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Comparison of childhood household injuries and risk factors between urban and rural communities in Ghana: A cluster-randomized, population-based, survey to inform injury prevention research and programming

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ABSTRACT

Background: Childhood household injuries incur a major proportion of the global disease burden, particularly in low- and middle-income countries (LMICs). However, household injury hazards are differentially distributed across developed environments. Therefore, we aimed to compare incidence of childhood household injuries and prevalence of risk factors between communities in urban and rural Ghana to inform prevention initiatives.

Methods: Data from urban and a rural cluster-randomized, population-based surveys of caregivers of children <5 years in Ghana were combined. In both studies, caregivers were interviewed about childhood injuries that occurred within the past 6 months and 200 meters of the home that resulted in missed school/work, hospitalization, and/or death. Sampling weights were applied, injuries and incidence rate ratios (IRRs) were described, and multi-level regression was used to identify and compare risk factors.

Results: We sampled 200 urban and 357 rural households that represented 20,575 children in Asawase and 14,032 children in Amakom, Ghana, respectively. There were 143 and 351 injuries in our urban and rural samples, which equated to 594 and 542 injuries per 1,000 child-years, respectively (IRR 1.09, 95%CI 1.05-1.14). Toddler-aged children had the highest odds of injury both urban and rural communities (OR 3.77 vs 3.17, 95%CI 1.34-10.55 vs 1.86-5.42 compared to infants, respectively). Urban children were more commonly injured by falling (IRR 1.50, 95%CI 1.41-1.60), but less commonly injured by flame/hot substances (IRR 0.51, 95%CI 0.44-0.59), violence (IRR 0.41, 95%CI 0.36-0.48), or motor vehicle (IRR 0.50, 95%CI 0.39-0.63). Rural households that cooked outside of the home (OR 0.36, 95%CI 0.22-0.60) and that also supervised older children (OR 0.33, 95%CI 0.17-0.62) had lower odds of childhood injuries than those that did not.

Conclusions: Childhood injuries were similarly common in both urban and rural Ghana, but with different patterns of mechanisms and risk factors that must be taken into account when planning prevention strategies. However, the data suggest that several interventions could be effective, including: community-based, multi-strategy initiatives (e.g., home hazard reduction, provision of safety equipment, establishing community creches); traffic calming interventions in rural community clusters; and passive injury surveillance systems that collect data to inform violence and broader prevention strategies.

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Introduction

Injury is a leading cause of preventable death and disability globally, particularly among children and young people [1]. Injuries account for 14% of toddler-aged child deaths and are the most common cause of death for children older than 13 years worldwide [1,2]. However, death is the least common manifestation of injury; injuries more commonly result in short- or long-term physical and psychosocial disability, school and social activity absenteeism, and stress within family and community structures [3]. The impacts of childhood injury are disproportionately experienced by children, families and communities in low- and middle-income countries (LMICs) due to a lack of prevention initiatives, limited access to timely trauma care, and a near-absence of holistic rehabilitation and community and school reintegration programs [2,4–6].

The lack of prevention initiatives in LMICs is due, in part, to a paucity of data regarding the incidence, hazards and risk mitigating factors of injury [2,3,7–9]. This is particularly true in sub-Saharan Africa, where childhood injuries are increasingly concentrated [1]. Given the extremes in developed environments of sub-Saharan Africa (i.e., differences in population densities, demography, community structures), there are likely considerable differences in the incidence of injuries, mechanisms, and types and distributions of hazards across these contexts [10–13]. Differences in injury characteristics by developed environments have been extensively studied in many high-income countries, and provide invaluable information for evidence-based injury prevention programming [14]. Equivalent data from sub-Saharan Africa are too sparse to allow meaningful conclusions to be drawn [15–17]. The differences in the burden of and risk factors for injuries among children who live in urban and rural Ghana are not well described, and are likely to be as common and diverse as in other sub-Saharan African countries.

Children are most commonly injured in or around the home [3,18]. Although there are a number of injury prevention initiatives that target household and neighborhood injuries among children in high-income countries (e.g., childproofing cabinets, thermoregulation of hot water heaters, smoke detectors, boundary gates, traffic calming), there is insufficient evidence to inform prevention initiatives or guidelines in LMICs, particularly those that might be unique to urban or rural communitites [2,3,8,9,19,20]. Although preventing injuries in LMIC households would support progress toward achieving Sustainable Development Goal 3.2 (i.e., reduce childhood mortality), little attention is paid to addressing this enormous and nuanced global public health problem that differentially affects urban and rural children and their families.

Therefore, we aimed to compare the incidence of household injuries among children who live in urban communities to that among children who live in rural communities in Ghana. Additionally, we aimed to describe structural and modifiable household risk factors for childhood injuries between these developed environments in an effort to identify potential prevention initiatives that could be differentially deployed to urban and rural communities.

Methods

Setting

Ghana is a lower-middle income country in West Africa that sits on the Atlantic Ocean and borders Togo, Cote d'Ivoire, and Burkina Faso [21]. Approximately 55% of Ghanaians live in urban communities (i.e., greater than 1,000 persons per square kilometer) [21]. Many rural communities are proximate to more populated areas that have some health resources (e.g., health promotion initiatives, organized prehospital care services, referral and tertiary hospitals), but there is markedly lower penetrance of health initiatives and poorer access to healthcare services in rural areas. As in other LMICs, rural communities in Ghana that are adjacent to more populated areas are often home to particularly marginalized people who work in very low-wage jobs within the adjacent urban area, agriculture or pastoralism, or practice subsistence activities.

Study design and sample strategies

We combined data from two cluster-randomized, population-based, surveys; one conducted in an urban district and one conducted in a rural district. The urban study was nested within the sampling frame of the Bill and Melinda Gates Foundation-funded Family Health and Wealth Study (FWHS) in Ghana that has been previously published [16,22]. Briefly, a sub-district within the metropolis of Kumasi, Ghana was randomly selected (Asawase sub-metropolis). Asawase was equally divided into four geographic units. Forty administrative areas were randomly selected using population proportional to size sampling. Twenty households per administrative area were randomly selected from a sampling frame of households constructed for each of the 40 administrative areas. Using the prevalence of recent injury of 12.6% reported by Atak et al., a 95% confidence interval and a margin of error of 10%, a sample size of 170 was calculated [23]. Two-hundred households were sampled to allow for non-consenting households or incomplete entries. Households that had at least one child aged <5 years were eligible for survey. The sample reflected the population of Asawase (312,258 people of which 8,848 were aged <5 years and 20,575 were aged <18 years) [24].

In the rural study, computer random sampling was used to select one rural district (i.e., population density less than 500 persons per square kilometer) that borders the Kumasi metropolis. Bosomtwe district was selected. Computer random sampling was then used to select one of three sub-districts (i.e., Amakom, Kuntanase, Jachi-Pramso), which were similar in demography and socioeconomic status according to data from the most recent census in 2010 published in 2014 [24]. Amakom was selected. Six community clusters were randomly sampled from a list of 11 community clusters in Amakom provided by the Ghana Statistical Service. Within each cluster, we exhaustively sampled each dwelling. Dwellings often were the home of multiple households. Only households within a dwelling with a child aged <5 years were eligible to participate in the survey. Using an injury rate of 29.7% over 6 months reported by Gyedu et al. in urban Ghana, a 95% confidence interval and a margin of error of 10%, a sample size of 314 was calculated. We chose 364 to allow for non-consenting households or incomplete entries. Field computer random sampling was used to select one eligible household within each dwelling. The sample reflected the population of Amakom (18,988 people of which 3,779 were aged <5 years and 14,032 were aged <18 years) [24].

Survey tool and technique

In both studies, one adult household member (i.e., sleeps in the home most nights and over age 18 years) who self-identified as the primary caregiver for at least one child aged <5 years on a daily basis was selected to undergo informed consent. Consenting respondents participated in the survey. Only one caregiver was sampled per eligible household. Caregivers were interviewed using a previously validated structured questionnaire about household characteristics and modifiable risk factors for childhood

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injuries [16]. Items in the survey were selected from the 2008 Ghana Demographic and Health Survey and were previously identified through household-based surveys of childhood injury [18,25,26]. The survey was administered in person by local enumerators in Twi, the predominant language spoken in southern and central Ghana.

A household injury was defined as one that: [16]

1. Occurred within 200 meters of the house;
2. Prevented the child from going to school or work, prompted healthcare treatment, or resulted in death; and
3. Occurred within the previous six months.

Recall periods of one to three months and one year have been proposed for surveys of less severe and more severe/fatal injuries in LMICs to mitigate recall bias, respectively. We used a recall period of six months to capture both moderate and severe injuries. We used the injury severity classification proposed by the United Nations Children's Fund (UNICEF) Innocenti Research Centre:

1. Moderate – missed ≥ 1 day of school or work or sought healthcare without being hospitalized,
2. Major - hospitalized for 1 – 9 days,
3. Serious - hospitalized for 10+ days,
4. Severe - resulted in permanent disability, or
5. Fatal - resulted in death.

Data management and analysis

Data were collected by the enumerators and transcribed into the Open Data Kit platform. Enumerators collected demographic and household characteristics, including on ownership of consumable goods and physical characteristics of the household, that were used to construct a wealth index using principal component analysis (PCA) in accordance with the methodology used by the Ghana Statistical Service [16]. Scores generated by the PCA were divided into socioeconomic quintiles. Injury epidemiology and household risk factors were described. Analyses incorporated sampling weights, which reflected the probability of being randomly sampled at the community and household levels.

Incidence and risk factors were compared with Mann Whitney U, Chi square and Exact Poisson tests, as appropriate. Injury incidence rates (IR), incidence rate ratios (IRR), and 95% confidence intervals were calculated with the Taylor series and Byar method, respectively. We performed univariate logistic regression to assess the relationship between risk factors and injury occurrence. The primary outcome variable was occurrence of at least moderate injury in a child aged <18 years. Multivariate, multilevel (i.e., community, household) logistic regression models incorporated covariates independently significant in the univariate analysis (p-value≤0.05) as well as variables that were felt to be important or confounding (e.g. age and sex of the child, caregiver level of education). Multicollinearity among covariates was assessed with tolerance and variance inflation factors. Collinear covariates were excluded. The model was then assessed after adjusting for other non-significant, but potentially important, risk factors using backward elimination. The fitted model was assessed using Hosmer and Lemeshow's goodness-of-fit test (p ≤0.10) and Akaike information criterion.

Results

Households

Table 1 describes our sample of 557 households (200 urban and 357 rural households), which represented 6,520 and 2,713 households in Asawase and Amakom, respectively. Urban households lived in dwellings that were more commonly rented and/or uncompleted compared to rural households (100 vs 28%, p<0.01) and had fewer sleeping rooms (p<0.01). Urban households more commonly used gas cookstoves (40.9 vs 2.8%, p<0.01) within 1 meter of the ground (i.e., within reach of a child aged <5 years; 69.7 vs 95.7%, p<0.01) and cooked within the home (i.e., not outside or in a sperate or communal structure; 50.1 vs 12.5%, p<0.01) compared to rural households. Rural households typically cooked with biomass fuels on open fires (e.g., wood, plant material, dung; 86% of rural households compared to 0% of urban households, p<0.01). Urban households also were more likely to have safe storage cabinets (i.e., lockable and able to store medications, cleaning liquids, and/or fertilizer; 78.8 vs 15.3%, p<0.01) compared to rural households.

Caregivers

Table 2 describes the caregivers of children. Caregivers had a weighted mean age of 33.9 years (SD 11.6) and most were female (88.3%); there were no differences between urban and rural caregiver age and sex (p=0.14 and p=0.23, respectively). However, urban caregivers were more commonly the injured child's mother (85.2 vs 78.6%, p<0.01) and exposed to higher levels of education (17.7 vs 7.7%, p<0.01). Urban caregivers were also more frequently concomitantly employed (80.2 vs 70.2%, p<0.01). Rural caregivers were more commonly supervised 3 or more children aged <5 years compared to urban caregivers (9 vs 2.2%, respectively; p<0.01). Conversely, urban caregivers more commonly cared for or were co-supervising with older children (88.5 vs 73.7% of households with ≥2 children aged <18 years, respectively; p<0.01).

Children and injuries

There were 637 children in the urban sample (275 children aged <5 years) that represented 20,575 children in Asawase (8,848 aged <5 years), which are described in Table 2. There were 1,016 children in the rural sample (492 children aged <5 years) that represented 14,032 children in Amakom (3,779 aged <5 years). The mean age of children was 6.9 years (SD 4.6 years) and not different between the urban and rural communities (p=0.48). There was no sex differences in children injured in urban and rural communities (52.6 vs 48.3% of girls and boys, respectively; p=0.13).

Table 3 details the injuries sustained by children in our sample. There were 143 and 351 moderate or worse injuries in our urban and rural samples, which equated to weighted, annualized incidence rates of 594 and 542 injuries per 1,000 child-years (IRR 1.09, 95%CI 1.0-1.14, p<0.01). Urban children were less likely to have been injured as infants (IRR 0.69, 95%CI 0.5-0.85), when aged 10 – 14 years (IRR 0.60, 95%CI 0.5-0.69), and when aged 15 – 17 (IRR 0.75, 95%CI 0.63–0.90) compared to their rural counterparts. No gender differences among the injured were identified between urban and rural children (male IRR 1.04, 95%CI 0.99–1.10; female IRR 1.00, 95%CI 0.94–1.06). There were also differences in the IRRs of specific injuries. As examples, urban children were more commonly injured by falling (IRR 1.50, 95%CI 1.4-1.60), contact with animals (IRR 1.67, 95%CI 1.2-2.25), near-drowning (IRR 2.42, 95%CI 1.6-3.66), and suffocation (IRR 3.05, 95%CI 1.9-4.80) than rural children. However, urban children were less commonly burned (IRR 0.51, 95%CI 0.4-0.59), injured by violence (IRR 0.41, 95%CI 0.3-0.48), or injured by a motor vehicle close to home (IRR 0.50, 95%CI 0.3-0.63) than rural children. Most injuries in both urban (98.3%) and rural children (96.1%, p=0.11) were moderate (i.e., missed ≥ 1 day of school or work or sought healthcare without being hospitalized) or major (i.e., hospitalized for 1 – 9 days).

Table 1
Urban and rural household characteristics in Asawase and Amakom, Ghana.

	Urban					Rural					p value
	Unweighted		Weighted			Unweighted		Weighted			
	%	Frequency	%	Frequency	95% CI	%	Frequency	%	Frequency	95% CI	
Household structure											
Rented room	71.5	143	70.9	4,619	64.-76.7	18.3	65	18	488	13.-23.6	<0.01
Rented flat	21.0	42	21.8	1,425	16.-28.2	3.9	14	1.4	38	1.-2.4	
Uncompleted accommodation	7.5	15	7.3	476	4.-11.8	10.7	38	8.6	233	6.-11.9	
Owned home	0.0	0	0.0	0	0.-0.0	67.1	239	72	1,953	66.-77.2	
Number of sleeping rooms											
1	67.5	135	66.3	4,312	59.-72.6	51.8	185	43.1	1,169	37.-48.4	<0.01
2	30.5	61	32.2	2,099	26.-39.1	27.7	99	30.6	830	24.-37.8	
3	2.0	4	1.5	101	0.-4.2	20.5	73	26.3	713	20.-32.6	
Type of fuel used											
Charcoal	56.5	113	59.2	3,856	51.-66.1	12.6	45	11.4	309	7.-16.3	<0.01
Biomass	0.0	0	0.0	0	0.-0.0	84.0	300	85.8	2,327	80.-89.9	
Gas	43.5	87	40.9	2,664	34.-47.9	3.4	12	2.8	76	1.-6.1	
Cooking place											
In home	52.0	104	50.1	3,267	44.-55.7	21.0	75	12.5	339	9.-16.4	<0.01
Separate building	15.5	31	15.8	1,030	11.-21.8	49.0	175	52.3	1,418	45.-59.5	
Outdoor	32.5	65	34.1	2,223	28.-40.4	30.0	107	35.3	957	28.-43.1	
Height of cookstove											
Not within reach of child ≤5 years	37.5	75	30.3	1,975	24.-36.3	5.0	18	4.3	117	2.-7.6	<0.01
Within reach child ≤5 years	62.5	125	69.7	4,544	63.-75.1	95.0	339	95.7	2,595	92.-97.6	
Safe storage cabinets											
No	21.0	42	21.2	1,381	16.-27.5	81.5	291.0	84.6	2,294	81.-87.5	<0.01
Yes	79.0	158	78.8	5,139	72.-84.0	18.5	66.0	15.3	415	12.-18.8	

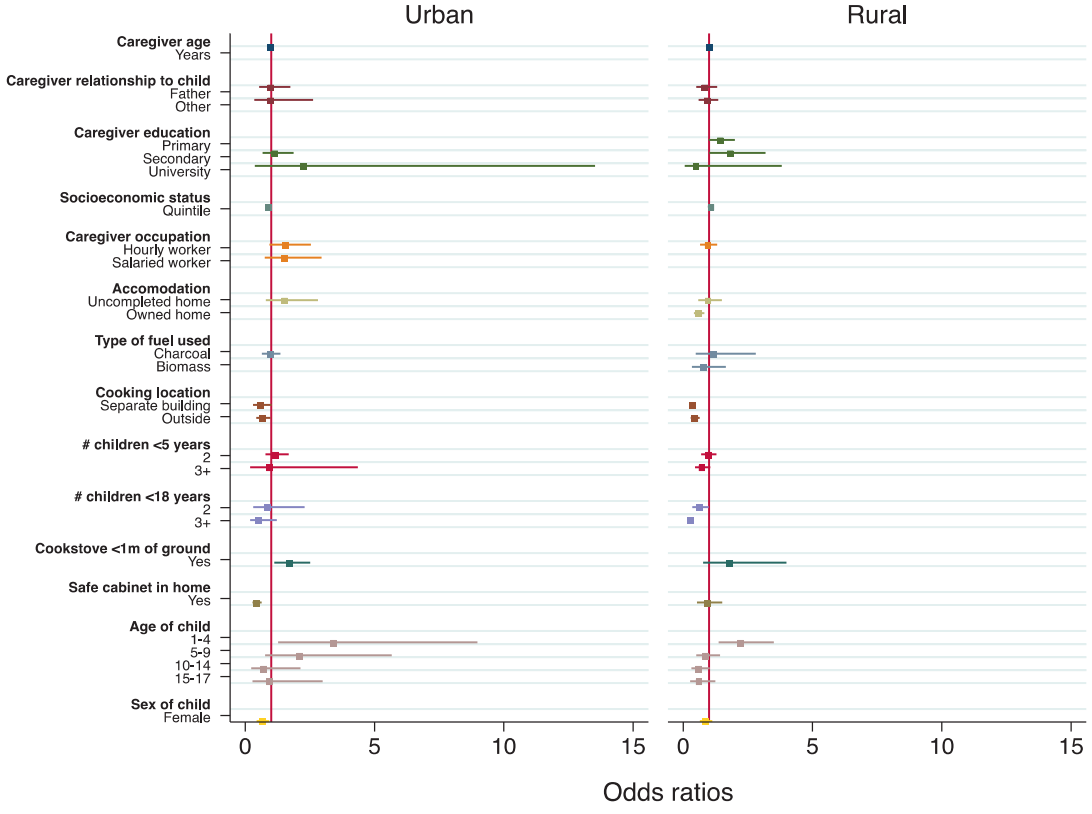

Fig. 1. Univariate models of risk factors for childhood household injuries urban and rural communities in Ghana. Socioeconomic quintile – lowest is most poor; m – meter; cookstove ≤1 meter from the ground is considered to be within reach of a child aged <5 years

Risk factors

The univariate models of risk factors for household injury among urban and rural children described in Fig. 1 demonstrated several differences between these groups. First, in rural communities, having older children within the household (e.g., ≥3 children between the ages of 5 and 18 years) reduced the odds of injury (OR 0.26, 95% CI 0.17–0.41) compared to households with only one child. This association was not evident in urban communities. Second, children with caregivers who had completed only primary or secondary school had a higher odds of injury compared to caregivers with no education (e.g., completed secondary school,

Table 2
Urban and rural caregiver and child characteristics in Asawase and Amakom, Ghana.

	Urban					Rural					p value
	Unweighted		Weighted			Unweighted		Weighted			
	%	Frequency	%	Frequency	95% CI	%	Frequency	%	Frequency	95% CI	
	%	Frequency	%	Frequency	95% CI	%	Frequency	%	Frequency	95% CI	
Caregiver											
Age in years (mean, SD)	33.9	7.0	33.8	7.0	32.-34.9	34.6	12.8	32.9	18.5	31.-34.8	0.14
Female	88.5	177	88.0	5,738	83.-91.7	88.2	315	92.2	2,500	89.-94.4	0.23
Relationship to child											
Mother	86.0	172	85.2	5,554	80.-90.1	76.2	272	78.6	2,132	73.-83.4	<0.01
Father	11.0	22	11.7	763	7.-15.9	9.0	32	6.0	163	4.-8.7	
Other	3.0	6	3.1	202	0.-5.7	14.9	53	15.4	418	10.-20.8	
Caregiver education											
None	17.0	34	15.9	1,038	10.-21.0	21.0	75	24.3	659	18.-31.2	<0.01
Basic	66.0	132	66.4	4,333	59.-73.5	69.8	249	68.0	1,844	60.-74.3	
Senior high school	15.5	31	16	1,040	10.-21.5	7.8	28	5.9	160	3.-9.4	
Tertiary school	1.5	3	1.7	109	0.-3.6	1.4	5	1.8	49	0.-5.3	
Caregiver employment status											
Unemployed	21.5	43	19.9	1,294	14.-25.5	25.6	91	29.7	805	22.-38.0	<0.01
Hourly worker	66.5	133	68.4	4,457	61.-75.1	73.6	262	69.0	1,871	60.-76.3	
Salaried worker	12.0	24	11.8	769	7.-16.5	0.8	3	1.2	33	0.-5.4	
Number of children <5 years in household											
1	64.0	128	62.7	4,088	56.-68.9	60.5	216	59.6	1,616	52.-66.3	<0.01
2	34.5	69	35.0	2,282	29.-41.6	29.4	105	31.3	849	25.-38.6	
3+	1.5	3	2.2	143	1.-4.5	10.1	36	9.0	244	6.-13.0	
Number of children <18 years in household											
1	10.0	20	11.6	756	8.-16.2	24.7	88	26.3	713	19.-33.8	<0.01
2	25.0	50	26.8	1,747	21.-33.1	24.7	88	26.3	713	20.-33.8	
3+	65.0	130	61.7	4,023	55.-67.9	50.6	181	47.4	1,285	40.-54.5	
Age of injured child (years)											
<1	6.3	40	6.7	93	4.-8.6	12.0	122	13.5	103	10.-17.0	<0.01
-4	36.9	235	37.2	2,844	33.-40.4	36.5	370	38.0	1,147	34.-41.8	
-9	27.5	175	27.5	1,554	24.-30.2	26.4	268	24.6	1,700	22.-27.4	
1-14	18.7	119	18.4	697	15.-21.3	17.7	180	16.7	349	14.-19.7	
1-17	10.7	68	10.2	215	8.-12.4	7.4	75	7.2	90	5.-9.2	
Age of injured child											
Mean years, SD	6.8	4.9	6.7	5.2	6.-7.1	6.8	4.5	6.6	4.0	6.-7.0	0.48
Sex of injured child											
Male	47.9	305	48.4	1,479	44.-52.5	51.7	525	51.7	983	47.-55.9	0.13
Female	52.1	332	51.6	1,576	47.-55.7	48.3	491	48.3	918	44.-52.5	
Child injury severity											
Moderate	94.4	135	93.8	5,731	89.-98.0	83.0	220	82.2	3,125	75.-87.2	0.11
Major	4.2	6	4.5	275	0.-8.1	12.8	34	13.9	528	9.-20.4	
Serious	0.7	1	0.8	49	0.-2.2	3.0	8	3.0	114	1.-6.5	
Severe	0.7	1	0.9	55	0.-2.7	0.8	2	0.5	19	0.-2.0	
Death	0	0	0.0	0	0.-0.0	0.4	1	0.4	15	0.-2.9	

SD – standard deviation; United Nations Children's Fund (UNICEF) Innocenti Research Centre injury severity classification: moderate – missed ≥ 1 day of school or work or sought healthcare without being hospitalized; major - hospitalized for 1 – 9 days; serious - hospitalized for 10+ days; severe - resulted in permanent disability, or fatal - resulted in death.

OR1.79, 95%CI 1.01–3.18). There was no evidence for an association between caregiver education and injury in urban communities. Next, in urban communities, households with low cookstoves (i.e., <1 meter from the ground and within reach of a child aged <5 years) had higher odds (OR 1.68, 95%CI 1.12–2.51) of childhood injuries than households with high cookstoves. Households with a safe cabinet to store hazardous substances and medications had lower odds of childhood injuries (OR 0.42, 95%CI 0.25–0.64). There was no evidence that these risk factors (i.e., cookstove height, safe cabinet) were associated with injury in rural households. Lastly, girls had a higher odds of injury in urban households (OR 0.64, 95% CI 0.44–0.92) compared to boys; there was no association between sex and injury in rural households. In both communities, not cooking within the home (e.g., outside or within a separate building) was associated with a lower odds of injury (e.g., within a separate building, OR 0.65 vs 0.43, 95% CI 0.42–0.98 vs 0.29–0.63, in urban and rural households, respectively) compared to households that cooked within the home.

Children in urban communities with older caregivers had a lower odds of injury than those in rural communities (OR 0.94 vs 0.98, 95%CI 0.9-0.97 vs 0.96-0.99, respectively). In both communities, toddler-aged children had the higher odds of injury than infants (OR 3.38 vs 2.19, 95%CI 1.27-8.98 vs 1.37-3.50), and greater odds than other age groups.

In the multivariate analysis detailed in Fig. 2, urban households with a safe storage cabinet (OR 0.54, 95%CI 0.30-0.97) and girls (OR 0.64, 95%CI 0.42-0.97) had lower odds of injury than those without a safe cabinet and boys, respectively. Toddler-aged children had a higher odds of injury than infants in both urban (OR 3.77, 95%CI 1.34-10.55) and rural communities (OR 3.17, 95%CI 1.86-5.42). Rural households that owned their home (OR 0.59, 95%CI 0.40-0.88), cooked outside of the home (OR 0.36, 95%CI 0.22-0.60), and that supervised older children (OR 0.33, 95%CI 0.17 – 0.62) had lower odds of childhood injuries than those that were rented, cooked within the home and supervised fewer older children, respectively. There was no evidence for similar associations in urban households. Regardless of developed environment, age and sex of child, place of cooking, stove height, fuel type, and having older children in the home were not associated with burn injury ($p>0.10$ for all). Similarly, age, sex, having older children in the home, and having a safe cabinet were not associated with poisoning in urban or rural households ($p>0.10$ for all).

Table 3
Urban and rural weighted, annualized incidence of childhood household injuries in Asawase and Amakom, Ghana.

	Urban injuries %	Rural injuries Incidence	%	Incidence	IRR	p value	95% CI
Age (years)							
<1	14.2	284.3	20.5	410.4	0.69	<0.01	0.5-0.85
1-4	45.8	916.9	45.9	918.9	1.00	0.93	0.9-1.06
5-9	30.0	600.6	23.8	476.5	1.26	<0.01	1.1-1.35
10-14	11.7	234.2	19.5	390.4	0.60	<0.01	0.5-0.69
15-17	12.7	254.3	16.9	338.3	0.75	<0.01	0.6-0.90
Sex							
Male	34	668.7	33.0	659.4	1.04	0.15	0.9-1.10
Female	25	505.8	27	532.3	1.00	0.94	0.9-1.06
Mechanism							
Fall	15.8	315.7	10.5	210.9	1.50	<0.01	1.4-1.60
Laceration	6.0	119.2	6.3	125.6	0.96	0.31	0.8-1.04
Burn	1.6	31.2	3.2	63.1	0.51	<0.01	0.4-0.59
Falling object	0.8	16.9	0.8	15.1	1.06	0.63	0.8-1.36
Violence	1.4	27.1	3.4	67.5	0.41	<0.01	0.3-0.48
Animal injury	0.7	14.9	0.4	8.5	1.67	<0.01	1.2-2.25
Near-drowning	0.5	10.3	0.2	4.1	2.42	<0.01	1.6-3.66
Poisoning	0.5	10.6	0.6	11.5	0.87	0.34	0.6-1.16
Electric shock	0.5	9.8	0.4	8.5	1.17	0.33	0.8-1.61
Suffocation	0.5	10.7	0.2	3.3	3.05	<0.01	1.9-4.80
Road traffic	0.6	12	1.2	24.1	0.50	<0.01	0.3-0.63
Other	0.8	15.2	0.0	0.0	-	-	-
Total	29.7	593.6	27.1	542.3	1.09	<0.01	1.0-1.14

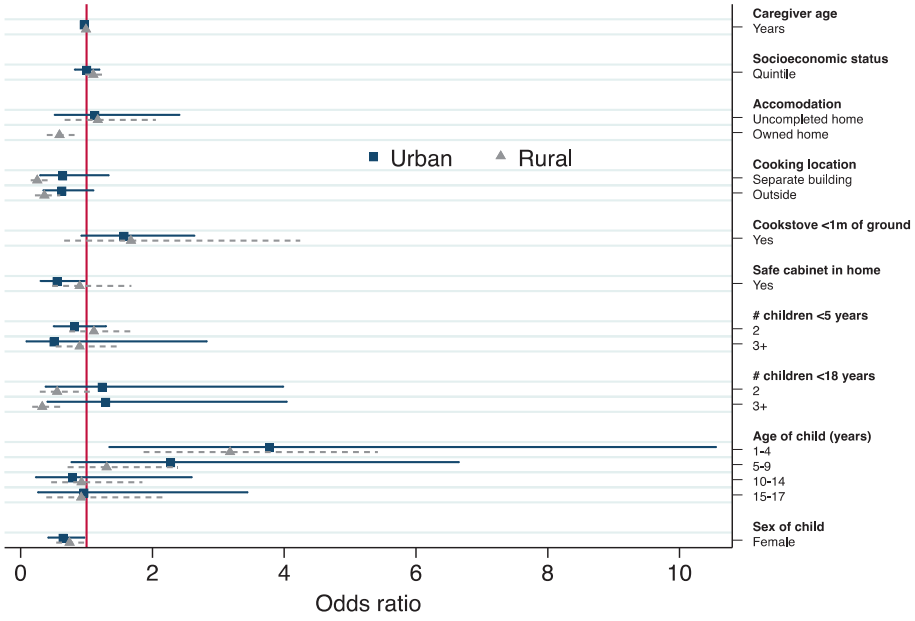

Fig. 2. Multivariate models of risk factors for childhood household injuries urban and rural communities in Ghana. Socioeconomic quintile – lowest is most poor; m – meter; cookstove ≤1 meter from the ground is considered to be within reach of a child aged <5 years.

Discussion

This study compared the incidence of household injuries among children who lived in urban communities to that among children who lived in rural communities in Ghana. We also described the distribution of risk factors for childhood injuries between developed environments to identify potential prevention targets that might need to be differentially deployed to urban and rural communities. The results offer several important findings. First, despite a higher prevalence of commonly perceived household injury risk factors, household injuries were more common in urban communities, particularly fall injuries. Second, toddler-aged children had higher odds of having been injured in both communities, but infants and older children in rural households seemed to be at markedly greater risk of injury compared to children in urban communities. Next, mechanisms of injury differed between communities: falls were more common in urban households; and burns, violence-related injuries, and road traffic injuries were more common in rural households. Lastly, although a number of commonly perceived household risk factors were not associated with injury in either urban or rural households, others were differentially associated with an increased odds of injury among urban and rural households. These findings can be used to inform hazard reduction and injury prevention interventions, as well as targets for future study.

Urban communities had a higher childhood injury incidence rate than rural communities, despite a lower prevalence of commonly perceived household risk factors. However, much of the

total injury incidence rate in urban households resulted from falls. Other population-based, household surveys of childhood injury in urban communities have reported similarly high incidence rates of falls [15,27,28]. Investigators have implicated uncompleted housing, concrete flooring, insufficient lighting, lack of window guards, stair construction without national or international building codes (e.g., standards that govern evenness, railings, riser height, surface materials that reduce slippage), balconies without guardrails, lack of stairway gates, and lack of supervision [29]. Most of the home modification interventions to reduce fall injuries have been performed in high-income countries and have focused on preventing elderly falls [19,30]. Several studies have evaluated the effects of home modification to reduce fall hazards [31–34]. These reports included installation of stair rails, non-slip surfaces on highly trafficked areas, and night-lights. The results were mixed: falls were not reduced among people with no history of falls and home modification without behavior modifications did not reduce fall injuries. A Cochrane Review on the impacts of home modifications to reduce fall injuries also reported insufficient evidence to support this strategy for large-scale injury prevention [30]. The 'Children Can't Fly' program in New York, USA in the 1970s aimed to prevent childhood fall injuries via four mechanisms: i) reporting of falls by hospital emergency rooms and police precincts, followed up by counseling, referral, and data collecting by public health nurses; ii) a media campaign to inform the public and elevate their awareness of fall hazards; iii) community education for prevention through door-to-door hazard identification, counseling by outreach workers, community organizations, schools, tenant groups, clinics, churches, and health care providers; and iv) provision of free, easily installed window guards to families with young children living in high-risk areas [35]. The program resulted in a significant reduction in falls, including a 50% reduction in high-risk areas. This and more recent, similar programs could be adapted to contexts and hazards common in urban and rural communities of LMICs to potentially avert injuries, and the financial burdens associated with hospitalization, rehabilitation, and care of the injured and permanently disabled.

Toddler-aged children had higher odds of having been injured in both communities, but infants and older children in rural households seemed to be at markedly greater risk of injury compared to children in urban communities. The findings suggest that barrier interventions and shared supervision models may reduce childhood household injuries among newly mobile children, particularly in rural households (e.g., lower injury rates in households with multiple rooms, households that cook outside of the home, and households with older children that could serve co-supervisory roles). Observational studies have demonstrated a reduced odds of childhood injury in homes with barriers (e.g., stair and door gates, fences around water bodies) compared to homes without barriers [29,36]. In households without the ability to remove hazards, interventions that provide safety equipment (e.g., barriers, gates), opportunities for shared supervision responsibilities (e.g., creation and maintenance of community creches), and teach children rules and routines might reduce childhood injuries [37]. As example, 211 households in South Africa were randomized to supportive home visits to identify and mitigate hazards for falls, burns, and poisonings [38]. Locally trained supportive visitors provided educational inputs, safety devices, and an implicit enforcement strategy. There was a significant reduction in the hazards associated with electrical appliances and paraffin stoves, as well as in hazards related to poisoning. However, non-significant changes were observed for burn safety household practices and fall injury hazards. Although community-based, multi-strategy initiatives that include home hazard reduction have been examined, additional formative research is required, particularly in LMICs and with interventions specific to urban and rural community contexts.

Mechanisms of injury differed between communities (e.g., falls, near-drowning, and animal-related injuries were more common in urban households; burns, violence-related injuries, and road traffic injuries were more common in rural households). The disproportionately high incidence rates of burns and violence-related injuries in rural households require specific attention. Dissemination of improved or clean cookstoves to LMIC households that currently use open fires or traditional cooking arrangements promises a reduction in the harmful effects of exposure to indoor air pollution, deforestation and surface erosion from harvest of biomass fuels, and gender inequity due to lower fuel consumption and more efficient cooking, which is commonly performed by women and girls [39–41]. However, little attention has been paid to the safety of improved and clean cookstoves [42]. A large cluster randomized controlled trial in Malawi was performed to determine the impact of improved cookstove provision on continuation of open fire cooking, childhood pneumonia, and burns [43]. More than 10,000 children from 8,626 households across 150 community clusters were randomized. There was no difference in the incidence rate of burn injuries between the groups (IRR 0.91, 95% CI 0.3-2.23), suggesting that provision of improved cookstoves alone will not reduce childhood burn injuries. Gallagher et al. have proposed a safety evaluation and scoring system for improved cookstoves; [42] however, no study has correlated injury rates to stove safety performance scores. Further, too few studies have investigated the impacts of cooking arrangements (e.g., stove stacking) and specific behaviors on rates of burn injuries to inform prevention initiatives [40,42–45].

The high incidence of violence-related injuries in rural households was surprising. However, reports from the United States, Nigeria, Uganda, Democratic Republic of Congo and Angola have described higher rates of gender-based violence among women in rural communities than those in urban communities [46–50]. Further, women in rural communities at risk of or experiencing gender-based violence are also less likely to be able to access violence prevention and safety services [48]. We did not ask caregivers about the causes of violence-related injuries to avoid social response bias and maintain the integrity of the larger survey. Therefore, we do not know the proportion of these injuries attributable to child abuse, gender-based violence, non-partner sexual violence, or assault among children. Given that violence in childhood plays a central role in propensity to perpetrate violence or vulnerability to violence in adulthood in Ghana and elsewhere, the causes and risk factors of violence-related injuries in rural Ghana must be identified and addressed to interrupt the cycle of violence [47,51]. A systematic review of opportunities to protect children from violence in sub-Saharan Africa provided several recommendations useful for policy makers, public health officials and healthcare providers [52]. The review suggested mandatory reporting by health programs, which should include community health workers and healthcare facilities. Countries might also consider mandatory reporting by school systems [53]. In the absence of active surveillance using cluster-randomized, population-based surveys such as the present study, passive surveillance systems are required to protect children and better understand and address the roots of violence against children, particularly in rural communities with fewer social services.

Road traffic injuries are often associated with urban communities [54,55]. However, these findings suggest that children in households within rural community clusters are at particular risk, likely due to a lack of traffic calming measures and higher vehicular travel speeds along inter-urban roadways with little traffic [56,57]. These findings corroborate those from other studies in Ghana, which have reported that more than 60% of road traffic fatalities and injuries occur on roads in rural areas and 58% more people die on roads in rural compared to those in urban areas

[57,58]. It is unlikely that Ghana is unique among LMICs with regard to road traffic injury epidemiology; [59] therefore, dedicated attention to road safety interventions in rural communities is required.

Prior to drawing conclusions from the findings, several limitations must be considered. First, the results were generated from caregiver report. These responses were not triangulated with those from other members of the household or independently verified. However, multiple reports have demonstrated the validity of caregiver reports when approached by trained enumerators with validated surveys, including reports from Ghana [16,25,60]. Second, the findings may reflect some degree of recall bias. To mitigate that risk, we used a recall period of six months given data from the same region that determined that a six-month recall resulted in a 75% decrease in reporting of minor injuries, 40% decrease in reporting of moderate injuries, and no change in reporting of major injuries compared to a one-month recall period [25]. Third, caregivers may have provided socially desirable responses. This may explain why there were very few injuries that resulted in permanent disability or death. Additionally, this bias may have resulted in lower than actual rates of reported violence-related injuries. Next, only information on injuries that occurred within 200 meters of the home were recorded. Road traffic injuries that occurred further away from the home were not interrogated, which may be more common in urban communities. Thus, these findings likely reflect lower rates of injury among older children, who are more likely to be injured further from home. Lastly, this study used cross-sectional data. Although we detected associations between injury and some risk factors, assumptions about causality should not be inferred. Despite these limitations, reasonable conclusions can be drawn about the incidence of household injuries among children in urban and rural Ghana and the prevalence of specific household risk factors.

Conclusion

Childhood injuries were common in both urban and rural Ghana, with different patterns of mechanisms and risk factors that must be taken into account when planning prevention strategies. The data suggest that several prevention interventions may be worth study, with attention to differences across developed environments, including:

- Develop and implement context-appropriate building codes that reduce structural home hazards (e.g., unsafe stairs, lack of balcony guardrails, window guards); and
- Organize community-based, multi-strategy initiatives that include home hazard reduction, provision of safety equipment (e.g., barriers), and education tailored to specific community risk factors; and
- Deploy traffic calming interventions along inter-urban roadways near rural community clusters.

Additionally, the findings also generate important priorities for research and injury surveillance:

- Identify structural home hazards in rural households that could be modified to reduce childhood injuries;
- Estimate the impacts of cooking arrangements (e.g., stove stacking) and behaviors on rates of burn injuries specific to cookstove and fuel type, particularly in rural households;
- Describe the impacts of implementing recommendations on traffic calming measures along inter-urban roadways; and
- Create passive injury surveillance systems that collect data to inform prevention strategies broadly, and to protect children and better address the roots of violence against young people.

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Disclosure

The authors have no real or potential conflict of interests to disclose.

Data availability

All data will be made available after reasonable request.

Declaration of Competing Interest

The authors have no real or potential conflicts of interest to disclose.

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