ORIGINAL RESEARCH

Risk Factors for Injuries in Landslide- and Flood-Affected Populations in Uganda

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Abstract

Introduction: The frequency of occurrence of natural disasters has increased over the past several decades, which necessitates a better understanding of human vulnerability, particularly in low-resource settings. This paper assesses risk factors for injury in the March 2010 floods and landslides in Eastern Uganda, and compares the effects of location, injury type, and severity.

Methods: A stratified cluster survey of the disaster-affected populations was conducted five months after onset of the disasters. Probability proportional to size sampling was used to sample 800 households, including 400 affected by floods in Butaleja District and 400 affected by landslides in Bududa District.

Results: Flood- and landslide-affected populations were surveyed in July 2010 using a stratified cluster design. The odds of injury were 65% higher in the flood-affected groups than the landslide-affected groups in a logistic regression (OR = 0.35; 95% CI, 0.24-0.52; $P < .001$). The injury rate was greater in individuals under 42 years of age, and location of injury was a contributing factor. More people were injured in the flood-affected population as compared with the landslide-affected population, and injuries were more severe.

Conclusions: This study illustrates differences between populations injured by flood and landslide disasters that occurred simultaneously in Eastern Uganda in 2010. In areas where landslides are prone to occur due to massive rainfalls or floods, preventative measures, such as early warning systems and evacuation, are more likely to increase the likelihood of people surviving, while for areas with massive floods, immediate and effective medical attention can save lives and improve injury outcomes.

Agrawal S, Gopalakrishnan T, Gorokhovich Y, Doocy S. Risk factors for injuries in landslide- and flood-affected populations in Uganda. *Prehosp Disast Med*. 2013;28(4): 314-321.

Introduction

Natural disasters can have significant impacts on the health and development of a region. Disasters such as floods, landslides, earthquakes, tropical cyclones, volcanic eruptions, and tsunamis have the potential to be catastrophic and lead to massive alterations in the lives of those affected; effects include loss of property and life, injury and morbidity, long-term displacement, disruptions in livelihoods, and widespread economic effects. The growing impact of natural disasters has triggered a need to enhance the understanding of human and social vulnerability to disasters[1-3] and to improve both the quality of data and management of information that guides the humanitarian response following disasters. It is important that relief and recovery efforts be informed in order to target assistance and response interventions appropriately and facilitate recovery. Analysis of risk factors for outcomes such as mortality, injury, and displacement can serve to inform both disaster response and risk reduction efforts. Information gathered from previous disasters can serve as a basis for an improved understanding of the most vulnerable groups, which can be applied in targeting of early warning messaging and humanitarian assistance in the immediate aftermath of disasters.

In late February of 2010, several consecutive days of heavy rains in the Butaleja and Bududa Districts of Eastern Uganda precipitated flooding and landslides which resulted in the destruction of crops, infrastructure, water and sanitation facilities; widespread displacement; and increased morbidity and mortality.[4-6] The Butaleja floods were concentrated in low-lying areas adjacent to the River Manafwa and affected more than 38,780 people[7] while the Bududa landslides resulted in 388 deaths, and was the deadliest disaster in Africa during 2010.[8] Disaster modeling and surveys of affected populations have a practical role in assisting governments and humanitarian organizations in disaster response by promoting informed management and decision making. Assessments characterizing aspects of population movements, unmet needs, living conditions, and health data with spatial modeling are ideal for providing information on disaster vulnerability and impact. The objective of this study was to assess the impacts of the floods and landslides on the local populations and to ascertain risk factors for outcomes such as injuries.

Methods

A stratified cluster design was used to enable comparison between the two affected populations where 20 clusters of 20 households were surveyed in both the flood- and landslide-affected areas. Because numerous indicators were assessed, sample size calculations were based on a maximally conservative proportion of 0.50 and on the assumption that disaster type and geographic location were the most important determinants of impact. Sample size calculations assumed 80% power and a significance level of .05 and were performed at the household level. A final sample size of 800 was determined, including 400 households affected by each disaster type. A household was considered "affected" and included in the study if it was within the target districts of Bududa or Butaleja and there was a death or injury of a household member, damage or destruction of the home, destruction of crops, and/or if the household's livelihood was adversely affected.

In the flood-affected District of Butaleja, a sub-county level environmental vulnerability index was created with Geographic Information Systems (GIS) using administrative boundaries from the United Nations, regional rainfall data for the January to May time period, and spatially distributed population data from the Global Rural Urban Mapping Project (GRUMP).[9-11] Monthly intensity of rainfall was used as a proxy of risk and population density was used to approximate the size of the population at risk. Clusters were then allocated using probability proportional to size sampling methods based on the vulnerability analysis. Clusters were randomly assigned to parishes in each sub-county using lists provided by local authorities; a similar process was used to select a village within each parish.

In the landslide-affected area district of Bududa, a list of most-affected villages was compiled based on the United Nations interagency assessment report and discussions with the Bulecheke Camp Chairman. Fourteen villages were affected, with six classified as most affected. The sample was limited to most-affected villages because of access constraints. A total of 14 clusters were assigned to the most-affected communities; Nametsi was allocated double the number of clusters as the other most-affected villages because its population was approximately twice that of other communities. QJ;No reliable estimate on the proportion of households remaining in the villages was available, though local sources indicated approximately half of the affected population was residing in the camp. As a result, clusters assigned to the six most-affected communities were evenly divided between households in communities and those resettled in the camps. The remaining six clusters were assigned to camp residents from the other eight affected villages. The total affected population of each village as reported by the community leader was used to determine the sampling interval for systematic sampling of households. In camp settings, a similar process was used; however, potential respondents were screened by community of origin to ensure the sample was representative of the exposed population.

The interview team was comprised of Ugandans affiliated with Makerere University School of Public Health. Interviewers were fluent in English and Luganda, and the majority spoke at least one other local dialect. Interviewers received two days of training on informed consent, survey research and sampling methods, and questionnaire administration. The survey instrument was developed in English and translated to Lumasaba, the predominant local language; prior to finalization, the questionnaire was piloted. The survey required 25-45 minutes per household to complete. Interviewers worked in two teams, each of which was accompanied by a supervisor who managed sampling and reviewed questionnaires. If respondents did not speak English or Lumasaba, oral translation into the local dialect was used. Consent of the District Administrative Officer and local community and/or camp leaders was sought prior to conducting interviews in each location. The study was reviewed and approved by Institutional Review Boards at Johns Hopkins Bloomberg School of Public Health and Makerere University School of Public Health.

The baseline characteristics of sex, age, and age-specific injury rates of the two populations impacted by the natural disasters were examined separately. Simple logistic regression was done to measure the crude odds ratio of injury based on the event (landside vs flood), sex, and age spline variables. Multiple logistic regressions were then used to measure the adjusted odds ratio of injury based on the event, sex, and age spline variables. Wald test statistics were used to assess associations. A second simple logistic regression was run that included only the injured to measure the crude odds ratio of event (landslide vs flood) based on the sex, age spline, effects of location, severity and type of injury, and final injury outcome. Lowess smoothing plots were used to determine that age should be converted to a spline variable, with age 42 for the first model. Data was analyzed using Stata, version 11.0 (StataCorp LP, College Station, Texas, USA).

Results

A total of 3211 individuals in flood-affected households and 3140 in landslide-affected households were exposed to each disaster. Flood and landslide populations were similar in terms of age ($P = .585$) and sex ($P = .597$), but statistically different in terms of total injuries ($P < .001$). A total of 137 injuries were reported, including 101 in the flood-affected population and 36 in the landslide-affected population (Table 1).

The odds of an injury in the landslide-affected population were significantly different between females and males, where females were 59% less likely to be injured than males (OR = 0.41; CI, 0.20-0.83; $P = .013$). No significant difference in odds of injury was observed by sex in flood-affected populations ($P = .859$). In the flood-affected population, increased odds of injury (OR = 2.12; CI, 1.03-4.37; $P = .042$) were observed among older adults (age > 60 y) as compared with a reference population of children (<17 y); the odds of injury were similar among working-age adults (18-59 years) when compared with children ($P = .723$). Conversely, in the landslide population, increased risk of injury was observed in the working-age adults (OR = 10.91; CI, 4.22-28.20, $P < .001$); the odds of injury were similar for older adults when compared with children ($P = .197$).

Injuries among the flood-affected population							
	Total Exposed	Total Injured	Injury Rate (per 1000)		Odds of Injury		
			Point Estimate	95% CI	OR	95% CI	*P* Value
Overall	**3211**	**101**	**31**	**26-38**			
By Sex							
Male	1530	49	32	24-42	Reference	-	-
Female	1681	52	31	23-40	0.965	0.65-0.43	.859
By Age Category							
0-17	1950	57	29	22-38	Reference	-	-
18-59	1111	35	32	22-46	1.08	0.70-1.66	.723
60+	150	9	60	28-111	2.12	1.03-4.37	.042
Age Specific Injury Rates, Males							
0-17	953	33	35	24-48	Reference	-	-
18-59	503	12	24	12-41	0.681	0.35-0.33	.262
60+	74	4	54	15-133	1.593	0.55-4.62	.392
Age Specific Injury Rates, Females							
0-17	997	24	24	15-34	Reference	-	-
18-59	608	23	38	24-56	1.59	0.89-2.85	.116
60+	76	5	66	22-147	2.86	1.06-7.70	.038
Injuries among the landslide-affected population							
	Total Exposed	**Total Injured**	**Injury Rate (per 1000)**		**Odds of Injury**		
			Point Estimate	**95% CI**	**OR**	**95% CI**	***P* Value**
Overall	**3140**	**36**	**11**	**8-16**			
By Sex							
Male	1517	25	16	11-24	Reference	-	-
Female	1623	11	7	3-12	0.407	0.20-.083	.013
By Age Category							
0-17	1947	5	3	0-6	Reference	-	-
18-59	1098	30	27	19-39	10.91	4.22-28.20	<.001
60+	95	1	11	1-58	4.13	0.48-35.72	.197
Age Specific Injury Rates, Males							
0-17	926	1	1	0-6	Reference	-	-
18-59	536	23	43	27-64	41.471	5.58-307.98	<.001
60+	55	1	18	5-97	17.129	1.06-277.60	.046
Age Specific Injury Rates, Females							
0-17	1021	4	4	1-10	Reference	-	-
18-59	562	7	12	5-26	3.21	0.94-11.00	.064
60+	40	0	0	-	-	-	-

Table 1. Injury Characteristics of Flood- and Landslide-Affected Populations

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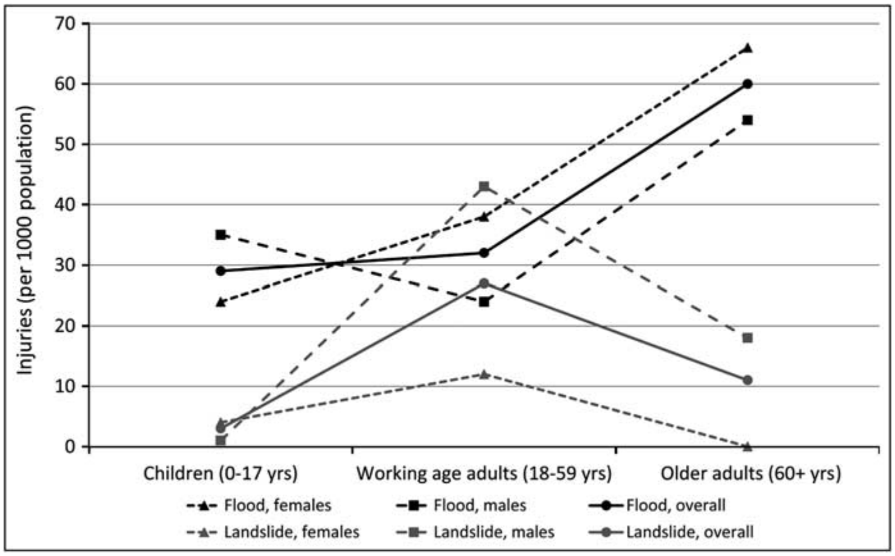

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Figure 1. Flood and Landslide Injury Rates by Sex and Age Group

The age-specific injury rate is significant for the different age categories in the landslide-affected population, with working-age and older males being 41 and 17 times, respectively, more likely to be injured by a landslide than male children (OR = 41.47; CI, 5.58-308.0; $P < .001$; and OR = 17.13; CI, 1.06-277.6; $P = .046$, respectively). Injury risk was statistically similar among males in the three age groups in the flood-affected population. Among females, no significant difference in injury risk was observed in the landslide-affected population. In the flood-affected population, older females were significantly more likely to be injured as compared with female children (OR = 2.86; CI, 1.06-7.70; $P = .038$) and injury risk was statistically similar among working-age females and female children ($P = .116$). Age- and sex-specific injury rates for the two disasters are presented in Figure 1.

The ANOVA tests for the equality of means across different subcategories were not significant for the type of injury ($P = .120$) or the final outcome of the injury ($P = .200$) but were for the location of first care ($P < .001$). This indicates that the type of injuries in both flood- and landslide-affected populations were similar. However, the Bartlett's test for the ANOVA for final outcome of injury or location of first care was not significant ($P = .240$; $P = .062$), so the equality of means for these variables in the two populations may not be accurate.

Characteristics of the circumstances of injuries in floods and landslides are summarized in Table 2. Within only the injured population, a comparison of the odds of the event (flood or landslide) for different covariates indicates that there is a statistically significant association between the natural disaster (flood or landslide) and location where the injury occurred ($P < .001$), the severity of the injury ($P = .002$), and the final outcome of the injury ($P = .013$). There was, however, no statistically significant association found between the natural disaster and type of injury ($P = .243$). Floods injuries were more likely to occur at home (78.2%) while more landslide injuries occurred outdoors (33.3%). When examining the types of injuries, flood injuries were predominantly bruises or abrasions (31.7%) followed by broken bones or fractures (21.8%) and sprains or strains (11.9%). Among those injured in the landslide, broken bones and fractures (44.4%) were the most common type of injury followed by bruises and abrasions (27.8%) and internal organ injuries (11.1%).

The results of the regression with the odds of injury as the outcome showed a statistically significant association with the event (flood or landslide), indicating that the odds of injury were 65% higher in the flood-affected population than in the landslide-affected population (MLR OR = 0.35; CI, 0.24-0.52; $P < .001$). This is described in Table 3. There was no association observed between log odds of injury and sex ($P = .139$) in the final multivariate model. The interaction terms that were generated included age, age categories, age spline at 42, sex, and event. There was a statistically significant effect modification observed between the natural disaster and age variables: age (OR = 1.02; CI, 1.00-1.04; $P = .033$), age category (OR = 3.09; CI, 1.60-5.97, $P < .001$) and age spline at 42 (< 42 OR = 1.06; CI, 1.02-1.09; > 42 OR = 0.86; CI, 0.77- 0.91; $P = .008$). This indicates that the difference in the odds ratio of injury between landslides and floods varies significantly with age. There was no interaction between sex and age or event.

Table 4 shows regression output conducted for the odds of the occurrence of the event within the injured population as the outcome. The crude estimate of sex was statistically significant (OR = 0.42; CI, 0.19-0.93; $P = .033$) while the adjusted estimate was not (OR = 0.61; CI, 0.18-2.15; $P = .445$) indicating the odds of injury due to landslides (vs floods) were 58% higher for males than for females when other factors are not accounted for, but that this association did not remain after adjusting for age and location. A significant age-dependent increase in the odds of injury due to landslides (vs floods) was observed in the unadjusted model (OR = 1.02; CI, 1.00-1.04; $P = .037$) indicating that the odds of injury due to landslide (vs floods) increased with age; however, similar to the findings for sex, this association was not significant in the adjusted model (OR = 1.03; CI, 1.00-1.06; $P = .089$). With respect to location, the odds that injury was due to landslide (vs flood) if the injury occurred indoors (not at home) were significantly greater in both unadjusted and adjusted models

	Comparison by Disaster Type				
	Floods		Landslides		
	n	%	n	%	*P* Value
Location where injury occurred	101		36		
At home	79	78.2	8	22.2	
Indoors	11	10.9	11	30.6	<.001
Outdoors	8	7.9	12	33.3	
In a vehicle	0	0.0	0	0.0	
Not reported	3		5		
Type of injuries	101		36		
Bruise or abrasion	32	31.7	10	27.8	
Sprain or strain	19	18.8	2	5.6	
Laceration (not infected)	4	4.0	3	8.3	
Laceration (infected)	2	2.0	0	0.0	
Broken bone or fracture	22	21.8	16	44.4	.243
Internal (organ) injury	12	11.9	4	11.1	
Internal head injury	2	2.0	1	2.8	
External head injury	5	5.0	0	0.0	
Other	11	10.9	1	2.8	
Unknown	2	2.0	1	2.8	
Not reported	4		5		
Severity of injuries	100		36		
Minor that did not require medical care	30	30.0	4	11.1	.002
Serious that required medical attention	67	67.0	25	69.4	
Not reported	3		7		
Final outcome of injuries	101		36		
Healed well/able to function regularly	58	57.4	11	30.6	.013
Partial loss of use	27	26.7	15	41.7	
Full loss of use or lasting disability	4	3.9	2	5.6	
Death	6	5.9	1	2.3	
Not reported	6		7		
Location where first care was received	90		34		
Hospital	31	34.4	19	55.9	
Clinic or primary health center	37	41.1	5	14.7	.087
Traditional healer	9	10.0	0	0.0	
Other	9	10.0	3	8.8	
Not reported	4		7		

Table 2. Comparison of Injuries Characteristics by Natural Disaster Type

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	Crude Odds			Adjusted Odds		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Event						
Flood	Reference	-	-	Reference	-	-
Landslide	0.36	0.24-0.52	<.001	0.35	0.24-0.52	<.001
Sex						
Male	Reference	-	-	Reference	-	-
Female	0.78	0.56-1.10	.154	0.77	0.55-1.09	.139
Age						
< 42 years	1.03	1.01-1.04	.000	1.03	1.01-1.04	.001
> 42 years	0.99	0.96-1.02	.394	0.98	0.95-1.01	.267

Table 3. Crude and Adjusted Odds Ratios of Injury
E (log odds of injury) = $ß_0 + ß_1$event + $ß_2$sex + $ß_3$age + $ß_4$(age − 42).[a]
[a]Spline term: if age < 42 = age OR if age ≥ 42 = (age − 42).

(SLR OR = 9.87; CI, 3.26-29.89; $P < .001$; and MLR OR = 12.22; CI, 3.22-46.38; $P < .001$, respectively). A similar association was observed for injuries that occurred outdoors (SLR OR = 14.81; CI, 4.67-46.91; $P < .001$; and MLR OR = 63.4; CI, 9.69-415.74; $P < .001$).

In terms of severity of injury, the unadjusted odds of a severe injury were 63% greater in the flood-affected vs landslide-affected populations (SLR OR = 0.27; CI, 0.10-0.44; $P < .001$); however, this finding did not remain significant in the adjusted model ($P = .266$). In most cases, no significant difference in the odds of injury type was observed between flood- and landslide-affected populations. However, in the final multivariate model it was significantly more likely that the more severe types of injuries, including broken bones or fractures (MLR OR = 57.55; CI, 3.61-961.4; $P = .004$) and internal organ injuries (MLR OR = 43.17; CI, 2.10-890.0; $P = .015$), were caused by landslides as compared with flood. With respect to final injury outcomes including permanent disability and death, no significant differences were observed in the final multivariate model between populations injured in the flood and landslide.

Discussion

This study was conducted to understand the consequences of two natural disasters that affected similar populations in neighboring districts of Eastern Uganda in 2010. While precipitated by the same heavy rains, the two disasters were very different in nature as were the responses they elicited. The landslide was a rapid-onset, high-mortality event that elicited a substantial response from both the national government and international community, including camps for the displaced population. The floods were a comparatively slow-onset event that affected a much larger population but that had low levels of mortality and a substantially smaller humanitarian response.

With respect to human impacts, mortality was significantly greater at 45.2 deaths per 1000 population (CI, 38.2-53.1) in the landslides than in floods where the mortality rate was 15.6 deaths per 1000 population (CI, 11.6-20.5). In contrast, injury rates were significantly greater in the flood-affected population at 31 per 1000 (CI, 26-38) as compared with 11 per 1000 (CI, 8-16) in the landslide-affected population. The relationship between age and sex and injury and mortality in each of the two events is illustrated in Figure 2. Lower levels of mortality among children (0-17 y) and higher levels of mortality among adults (regardless of age) and an elevated level of injury among working adults (18-59 y) were characteristic of the landslides. In contrast, high levels of mortality and injury were observed among older adults (> 60 y) in the floods, with similar levels of injury among children and working age adults and the lowest mortality in working-age adults. Overall, age-specific mortality rates were greater in the landslides and floods for all age groups whereas age-specific injury rates were higher in the floods than in the landslides for all age groups.

Numerous others factors contributed to observed differences in injury patterns between the populations, including differential risk between flood- and landslide-affected populations by age, location at the time the injury occurred, the severity and type of injury, and the final outcome of injury in terms of lasting disability or death. Moreover, floods caused more severe injuries than landslides and resulted in a higher degree of loss of function or disability. Landslides, on the other hand, caused a greater number of fractures and lacerations than floods. Location of injury was also an important contributing factor; more individuals were injured outdoors (or not in their homes) as compared with in their homes.

In evaluating the implications of such events and the ways in which the local and national government can be better prepared, it is pertinent to examine the history of events in the area. Floods and landslides are a recurrent problem;[12] however, the scale of the flooding in 2010 stands out with respect to intensity and level of damage. The last major flooding that affected the area occurred in 1997, following the El Niño rains. The timing of the 2010

	Crude Odds			Adjusted Odds		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Sex						
Male	Reference	-	-	Reference	-	-
Female	0.42	0.19-0.93	.033	0.61	0.18-2.15	.445
Age	1.02	1.00-1.04	.037	1.03	1.00-1.06	.089
Location of Injury						
In the home	Reference	-	-	Reference	-	-
Indoors (elsewhere)	9.87	3.26-29.89	<.001	12.22	3.22-46.38	<.001
Outdoors	14.81	4.67-46.91	<.001	63.46	9.69-415.7	<.001
Category of Injury						
Sprain or strain	Reference	-	-	Reference	-	-
Bruise or abrasion	5.14	0.60-44.39	.136	23.19	1.57-343.5	.022
Laceration (uninfected)	15.99	0.96-267.0	.054	6.07	0.23-158.7	.279
Broken bone or fracture	10.39	1.22-88.17	.032	57.55	3.61-916.4	.004
Internal organ injury	4.36	0.40-47.61	.227	43.17	2.10-890.0	.015
Internal head injury	7.99	0.35-184.3	.194	17.72	0.43-736.6	.130
Other	1.45	0.82-25.81	.798	2.81	0.10-77.49	.541
Severity of Injury						
Minor	Reference	-	-	Reference	-	-
Severe	0.27	0.10-0.44	<.001	2.36	0.52-10.72	.266
Final Injury Outcome						
No loss of function	Reference	-	-	Reference	-	-
Some loss of use	2.93	1.19-7.22	.020	2.53	0.70-9.13	.156
Full loss of use	2.64	0.43-16.20	.295	1.12	0.13-9.99	.916
Died as a result of injury	0.88	0.10-8.03	.909	0.36	0.02-5.20	.451

Table 4. Crude and Adjusted Odds Ratio of Event Given a Subpopulation of Deceased
E (log odds of event in injured population) = $ß_0 + ß_1$age + $ß_2$sex + $ß_3$location of injury + $ß_4$injury severity + $ß_5$final injury outcome.

floods were also earlier than usual, as they happened before the start of the main rain season, which is usually expected around mid-March.[7] Regardless, in order to mitigate injuries and mortality in any flood-prone areas, flood prevention and mitigation strategies need to be evaluated with respect to the local context and acted upon.[13,14]

Limitations

This study had several important limitations. First, a larger sample size would have enabled more statistical power for analyses. This would have been advantageous considering the relatively small number of total injuries and, in the case of some variables, the existence of missing values. Second, the data may not be representative of the entire population because high rates of displacement are common after floods and landslides. Limited information was available on the size and location of the affected populations, including the displaced population and returnees. Households that resettled a significant distance away and did not return were not included in the sampling frame; if a sizable proportion of the population resettled elsewhere, it is possible the sample is not representative of the exposed population which could result in bias. Finally, the household survey design was such that it did not capture any health facility data. Health facility records may have provided more accurate information on injuries. While some health facility data was obtained in Butaleja, its utility was limited because it was unlikely to be representative

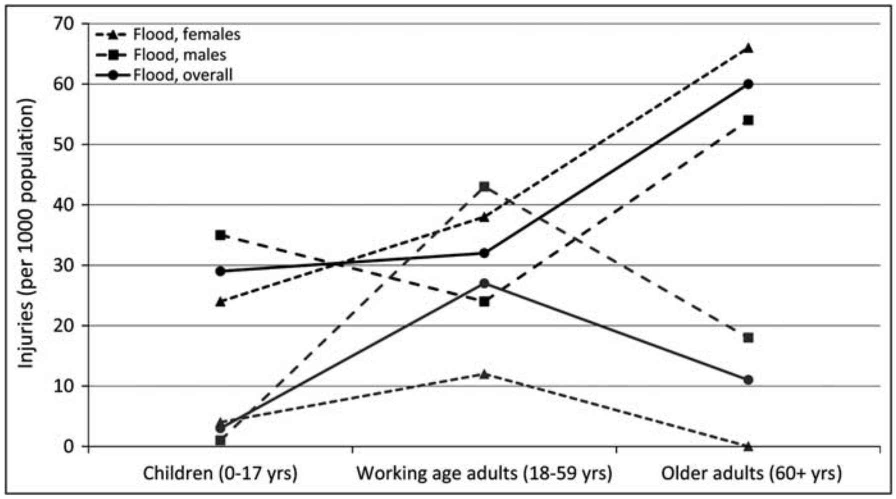

Figure 2. Flood and Landslide Injury and Mortality Rates by Age Group

of all the injuries in the immediate post-disaster period when many facilities in the most affected areas were either closed or inaccessible.

Conclusions

In the 2010 floods and landslides in Uganda, injury rates were greater in the flood-affected population as compared with the landslide-affected population; however, this finding must be interpreted in conjunction with significantly higher mortality rates in the landslide-affected population. In the landslide-affected population, the highest injury rates were observed among working-age adults, whereas in the flood-affected population injury was most prevalent among older adults. Injury rates were similar by sex in the floods, whereas males were significantly more likely to be injured in the landslide. Location of the individual at the time injury occurred was also an important contributing factor; in both events, more individuals were injured outdoors or inside but not at home compared with those who were at home. With respect to the type of injuries observed, the most prevalent injuries in floods were bruises and abrasions, broken bones or fractures, and sprains or strains. In landslides, the most prevalent injuries were broken bones or fractures, bruises or abrasions, and internal organ injuries. The results of this study illustrate the important differences between the injured populations impacted by the separate natural disasters (flood and landslide). In areas where landslides are prone to occur due to massive rainfalls or floods, preventative measures such as early warning systems and evacuation are more likely to increase the likelihood of people surviving, while for areas with massive floods, immediate and effective medical attention can save more lives. This is particularly important for regions like Eastern Uganda where heavy rainfalls, flooding. and landslides are reoccurring acts of nature.

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