

# Fatal and non-fatal injury outcomes: results from a purposively sampled census of seven rural subdistricts in Bangladesh



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## Summary

**Background** 90% of the global burden of injuries is borne by low-income and middle-income countries (LMICs). However, details of the injury burden in LMICs are less clear because of the scarcity of data and population-based studies. The Saving of Lives from Drowning project, implemented in rural Bangladesh, did a census on 1·2 million people to fill this gap. This Article describes the epidemiology of fatal and non-fatal injuries from the study.

**Methods** In this study, we used data from the baseline census conducted as part of the Saving of Lives from Drowning (SoLiD) project. The census was implemented in 51 unions from seven purposively sampled rural subdistricts of Bangladesh between June and November, 2013. Sociodemographic, injury mortality, and morbidity information were collected for the whole population in the study area. We analysed the data for descriptive measures of fatal and non-fatal injury outcomes. Age and gender distribution, socioeconomic characteristics, and injury characteristics such as external cause, intent, location, and body part affected were reported for all injury outcomes.

**Findings** The census covered a population of 1169 593 from 270 387 households and 451 villages. The overall injury mortality rate was 38 deaths per 100 000 population per year, and 104 703 people sustained major non-fatal injuries over a 6-month recall period. Drowning was the leading external cause of injury death for all ages, and falls caused the most number of non-fatal injuries. Fatal injury rates were highest in children aged 1–4 years. Non-fatal injury rates were also highest in children aged 1–4 years and those aged 65 years and older. Males had more fatal and non-fatal injuries than females across all external causes except for burns. Suicide was the leading cause of injury deaths in individuals aged 15–24 years, and more than 50% of the suicides occurred in females. The home environment was the most common location for most injuries.

**Interpretation** The burden of fatal and non-fatal injuries in rural Bangladesh is substantial, accounting for 44 050 deaths and 21 million people suffering major events annually. Targeted approaches addressing drowning in children (especially those aged 1–4 years), falls among the elderly, and suicide among young female adults are urgently needed to reduce injury deaths and morbidity in Bangladesh.

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## Introduction

There is a declining trend in the global burden of diseases (GBD) due to injuries, owing in part to recent advances in injury research and prevention efforts.<sup>1</sup> Despite this progress, injuries still accounted for 5 million lives lost in 2015, and are responsible for 9% of all deaths in that year.<sup>2–4</sup> The proportionate mortality of deaths and disability-adjusted life-years (DALYs) lost because of injuries are also on the rise relative to communicable diseases.<sup>1,5</sup> Unintentional injuries such as road traffic injuries, drowning, falls, and burns account for 72% of all injury deaths; whereas intentional injuries such as homicide and suicide account for the rest.<sup>3,4</sup> For every fatal injury outcome, about 1000 non-fatal injury events present at emergency departments, and several thousands go unreported.<sup>6</sup>

More than 90% of global deaths and DALYs lost because of injuries occur in low-income and middle-income countries (LMICs), with death rates being three-to-four times

greater in LMICs than in high-income countries.<sup>1,4,5–8</sup> Regional assessments of the GBD trend also reveal the disparities in injury rates; although injury mortality and morbidity rates are rapidly declining in higher-income regions, the declining rates are much slower or flat in most LMICs.<sup>14</sup> Even so, injury estimates for LMICs might not be accurate because of the paucity of vital registration data and population-based injury studies in LMICs.<sup>15,9</sup> Indeed, the burden of injuries in LMICs might be much bigger than observed because of under-reporting of both fatal and non-fatal injury outcomes,<sup>10</sup> and calls have been made for improvements to national vital registration and population-based data from LMICs.<sup>1</sup>

Various efforts to improve the quality and scope of data on the burden and epidemiology of injury in several LMICs have been undertaken in recent times.<sup>11–13</sup> With about 1·2 million people under injury and demographic surveillance, the Saving of Lives from Drowning project



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### Research in context

#### Evidence before this study

We searched PubMed and Google Scholar to identify publications on burden and epidemiology of injuries in low-income and middle-income countries (LMICs) between Jan 1, 1980, and Dec 30, 2016, using keywords such as (“injury” OR “injuries” OR “trauma” OR “road injuries” OR “drowning” OR “burns” OR “fire” OR “falls” OR “poisoning” OR “violence” OR “suicide” OR “homicide”) and (“rates” OR “counts” OR “frequency” OR “distribution”) and (“epidemiology” OR “risk factors” OR “determinants”) and (“low and middle income countries” OR “developing countries” OR “Bangladesh” OR “South Asia”), without language restrictions. Most studies were based on trauma registries and other hospital-based data. They reported on the significant mortality and morbidity due to road traffic injuries in LMICs and highlighted injuries as one of the leading causes of death in children worldwide. Scarce data examined the burden and risk factors of other injuries, including intentional injuries such as suicides. Common risk factors for injuries include gender, occupation, age, socioeconomic status, and lack of supervision for young children. Very few studies described the nature and characteristics of non-fatal injury outcomes from a population perspective.

#### Added value of this study

This study provides current population-based estimates of mortality and morbidity due to injuries in an LMIC, and

describes the distribution of different external causes of injuries (based on International Classification of Diseases, 10th edition) by sociodemographic factors, in rural areas. More than 60 000 deaths are due to injuries in Bangladesh annually, and about 29 million people experience non-fatal injuries severe enough to result in loss of days at work or school. This study also highlights drowning as the leading cause of injury deaths for all ages in rural Bangladesh (and not just in children) and the huge burden of suicide, especially in female adolescents and young adults. The study suggests the modifying effects of age and gender on suicide, burns, and falls rates, and the significance of socioeconomic status in the distribution of non-fatal injuries. Most fatal injuries occur within and around the home environment, and the hand is the most likely body part to be injured in an LMIC setting such as Bangladesh.

#### Implications of all the available evidence

The burden of injuries in LMICs is significant, and targeted approaches addressing drowning in children, falls in the elderly, and suicide in young female adults are urgently needed to reduce injury deaths and morbidity in an LMIC such as Bangladesh. There is also a need for additional population-based studies to estimate the true nature and distribution of injuries, especially intentional injuries, in LMICs.

(SoLiD) in Bangladesh is one of such large efforts.<sup>14,15</sup> SoLiD was designed in part to address the absence of accurate population-based data for injuries from LMICs, and to inform our understanding of the epidemiology of unintentional injuries in Bangladesh. Previous injury studies in Bangladesh have focused on children less than 18 years of age, and little is known about the burden and epidemiology of injuries in adults. The most recent population-based estimates from the 2003 Bangladesh Health and Injury Survey are more than 14 years old, and the survey reported more than 30 000 injury deaths in children younger than 18 years, in which drowning accounted for 23% of these deaths.<sup>16–18</sup>

In this study, we aimed to describe the burden and characteristics of fatal and non-fatal injuries in rural Bangladesh, using data from the baseline census done as part of the SoLiD project. We also provide information about the nature and intent of injuries across gender, age, and socioeconomic status, and hope that this Article will contribute to the understanding of the epidemiology of injuries across all age groups and to improved estimates of the burden of injuries in LMICs.

## Methods

### Data collection

For this analysis, we used data from a baseline census that was done as part of the SoLiD project over a 6-month

period (June–November, 2013). The census covered all populations in 51 unions (out of 83 unions) from seven purposively selected rural subdistricts of Bangladesh, including Matlab North, Matlab South, Daudkandi, Chandpur Sadar, and Manohardi in the central section of the country, and Raiganj and Sherpur in the north. Based on the 2011 Bangladesh national census,<sup>19</sup> there are 1·16 million people in the 51 unions covered by the baseline census. The seven subdistricts were purposively selected because they represent geographically diverse rural populations in Bangladesh with potentially high rates of childhood drowning, and key partners under the SoLiD project had ongoing surveillance activities within these subdistricts to facilitate the census data collection.<sup>14,15</sup> The 51 unions were selected to exclude unions with any history of major injury prevention programme.

A case of injury was operationally defined as any household member who sought treatment or lost at least 1 working day or could not go to school for at least 1 day due to an injury event.<sup>11</sup> The injury events listed were based on the injury, poisoning, and consequences of external causes in chapter XIX, and the external causes of morbidity and mortality in Chapter XX of the International Statistical Classification of Diseases and Related Health Problems, 10th edition (ICD-10).<sup>20</sup> The injury events considered include attempted suicide or suicide, road traffic injury, violence, fall, cut, burn, near

drowning or drowning, poisoning, machine injury, electrocution, insect or animal injury, and injury by blunt object. Near drowning was defined as surviving a drowning event (ie, injury from submersion of face in water that results in respiratory impairment).<sup>21</sup> Information on non-fatal injuries was collected for events that occurred in the last 6 months before the census, whereas all injury death information was collected over a 1-year recall period.<sup>11</sup> The baseline census also collected information on social and demographic characteristics, physical environment, and health-seeking behaviour on all people in the census area.

Ethical clearance for this study was obtained from the Institutional Review Boards of the Johns Hopkins Bloomberg School of Public Health, USA; International Centre for Diarrheal Disease Research, Bangladesh; and the Center for Injury Prevention Research, Bangladesh.

### Procedures

All information was collected directly from the head of household or any adult aged 18 years and older with sufficient knowledge of the household. Data was collected using a questionnaire covering seven modules (1: household characteristics and socioeconomic census, 2: birth history, 3: household environment, 4: death confirmation, 5: injury morbidity, 6: injury mortality, and 7: injury mechanism). See appendix for the questionnaire forms, interviewers' manual, and protocol used for the census. The death confirmation module comprised of four forms: child notification, injury notification, death notification, and death confirmation. The child notification form was used to identify eligible children that will receive drowning interventions being implemented under the SoLiD project. The injury notification form was used to identify any case of injuries for follow-up data collection. The death notification form was used to ascertain any death in the household. The death confirmation form was used to classify deaths under broad categories (injuries and non-injuries) and it was based on the WHO standard for verbal autopsies.<sup>22</sup> The injury mechanisms module comprised of 12 forms that covered each of the injury events listed under the definition of injuries.

Data collection was implemented by two sets of trained data collectors. The first set of data collectors completed the questionnaire forms in module 1–4. Based on the outcome of injury notification forms in module 4, a second set of data collectors completed the questionnaire forms in module 5–7 within 2 days of the first set of data collectors, only in households with reported injury event. Trained data collectors were adults aged 18 years and older, who had completed at least secondary school education and had undergone 5 days of field training. The daily activities of each data collector were supervised by field supervisors or field research officers, who reported directly to a field research or subdistrict manager. The managers reported directly to

the central office. To ensure data quality, each field supervisor observed 10% of all interviews, reviewed 10% of randomly-selected completed forms, and re-interviewed 2% of households daily. The field research manager also rechecked 20 randomly selected completed forms daily for any inconsistencies.

Before data collection, field supervisors in each of the 51 unions did village mapping, and village codes were provided to data collectors based on the mapping exercise. The data collectors then did household listing in each village starting from the southeast corner of a village and proceeding counter clockwise. Each identified household was assigned a serial number by data collectors based on a predetermined format. All households in the 51 unions participated in the census. Each set of the questionnaire forms took between 40–50 min to complete. Written informed consent was obtained before data collection. Databases used include SQL Server 2008 with ASP.net for the front end of data entry and Microsoft Access software.

### Statistical analyses

Descriptive statistical analysis was done to estimate the counts, frequencies, and 95% CIs of fatal and non-fatal injury outcomes by sociodemographic factors such as age, gender, occupation, educational level, and socioeconomic status. The 95% CIs for categories under each sociodemographic variable were compared to assess statistical significance. The SES indices were derived based on statistical weights assigned to household living condition and asset variables estimated using principal component analysis. Count, frequencies, and 95% CIs for both fatal and non-fatal injury outcomes were also derived based on the injury characteristics, including factors such as: the external causes, intent, body part affected, and location where the injury occurred. Both injury mortality and morbidity rates were derived.

See Online for appendix

	Bangladesh population (n=144 043 697)	SoLiD population (n=1 169 593)
<b>Age group (years)</b>		
<1	2 492 554 (2%)	22 141 (2%)
1–4	11 846 958 (8%)	90 523 (8%)
5–9	17 217 871 (12%)	139 728 (12%)
10–14	19 260 260 (13%)	142 121 (12%)
15–17	7 323 211 (5%)	62 098 (5%)
18–24	17 491 155 (12%)	133 534 (11%)
25–64	60 384 026 (42%)	508 059 (43%)
≥65	6 605 129 (6%)	71 389 (6%)
<b>Sex</b>		
Male	72 109 797 (51%)	567 674 (49%)
Female	71 933 900 (50%)	601 919 (51%)
SoLiD=Saving of Lives from Drowning project.		
<b>Table 1: Sociodemographic characteristics of the Bangladesh population versus the SOLID population</b>		

	Total population	Fatal injury outcomes*		p value	
		n	Mortality rate per 100 000 per year (95% CI)		
Overall (n)	1169 593	449	38 (35–42)		
Age group (years)					
<1	22 141 (2%)	7	32 (15–66)	<0.0001	
1–4	90 523 (8%)	109	120 (100–145)		
5–9	139 728 (12%)	46	33 (25–44)		
10–14	142 121 (12%)	24	17 (11–25)		
15–17	62 098 (5%)	21	34 (22–52)		
18–24	133 534 (11%)	39	29 (21–40)		
25–64	508 059 (43%)	123	24 (20–29)		
≥65	71 389 (6%)	80	112 (90–140)		
Sex					
Male	567 674 (49%)	253	45 (39–50)	0.001	
Female	601 919 (51%)	196	33 (28–38)		
Occupation†					
Agriculture (mainly farmers)	104 956 (89%)	46	44 (33–59)	<0.0001	
Business (mainly traders)	61 661 (5%)	18	29 (18–46)		
Skilled labour (professional)	89 151 (8%)	35	39 (28–55)		
Unskilled or domestic (unskilled)	24 520 (2%)	6	24 (11–54)		
Rickshaw or bus (transport)	17 037 (1%)	16	94 (58–153)		
Students	312 537 (27%)	66	22 (17–27)		
Retired, unemployed, or homemaker	408 583 (35%)	124	30 (25–36)		
Other‡	150 402 (12%)	136	90 (75–106)		
Socioeconomic status					
Lowest	211 601 (18%)	97	46 (37–56)		0.518
Low	218 695 (19%)	87	40 (32–49)		
Middle	238 371 (20%)	91	38 (33–49)		
High	247 716 (21%)	93	38 (31–46)		
Highest	253 210 (22%)	81	32 (26–40)		
Education†					
No education	295 314 (25%)	156	53 (45–62)	<0.0001	
Primary	407 923 (35%)	90	23 (18–28)		
Secondary	289 658 (25%)	71	25 (19–31)		
Post-secondary	63 873 (5%)	14	21 (13–37)		
Not applicable (under 5)	112 664 (10%)	116	102 (86–126)		
Subdistrict					
Matlab North	265 897 (23%)	111	41 (35–50)	0.161	
Matlab South	209 772 (18%)	70	33 (26–42)		
Chandpur Sadar	128 356 (11%)	36	28 (20–39)		
Raigunj	104 357 (89%)	53	51 (39–66)		
Sherpur	228 519 (20%)	84	37 (30–46)		
Manohardi	204 319 (17%)	83	41 (33–50)		
Daud Kandi	28 373 (2%)	12	42 (24–74)		

Data are n (%), unless otherwise stated. \*Fatal injury outcome was reported over a 1-year recall period.  
†Missing: education (<1%) and occupation (<1%). ‡Other comprises mostly children, including all under-5 children.

Table 2: Sociodemographic characteristics of fatal injury outcomes in Bangladesh

Because fatal and non-fatal injury outcomes were recorded over 1-year and 6-month recall periods, respectively, the morbidity rates were annualised by

doubling the non-fatal outcomes to make mortality and morbidity rates similar. Both injury mortality and morbidity rates were reported per 100 000 population per year. Statistical analyses were completed with Stata 14 I/C package.

### Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

### Results

The SoLiD census covered 1169 593 people from 270 387 households and 451 villages and recorded 6303 deaths over a 1-year recall period. The age and gender distribution in the SoLiD census area is similar to that of the total population of Bangladesh<sup>19</sup> (table 1).

The overall death rate was 539 per 100 000 population per year: 626 (95% CI 606–648) per 100 000 for females and 456 (440–473) for males, (with male to female death ratio of 1.3:1). The highest death rates were recorded in individuals aged 65 years and older (4349 [95% CI 4202–4501] per 100 000) followed by children younger than 1 year (2769 [95% CI 2560–2993] per 100 000).

There were 449 injury deaths recorded over the 1-year recall period. Proportionate mortality due to injuries was 7.1% (95% CI 6.5–7.8%). The absolute injury mortality rate was 38 injury deaths (95% CI 35–42) per 100 000 population per year. Injury mortality rates were substantially higher at both extremes of age: children aged 1–4 years (120 injury deaths per 100 000 [95% CI 100–145]) and adults aged 65 years and older (112 per 100 000 [90–140]) had significantly higher injury mortality rates than other age groups ( $p < 0.0001$ , table 2). Males had significantly higher injury mortality rates than females across all ages ( $p = 0.0001$ ). However, females had higher injury mortality rates in children younger than 1 year and adults aged 65 years and older compared with males in similar age groups (appendix). Injury mortality rates were highest among rickshaw and bus drivers (94 per 100 000 [95% CI 58–153]; table 2), and were significant compared with other occupational classes ( $p < 0.0001$ ). There was no difference in injury mortality rates comparing socioeconomic status ( $p = 0.518$ ). Injury mortality rate was, however, significantly higher in those with no education, 53 per 100 000 (95% CI 45–62), than in those with varying levels of education ( $p < 0.0001$ ).

Drowning was the leading external mechanism of injury death, accounting for 38.31% of all injury deaths for all ages, followed by road traffic injuries (17.82%), fall injuries (13.14%), and suicide (8.69%; table 3). Males accounted for more deaths for all external mechanisms of injury deaths assessed, except for burn injuries. All burn deaths ( $n = 25$ ) were recorded in females, except for two deaths.

89% of all injury deaths were unintentional in nature. Of the 60 deaths that were intentional in nature, 39 (65%) of the deaths were suicides, while the rest were mostly due to assault and violence (table 3). Most suicide deaths were implemented by hanging (59%) and poisoning (31%). About 60% of all injury deaths occurred within, or around, the home environment, most of which were drowning (30%) that occurred in a water reservoir (ie, ponds and wells close to the home; table 3).

Drowning accounted for 92% of injury deaths in children aged 1–4 years and 67% in children aged 5–9 years (appendix). Drowning also topped the list of injury deaths in children aged 10–14 years. In adolescents aged 15–17 years and young individuals aged 18–24 years, suicide was the leading cause of injury deaths, at 33% and 26%, respectively, and more than half of these deaths in each age group occurred in females. At 14 deaths (95% CI 4–36) per 100 000 population per year, the highest age-specific suicide rate was in females aged 15–17 years (table 4). In adults aged 25–64 years, road traffic injury deaths (31%) were the most common, followed by drowning (13%) and suicide (11%); 64% of the suicides in this age group were reported in males. Among individuals aged 65 years of age and older, approximately 49% of deaths were due to falls (appendix). Sex-specific fatal rates and frequency for various external causes of injuries are further shown in the appendix.

Frequency of fatal injuries showed a clear seasonal pattern. More than 70% of all drowning cases occurred during the rainy monsoon season (June–September), whereas more than 80% of fatal burns occurred during the winter season (October–March).

104 703 individuals had 119 669 non-fatal injury events over a 6-month recall period. 14% of those injured (n=14 966) reported multiple injuries, that is, two or more injury events from the same external cause or different causes. 80% (n=11 989) of individuals that reported multiple injuries had only two events. The overall annualised injury morbidity rate was 18 002 injuries per 100 000 population (both per 100 000 population and per 100 000 events estimates yielded similar comparisons when counts and rates were compared by socio-demographic factors; hence, only the counts and rates per population are described subsequently). The overall injury mortality to morbidity ratio was 1:474.

Rates of non-fatal injury events were significantly different comparing populations of different age groups: non-fatal rates were highest in adults aged 25–64 years (21 170 per 100 000 [95% CI 21 002–21 340]), closely followed by adults aged 65 years and older (20 210 per 100 000; table 5). Similar to results based on fatal injury rates, non-fatal injury rates were significantly higher in males across all ages (20 510 per 100 000, [20 352–20 670]) than in females (15 634 per 100 000 [15 498–15 770]), p<0.0001; table 5). However, age-specific non-fatal rates were higher in females for those aged 65 years and older (appendix). Rates of non-fatal injuries were highest in

	Fatal injury outcomes (n=449)		Non-fatal injury outcomes (n=104 703)	
	n	Percentage (95% CI)	n	Percentage (95% CI)
<b>External cause</b>				
Suicide	39	8.69% (6.2–11.4)	50	0.05% (0.04–0.07)
Road traffic injuries*	80	17.82% (14.1–21)	9359	8.99% (8.82–9.17)
Violence†	20	4.45% (2.8–6.6)	2956	2.79% (2.69–2.89)
Fall	59	13.14% (10.01–16.2)	39 935	38.34% (38.05–38.64)
Cut injury	5	1.11% (0.4–0.25)	22 990	22.03% (21.79–22.29)
Burn	25	5.57% (3.6–7.9)	5528	5.33% (5.2–5.47)
Drowning	172	38.31% (35.6–44.5)	2895	2.78% (2.69–2.88)
Unintentional poisoning	6	1.34% (0.5–2.8)	71	0.07% (0.05–0.08)
Machine injury	3	0.67% (0.2–2.0)	1115	1.06% (1.0–1.12)
Electrocution	13	2.90% (1.63–4.7)	754	0.72% (0.67–0.77)
Animal bite injury	8	1.78% (0.8–3.4)	8330	7.97% (7.81–8.14)
Injury by blunt object	9	2.00% (1.01–3.7)	10 180	9.71% (9.53–9.89)
Suffocation	10	2.23% (1.2–3.9)	136	0.13% (0.11–0.15)
Others	0	0	2	0.0017% (0.0005–0.0067)
<b>Intention</b>				
Unintentional	389	88.64% (82.2–88.7)	101 827	97.62% (97.52–97.71)
Intentional	60	12.36% (10.4–16.7)	2419	2.31% (2.22–2.40)
Undetermined	0	0	59	0.06% (0.05–0.08)
<b>Place of injury</b>				
Home (internal)	79	17.60% (14.1–21.4)	22 849	21.82% (21.6–22.1)
Bedroom or living room	56	12.12% (9.4–15.4)	8897	8.50% (8.3–8.7)
Kitchen	15	3.25% (1.9–5.3)	8531	8.17% (8.0–8.3)
Bathroom	8	1.73% (0.8–3.4)	5421	5.15% (5.01–5.28)
Home (external)	189	40.91% (36.5–45.5)	33 924	32.45% (32.17–32.74)
Yard	49	10.91% (8.10–14.17)	31 436	30.02% (29.74–30.03)
Veranda	4	0.89% (0.24–2.27)	1665	1.59% (1.52–1.67)
Water reservoir	136	30.29% (26.69–34.77)	5889	5.62% (5.49–5.77)
Place of education‡	4	0.87% (0.3–2.3)	4589	4.37% (4.24–4.49)
Transport facilities§	96	20.78% (17.3–24.7)	20 169	19.29% (19.05–19.53)
Other¶	81	18.04% (16.9–24.3)	23 172	22.07% (21.8–22.33)

\*Road traffic injuries include pedestrian or bicycle, two-wheel, three-wheel, and four-wheel vehicles. For non-fatal outcomes, less than 0.5% of the events occurred in a boat or ferry. †Violence includes all injuries due to violence inflicted directly by another person or resulting from collateral impact. ‡Place of education includes classroom, school playground, hostel of educational institute, or other playground. §Transport includes all roads and highways. ¶Other includes agricultural field, industry, factory, workshop, market or bazaar, office, construction area, trees, or cowshed.

Table 3: Characteristics of fatal and non-fatal injury outcomes in Bangladesh

rickshaw and bus drivers (29 408 per 100 000 [28 560–30 490]), followed by individuals involved in farm or agricultural work (23 940 per 100 000) and unskilled labourers (22 480 per 100 000 [28 560–30 490]). The rates of non-fatal injuries were significantly lower in individuals in the highest socioeconomic status than those from other groups (p<0.0001); additionally, individuals with no education had significantly higher rates of non-fatal injury events than those with varying levels of education (p<0.0001; table 5).

Falls were the leading external mechanism of non-fatal injuries, accounting for 38% of all non-fatal injury deaths for all ages (table 3). This was followed by cut

	Leading external cause of fatal injury outcomes	n/N (%)	Mortality rate per 100 000 per year (95% CI)	2nd leading external cause of fatal injury outcomes	n/N (%)	Mortality rate per 100 000 per year (95% CI)
<b>Male</b>						
Age group (years)						
<1	Cut	2/3 (67%)	18 (2–65)	Suffocation	1/3 (33%)	9 (0–50)
1–4	Drowning	54/56 (96%)	117 (88–153)	Road traffic injury and poisoning	1/56 (2%)	2 (0–12)
5–9	Drowning	20/25 (80%)	28 (17–43)	Road traffic injury and animal bite	8/25 (8%)	11 (5–22)
10–14	Suicide	4/15 (27%)	6 (2–14)	Road traffic injury and drowning	3/15 (20%)	4 (1–12)
15–17	Suicide	3/12 (25%)	9 (2–26)	Road traffic injury and drowning	2/12 (17%)	6 (1–22)
18–24	Road traffic injury	8/22 (36%)	14 (6–27)	Drowning	6/22 (27%)	10 (4–23)
25–64	Road traffic injury	29/85 (34%)	12 (8–18)	Drowning	10/85 (12%)	4 (2–8)
≥65	Fall	16/34 (47%)	43 (24–69)	Road traffic injury	6/34 (18%)	16 (6–35)
All ages	Drowning	99/252 (39%)	17 (14–21)	Road traffic injury	52/252 (21%)	9 (7–12)
<b>Female</b>						
Age group (years)						
<1	Drowning	2/4 (50%)	18 (2–66)	Suffocation	2/4 (50%)	18 (2–66)
1–4	Drowning	47/53 (89%)	106 (78–141)	Road traffic injury	4/53 (8%)	9 (3–23)
5–9	Drowning	11/21 (52%)	16 (8–29)	Road traffic injury	6/21 (29%)	9 (3–19)
10–14	Drowning	3/9 (33%)	4 (1–13)	Road traffic injury	2/9 (22%)	3 (0–10)
15–17	Suicide	4/9 (44%)	14 (4–36)	Road traffic injury	2/9 (22%)	7 (1–25)
18–24	Suicide	7/17 (41%)	9 (4–19)	Burn	4/17 (24%)	5 (1–14)
25–64	Road traffic injury	9/37 (24%)	3 (2–6)	Drowning	6/37 (17%)	2 (1–5)
≥65	Fall	23/46 (50%)	68 (43–102)	Road traffic injury	4/46 (9%)	12 (3–30)
All ages	Drowning	73/196 (37%)	12.13 (10–15)	Road traffic injury and fall	28/196 (14%)	5 (3–7)

Table 4: External causes of fatal injury outcomes, frequency, and rates, by gender and age group

injuries (22%), injury by blunt objects (10%), and road traffic injuries (9%). For each injury mechanism, more than 50% of all non-fatal injuries occurred in males except for falls and burn injuries, for which more non-fatal injuries were reported in females (58% and 72%, respectively). 98% of non-fatal injuries were unintentional in nature. Of the 2419 intentional or self-inflicted injuries reported, 2% were attempted suicides and the rest were due to assault or violence.

About 33% (n=34 552) of all non-fatal injuries occurred around the home environment, such as in a yard, veranda, or in or near a water reservoir. Around 20% of all non-fatal injuries occurred on the roads, highways, and railway stations. In children, most injuries (37%) occurred around the home at early childhood for children aged less than 5 years, with a shift in location to roads with growing age (figure 1). In children aged 10–14 years and 15–17 years, a substantial percentage of injuries (15%, n=1047) also occurred in the school environment (classrooms, playgrounds, and residential hostels).

Hands (26%) were the most affected body part for all non-fatal injuries across both sexes. Among males of all ages, the most frequently affected body parts for all non-fatal injuries were hands (26%) and lower limbs (24%), and among females, it was hands (28%) and waist (20%; figure 2). However, the most frequently affected body part for fall injuries (the most common mechanism for

non-fatal injuries) was the waist. About 30% (n=11 865) of all fall injuries were sustained on the waist, while 53% (n=12 172) of all cut injuries (the second most common mechanism for non-fatal injuries) reported were sustained on the hands (appendix).

For infants and children aged 1–4 years, most of the non-fatal injuries occurred on the hands (appendix). With increasing age, more non-fatal injuries were sustained to the lower limbs. For elderly people aged 65 years and older, most injuries were sustained to the waist. Individuals across all occupations sustained more injuries to the hand and upper extremities, except for vehicle drivers, who had more injuries to their lower limbs.

## Discussion

The SoLiD baseline census covering approximately 1.2 million people from more than 270 000 households in rural Bangladesh represents one of the single largest population-based injury studies for all age groups from an LMIC. Other large population-based injury studies, including the 2003 Bangladesh Health and Injury Survey (BHIS; 820 347 people from 171 366 households), the 2003 Philippines National Injury Survey (450 000 people from 95 000 households), and the 2004 Thailand National Injury Survey (400 000 people from 101 179 households), were not as large and focused mainly on children aged 0–17 years, except for the 2003 BHIS.<sup>24</sup> Hence, the large

population size in SoLiD allows for precise estimation of the burden and pattern of fatal and non-fatal injuries for all ages in rural Bangladesh, and can inform estimates and understanding of the pattern of injuries in rural districts of other LMICs. About 72% of the Bangladeshi population resides in the rural areas.<sup>19</sup>

The overall burden of injuries in rural Bangladesh for all ages is remarkable. The injury mortality rate was 38 deaths per 100 000 people; and for every injury death, there were close to 500 individuals who suffered non-fatal injuries severe enough to require treatment and/or absenteeism from work or school for at least one day. These rates do not have a contemporary comparison within the country, even from the 2003 BHIS study.<sup>18</sup> However, if these rates were extrapolated to the entire country's population in 2015, it shows that about 44050 deaths occur, and 21 million people suffer non-fatal injuries in rural Bangladesh annually.<sup>25</sup> These estimates represent significant healthy life years lost with considerable economic cost. Based on 2013 injury economic data from the USA, the cost of such fatal and non-fatal injuries could amount to US\$1.4 billion and \$9.7 billion, respectively, adjusting for differences in gross domestic product per head.<sup>26</sup>

Percentage of deaths due to injuries in this study was 7.1%. Although this is close to the model-based estimate of 9% reported by the World Bank for Bangladesh between 2011 and 2015, the latter percentage is based on modelled data with certain assumptions and might not be similar to real population data as observed in this study.<sup>26</sup> Neighbouring countries such as India, Pakistan, Sri Lanka, and Nepal were also reported to have slightly higher proportions of injury-related deaths per the World Bank estimates, ranging between 11% and 14%.<sup>27</sup>

The epidemiology of fatal and non-fatal injuries described in this study conforms to the expected pattern based on previous studies from Bangladesh and other LMICs, that is, higher rates in males, uneducated individuals, and certain occupational classes.<sup>28–31</sup>

Similarly, the study also confirms drowning as the leading cause of injury deaths in children aged under 9 years, burn injuries being more common in females, and elderly people being more prone to falls.<sup>32–36</sup> Unlike other studies, however, this study highlights drowning as the leading cause of injury deaths for all ages in rural Bangladesh (and not just in children) and the huge burden of suicide, especially in female adolescents and young adults. It also suggests the modifying effects of age and gender on suicide, burns, and falls rates,<sup>35–37</sup> that most fatal injuries occur within and around the home environment;<sup>38–40</sup> the significance of socioeconomic status in the distribution of non-fatal injuries;<sup>33,40</sup> and that the hand is the most likely body part to be injured in a rural LMIC setting such as Bangladesh.

Most drowning deaths in rural Bangladesh occur in children, especially those aged 1–4 years, and interventions such as providing a safe environment in

	Total population	Non-fatal injury*	
	n (%)	n	Morbidity rate per 100 000† (95% CI)
Overall (n)	1 169 593	104 703	18 002 (17 898–18 106)
Age group (years)			
<1	22 141 (2%)	484	4496 (4116–4910)
1–4	90 523 (8%)	8743	19 394 (19 012–19 784)
5–9	139 728 (12%)	11 384	16 306 (16 022–16 596)
10–14	142 121 (12%)	10 284	14 480 (14 212–14 752)
15–17	62 098 (5%)	4296	13 848 (14 212–14 752)
18–24	133 534 (11%)	9029	13 538 (13 270–13 810)
25–64	508 059 (43%)	53 583	21 170 (21 002–21 340)
≥65	71 389 (6%)	6900	20 210 (19 762–20 666)
Sex			
Male	567 674 (49%)	57 897	20 510 (20 352–20 670)
Female	601 919 (51%)	46 806	15 634 (15 498–15 770)
Occupation‡			
Agriculture (mainly farmers)	104 956 (9%)	12 424	23 940 (23 546–24 336)
Business (mainly traders)	61 661 (5%)	5423	17 688 (17 244–18 144)
Skilled labour	89 151 (8%)	8425	18 966 (18 584–19 354)
Unskilled or domestic	30 176 (3%)	3392	22 480 (21 780–23 204)
Rickshaw or bus	17 037 (1%)	2 499	29 408 (28 560–30 490)
Students	312 537 (26.74)	22 545	14 434 (14 254–14 618)
Retired, unemployed, or housewife	408 583 (35%)	37 941	18 706 (18 528–18 886)
Other§	150 402 (12%)	11 989	16 718 (16 434–17 008)
Socioeconomic status			
Lowest	211 601 (18%)	20 227	19 240 (18 988–19 492)
Low	218 695 (19%)	20 743	19 064 (18 818–19 312)
Middle	238 371 (20%)	21 720	18 318 (18 086–18 552)
High	247 716 (21%)	22 051	17 894 (17 680–18 122)
Highest	253 210 (22%)	19 962	15 854 (15 644–16 066)
Education‡			
No education	295 314 (25%)	30 112	20 630 (20 410–20 852)
Primary	407 923 (34.88)	38 251	18 804 (18 638–18 984)
Secondary	289 658 (25%)	23 130	16 008 (15 810–16 206)
Post-secondary	63 702 (5%)	3973	12 472 (12 104–12 854)
Not applicable (under 5)	112 664 (10%)	9227	16 522 (16 202–16 848)
Subdistrict			
Matlab North	265 897 (23%)	25 509	19 290 (19 068–19 514)
Matlab South	209 772 (18%)	22 075	21 160 (20 898–21 426)
Chandpur Sadar	128 356 (11%)	9033	14 142 (13 862–14 426)
Raigunj	104 357 (9%)	13 481	25 984 (25 578–26 396)
Sherpur	228 519 (20%)	15 233	13 400 (13 196–13 608)
Manohardi	204 319 (17%)	15 547	15 310 (15 080–15 542)
Daud Kandi	28 373 (2%)	3825	27 146 (26 356–27 956)

p<0.0001 for males vs females and lowest vs highest socioeconomic status. \*Reported over a 6-month recall period. †Annualised. ‡Missing: education (<1%) and occupation (<1%). §Other comprises mostly children, including all under-5 children.

**Table 5: Sociodemographic characteristics of non-fatal injury outcomes in Bangladesh**

the form of crèches have shown promising results in reducing drowning risk among under-5 children.<sup>34</sup> The SoLiD project is currently testing the large-scale effectiveness of the use of crèches and playpens for

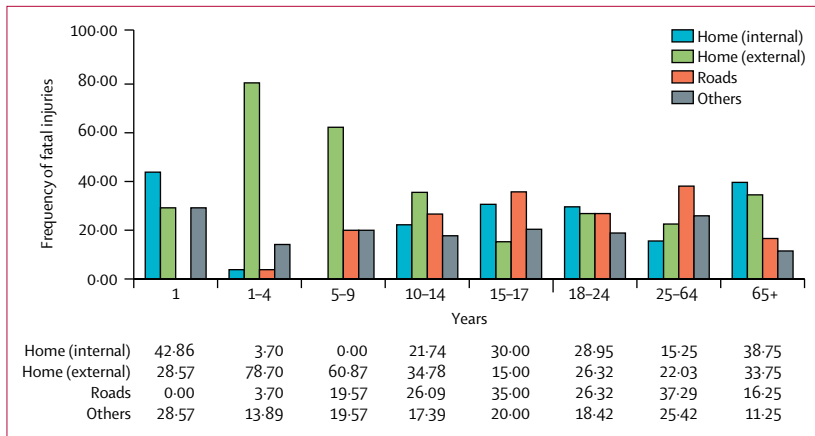


Figure 1: External causes of fatal injuries by place of injury occurrence

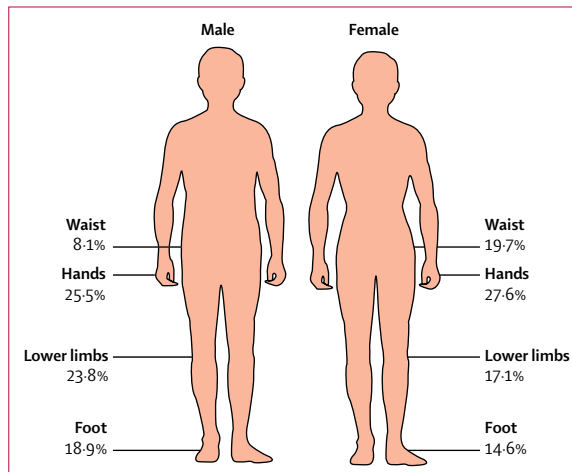


Figure 2: Top body parts affected by non-fatal injuries  
Human silhouettes designed by Freepik.<sup>23</sup>

drowning prevention in very young children.<sup>15</sup> Other childhood drowning prevention interventions such as swim lessons and rescue training for bystanders have also been implemented in Bangladesh with promising results.<sup>41,42</sup> Tackling the drowning issue for all age groups would require comprehensive strategies that address environmental challenges and hazards in the community, including resilience and flood risk management and implementing evidence-based water safety plans.<sup>43</sup> Such comprehensive approaches would also be required for addressing causal factors of fatal road traffic injuries and fall injuries, including road and vehicle safety regulations, and modifications to internal and external home environments.<sup>44</sup>

Suicide was the most common intentional injury mechanism and the fourth leading cause of injury deaths in rural Bangladesh.<sup>45-47</sup> This study suggests that about 168 suicides occur every day in the country, especially in female adolescents and young adults. The low status of women in the society, child marriage, economic

dependence on, and oppression from, husbands and in-laws, and illiteracy are some of the few reasons that have been previously reported for increased suicide rate in females.<sup>31,45</sup> It is crucial to initiate changes in the society by enforcing legislation, focusing on girls' education and creating opportunities to empower women to improve their status in society, and to curb intimate partner violence. Some researchers have called for more multidisciplinary research exploring the intersection of adolescent mental health and reproductive health and rights to adequately understand the underlying causal factors for suicide.<sup>48</sup>

Like suicide, the burden of burn injuries is disproportionately borne by young girls and women in rural Bangladesh.<sup>49</sup> Most fatal burn injuries in rural areas are due to flames from cooking fires, and because women traditionally cook and perform household chores in rural Bangladesh, they are more exposed to fatal burns.<sup>49</sup> Burns could also be a major mechanism for suicide in young females, and could result from intimate partner violence.

Although the disparities in the global burden of injuries is well established, this study highlights the disproportionately higher rates of non-fatal injuries in individuals from low socioeconomic status compared with those in the highest socioeconomic status group.<sup>6,44</sup> Therefore, the solution for confronting the global disparities of injuries should be addressed locally, and there is a social justice imperative to address social policies for protecting vulnerable populations in national injury prevention programmes.

This study was done in a predominantly rural setting and thus injury mortality and morbidity estimates might not be nationally representative for Bangladesh. Also, because the information was self-reported, the data might be subject to recall bias. Indeed, minor injuries might have been differentially recalled leading to underestimation of the non-fatal injury morbidity rates.<sup>50</sup> Although the study specified a case definition for injuries that conformed to the ICD-10 causes of death classification and the study questionnaires were based in part on the WHO standards for verbal autopsies, some injuries and fatal outcomes could still have been misclassified because of the questionnaires and the absence of a proper verbal autopsy study. In addition, other information bias and data collection or entry errors, including information on dates and gender, could have further led to misclassification of injuries by age and gender. Although missing data and incomplete records were not significant for this study generally, missing records for fatal and non-fatal injury outcomes would have affected the study's ability to estimate rates with precision and accuracy.

Notwithstanding these limitations, our study provides an all-inclusive sociodemographic assessment of fatal and non-fatal injury outcomes in one of the largest population-based injury studies in LMICs. The findings from our study are useful for developing evidence-based targeted interventions to reduce unintentional injuries in



children, adults, and the elderly population in rural Bangladesh and rural districts of other LMICs with similar environmental factors. The findings are also useful for accurate estimation of, and raising awareness about, the true nature of the burden of injuries in LMICs.

#### Contributors

OA conceived the paper, contributed to the study design and analyses, wrote the first draft, and managed subsequent revisions. PA contributed to the analyses and first draft of the manuscript. AT and QSR managed the study data and edited the manuscript. AFR, SE, and ALH contributed to the study design, reviewed, and edited the manuscript for intellectual content.

#### Declaration of interests

We declare no competing interests.

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