuries in Kenya, arising from crashes due to varied factors.<sup>36</sup> Indeed, all motorcycle-related and vehicle-related injuries were most frequent among subjects aged between 18 and 54 years compared with other age categories since this group is generally more active and productive while seeking livelihoods. Previous studies associate adults aged above >18 years with risky behaviours such as drunk riding, failing to wear a helmet while riding, riding with excess passengers and speeding among others.<sup>36 37</sup> For these reasons, road safety interventions including enforcement of mandatory

use of helmets, driver training and age-restricted motorcycle ownership and licensure could be instituted to reduce related injuries in similar rural settings.<sup>38</sup>

## CONCLUSION

The study established the existence of occurrences of physical injuries in a rural setting. Subjects who made a visit outside the subcounty of residence were more likely to report injuries relative to those who did not. Further, subjects not domesticating animals were more likely to report injuries relative to those domesticating animals. These findings suggest that tackling increasing risk exposures in rural western Kenya using targeted public health interventions could effectively reduce injuries across all age groups.

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