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Unintentional injuries: A profile of hospitalization and risk factors for in-hospital mortality in Beijing, China

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ABSTRACT

Introduction: Unintentional injuries (UIs) impose a significant burden on low- and middle-income countries (LMICs). However, available UI epidemiological data are limited for LMICs, including China. This article aimed to provide an overview of the UI hospitalization profile, identify risk factors for in-hospital mortality and provide diagnosis-specific survival risk ratios (SRRs) for reference by LMICs using hospital discharge abstract data (DAD) from Beijing, China.
Patients and methods: A cross-sectional study was conducted for patients sustaining UIs requiring admission. Information was retrieved from 138 hospitals in Beijing to describe the demographics, injury nature, mechanisms, severity and hospital outcomes. Multivariate logistic regression was performed to identify and evaluate risk factors for in-hospital mortality for UIs.
Results: Falls (57.1%), transport accidents (19.9%) and exposure to inanimate mechanical forces (16.4%) were the leading causes of UI hospitalization. Falls and transport accidents were responsible for 94.2% of the in-hospital deaths caused by UIs. Injury mechanisms differed among sex ($\chi^2 = 5322.1$, $P < 0.001$) and age ($\chi^2 = 24{,}143.3$, $P < 0.001$) groups. Male sex (OR: 1.50, 95% confidence interval (CI): 1.23–1.79), age ≥ 85 years (OR: 16.39, 95% CI: 7.46–36.00), Barthel Index at admission ≤ 60 (OR: 25.78, 95% CI: 13.30–49.95), modified Charlson comorbidity index ≥ 6 (OR: 2.60, 95% CI: 1.91–3.55), International Classification of Diseases-based injury severity score (ICISS) < 0.85 (OR: 15.17, 95% CI: 12.57–18.30), sustaining injuries to the head/neck (OR: 23.20, 95% CI: 7.31–73.64), injuries caused by foreign body entering through natural orifice (OR: 34.00, 95%CI: 6.37–181.54) and injuries resulting from transport accidents (OR: 1.71, 95% CI: 1.41–2.07) were important risk factors for in-hospital mortality for UIs.
Conclusions: Hospital DAD are an objective and cost-effective data source that allows for a hospital-based perspective of UI epidemiology. Sex, age, functional status at admission, comorbidities, injury nature, severity and mechanism are significantly associated with the in-hospital mortality of UIs in China. This study generates a reference dataset of diagnosis-specific SRRs from a large trauma population in China, which may be more applicable in injury severity estimation using ICISS in LMICs.

Introduction

Unintentional injuries (UIs) are a group of injuries with no evidence of predetermined intent, including transport accidents; falls; mechanical and natural forces; burns; threats to breathing; and other unintentional causes. UIs are the leading cause of mortality and disability, making them a serious public health concern worldwide, especially for low- and middle-income countries (LMICs). UIs have a significant influence on life

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expectancy and life quality, causing a profound economic burden to individuals and society [1]. The global prevalence of UIs was 931 million in 2015, causing an estimated 3.5 million deaths and 186 million disability-adjusted life-years (DALYs) [2–4]. The death rate and DALY rate are approximately double and triple in LMICs versus high-income countries (HICs) [1]. Deaths and DALYs attributed to UIs in China account for 15% and 18%, respectively, of the world total. UIs are unpredictable but preventable. A huge savings in terms of lives and reduced disabilities resulting from UIs could be experienced if LMICs, including China, were to discuss and implement more efficient prevention strategies. Defining the epidemiology of UIs and providing evidence for policy making to improve their prevention and control are imperative for LMICs.

The injury pyramid is composed of fatal injuries, injuries that require admission and emergency department treatment and those that do not require medical attention. Globally, there are 37.3 million falls each year that are severe enough to require medical attention [5]. Studies of nonfatal UIs are an important part of the overall picture of UIs [6,7]. Although much is known about fatal injuries via the vital registry system, there are limited data on nonfatal injuries in LMICs, with most information being based on questionnaire surveys and trauma registries or focused on a select group of injuries or population [8–12]. Although the National Injury Surveillance System (NISS) was built in China since 2006, it includes only 126 hospitals with limited representation and collects information using hard-copy forms, which leads to poor availability of real-time data [13]. Hospital discharge abstract data (DAD) could be an alternative and cost-effective data source with good availability for epidemiological studies of UIs. Injury severity is an important concern in injury epidemiology, which could be derived from diagnosis-specific survival risk ratios (SRRs) when only hospital DAD is available. Reference datasets of diagnosis-specific SRRs were reported in HICs [14], but have not been reported in LMICs.

Beijing has an area of 16,410 km^2 and a total population of 21.7 million. According to the national vital registry system, the crude death rate from injuries is 23 per 100,000, of which 62.4% are due to falls and road traffic injuries [15]. This study aimed to elucidate the demographics, injury nature, mechanisms, severity and hospitalization outcomes, to identify the risk factors for in-hospital mortality from UIs using hospital DAD from Beijing, and to generate a reference dataset for injury severity estimation in LMICs. Our results provide a key reference for policy makers, health care providers and epidemiological researchers in LMICs.

This study was approved by the Institutional Review Board of Peking Union Medical College Hospital at the Chinese Academy of Medical Sciences and Peking Union Medical College.

Patients and methods

Patients

UIs cases were defined as those with a primary diagnosis of injury (ICD-10 codes: S00-S09 or T00-T78) and an additional diagnosis of unintentional external causes of injury (ICD-10 codes: V00-V99, W00-X59). Admissions documented as injuries to an unspecified body region (T09.0-T09.2, T09.4-T09.9, T14), injuries caused by noxious substances (X40-X49), overexertion, travel and privation (X50-X57) and other unspecified injury mechanisms (X58-X59), and patients seeking rehabilitation therapy or who were admitted for a previously treated injury were excluded from this study.

Data source

A total of 107 (74.3%) secondary and 87 (75.0%) tertiary medical institutions in Beijing report their hospital DAD to the Beijing Municipal Commission of Health and Family Planning Information Center monthly. Information of eligible UI patients who were admitted to secondary and tertiary medical institutions from 1 January to 31 December 2017 were accessed from the Information Center. Data on patient demographics, ICD-10 codes for diagnoses translated by coders after discharge, the Barthel Index at admission, length of hospital stay (LOS), ICU admission, ventilator use and hospital outcome (defined as death or survival) were retrieved. In addition to the primary diagnosis of injury and an additional diagnosis of unintentional external causes of injury, 10 secondary diagnoses were obtained for each patient to examine the presence of multiple injuries and comorbidities.

Injury nature

Injuries were classified into 10 categories by their nature: injuries to the head/neck, thorax, abdomen/lower back/pelvis, upper extremities, lower extremities, spine/spinal cord, multiple injuries defined as injuries that occurred to more than two of the body regions described above, effects of foreign body entering through natural orifice, burns and corrosions, and other effects of external causes.

Injury mechanism

Injury mechanisms were defined according to ICD-10 as follows: transport accidents (V01-V99); falls (W00-W19); exposure to inanimate mechanical forces (W20-W49); exposure to animate mechanical forces (W50-W64); accidental drowning and submersion (W65-W74); other accidental threats to breathing (W75-W84); exposure to electronic currents, radiation and extreme ambient air temperature or pressure (W85-W99); exposure to smoke, fire or flames (X00-X09); contact with heat or hot substances (X10-X19); contact with venomous animals or plants (X20-X29); and exposure to forces of nature (X30-X39) [16]. Mechanisms coded as W65-W99 and X00-X39 were combined as a category "other mechanisms" in the multivariate logistic regression analysis.

Comorbidities

A modified Charlson comorbidity index (mCCI), which had been validated in trauma patients [17], was used to measure the comorbidities of the study population. Weights were assigned to each comorbid condition as described by Bouamra [17]. The mCCI was generated by adding the weights of the identified comorbidities for each patient.

Barthel Index

The Barthel Index is an indicator of the functional motility status that assesses independence in the activities of daily living [18]. A functional motility status with a Barthel Index ≤ 60 represents moderate to severe dysfunction requiring immense assistance to complete daily living activities.

Injury severity estimate

The International Classification of Diseases-based Injury Severity Score (ICISS) is an efficient tool to evaluate injury severity for hospital DAD [19,20]. The ICISS is calculated based on SRR, which is the proportion of patients surviving at discharge among all the patients admitted to the hospital. Traditional SRR and independent SRR are two algorithms of SRR; the former includes not only single injuries but also multiple injuries, and the latter takes only single injuries into consideration [21]. The ICISS also has two different formulas: as a product of the SRRs of multiple injuries and as the SRR of the single worst injury [22,23]. Kilgo et al. proposed that the single worst injury ICISS performed better in mortality prediction [23]. A systemic review has demonstrated that single worst injury ICISS with traditional SRR performs better in the prediction of injury mortality than other combinations [21]. Thus, single worst injury ICISS with traditional SRR was adopted in this study. SRRs assigned to each ICD-10 code at the four-digit level were obtained using the data source of this study. Injuries with ICISS < 0.85 were defined as severe injuries [22].

Statistical analysis

SPSS Version 23.0 (IBM Inc., Chicago, IL, USA) and SAS Version 9.4 (SAS Institute, Cary, NC, USA) were used for the statistical analysis. Normality was tested using the Kolmogorov-Smimov method for consecutive variables. Consecutive variables were described as the median and interquartile range (IQR) and analysed using a nonparametric test in this study. Statistical significance of differences in the proportions among different groups was determined using the χ^2 test. Frequencies and percentages were used to describe categorical variables. Clopper-Pearson 95% confidence intervals of SRRs for each ICD code were estimated.

Barthel Index at admission was not reported in 13.4% of the study population. Multiple imputation was used to deal with the missing values based on the assumption that the values are missing at random [24]. Ten "complete" datasets were created after imputation. A multivariate logistic regression model was adopted to test and estimate the effect of the variables on in-hospital mortality for each dataset. Pooled results were generated from the imputed datasets. The goodness of fit was evaluated using the Hosmer-Lemeshow test. The areas under the receiver operating characteristic curve (AUCs) and 95% CIs were calculated to assess the predictive power. When testing the model performance based on the 10 datasets generated by multiple imputation, the median and IQR of p value for the Hosmer-Lemeshow test and AUC value were used. A two-tailed test with $P < 0.01$ was considered significant.

Results

General characteristics

A total of 100,205 hospital admissions for UIs from 62 secondary and 76 tertiary medical institutions were included in the study. ICD-10 diagnosis-specific SRRs with 95%CI were derived from this population and listed in Supplemental Table. A total of 59,106 of the cases were males, and the male-to-female ratio was 1.44:1. The median age of the study population was 51 years (IQR: 34–66 years). Patients aged 15–64 years accounted for 67.3% of the total population. The male patients sustaining UIs were younger than the females (46 years vs 61 years, $P < 0.001$). The sex (male-to-female) ratios for patients aged $\leq$ 14, 15–44, 45–64, 65–74, 75–84 and $\geq$ 85 years were 1.84:1, 3.08:1, 1.54:1, 1:1.61, 1:2.03 and 1:1.78 ($\chi^2 = 9844.2$, $P < 0.001$), respectively.

The median LOS of the UI patients was 8 days (IQR: 4–15). Of the total patients, 5523 (5.5%) were admitted to the ICU, 3602 (3.6%) used a ventilator and 791 (0.8%) died before discharge. A significant difference was present between surviving and nonsurviving patients in the level of the medical institution, age, gender, ICISS, Barthel Index at admission, mCCI, LOS, ICU admission and ventilator use (Table 1).

Injury nature

The demographics and clinical features of the different natures of UI hospitalizations are presented in Table 2. There were 96,454 patients with injuries involving body regions, accounting for 96.3% of the total population. Over half of the patients were admitted for extremity injuries, followed by multiple injuries (22.4%), spine/spinal cord injuries (9.3%) and head/neck injuries (8.7%). Head/neck injuries and multiple injuries were responsible for 85.7% of all the deaths caused by UIs before discharge. Spine/spinal cord injuries mostly occurred in elderly patients, with a median age of 68 years (IQR: 59–79 years). The median ages of patients with injuries to other body regions and multiple injuries ranged from 43 to 57 years.

There were 1639 cases who were admitted to hospital due to effects of foreign bodies entering natural orifice and 1996 cases admitted for burns and corrosions. A total of 1048 (63.9%) patients admitted as a result of foreign body entry were children up to 14 years old, of which 734 (70.0%) were cases involving a respiratory foreign body. The median age of the patients with burns and corrosions, and other effects of external causes was 38 and 36 years, respectively.

Injury mechanism

The demographics and clinical features of the UIs are presented by the injury mechanisms in Table 3. The three leading mechanisms attributed to UI-related hospitalizations were falls (57.1%), transport accidents (19.9%) and exposure to inanimate mechanical forces (16.4%). Falls and transport accidents were responsible for 94.2% of all the deaths caused by UIs before discharge. Injuries caused by inanimate mechanical forces were mainly due to contact with machinery (29.4%), being struck by thrown, projected or falling object (21.0%) and contact with sharp glass (15.1%).

The injury mechanisms differed between the groups based on the sex ($\chi^2 = 5322.1$, $P < 0.001$) and age ($\chi^2 = 24{,}143.3$, $P < 0.001$) of the hospitalized UI patients (Fig. 1). The top 3 mechanisms for UI hospitalizations were falls (47.5%), exposure to inanimate mechanical forces (17.0%) and other accidental threats to breathing (12.8%) for patients up to 14 years old; falls (47.3%), exposure to inanimate mechanical forces (21.5%) and transport accidents (24.2%) for patients 15–64 years old; and falls (83.7%), transport accidents (10.9%) and exposure to inanimate mechanical forces (3.5%) for patients over 65 years old.

Patients hospitalized because of falls were mostly aged 65 years and over, accounting for 39.4% of the fall population. The sex (male-to-female) ratios of these patients were 1.89:1, 2.86:1, 1.21:1 and 1:2.13, 1:2.28 and 1:1.86 for patients $\leq$ 14, 15–44, 45–64, 65–74, 75–84 and $\geq$ 85 years ($\chi^2 = 6386.5$, $P < 0.001$). Patients hospitalized following transport accidents were predominantly male, with a sex ratio of 1.61:1. Patients aged 15–64 years accounted for 81.9% of the total hospitalizations sustaining injuries caused by transport accidents. Exposure to mechanical forces more commonly affected males than females, with a sex ratio of 3.88:1. Patients up to 14 years of age accounted for 40.6% of the patients admitted for thermal injury.

Severe injury and in-hospital mortality

The rates of severe injuries and in-hospital mortality for different ages and gender groups are presented in Fig. 2. The rate of severe injury (2.6% vs 1.1%, $\chi^2 = 277.4$, $P < 0.001$) and in-hospital mortality (1.0% vs 0.5%, $\chi^2 = 69.7$, $P < 0.001$) in males were higher than those in females. The rates of severe injuries for patients $\leq$ 14, between 15–44, between 45–64, between 65–74, between 75–84 and $\geq$ 85 years of age were 1.0%, 1.7%, 2.5%, 2.5%, 1.5% and 1.5%, respectively. In-hospital mortality increased with age, from 0.2% for patients $\leq$ 14 years old to 2.1% for those $\geq$ 85 years old.

Patients categorized into the group of other effects of external causes (ICD-10 code: T33-T78) had the highest rate of severe

Table 1
General and clinical characteristics of survivors, nonsurvivors and total patients sustaining unintentional injuries.

Characteristics	N (%)			P
	Total	Nonsurvivors	Survivors	
Medical Institution				0.002
Secondary	33812 (33.7)	226 (28.6)	33,586 (33.8)	
Tertiary	66393 (66.3)	565 (71.4)	65,828 (66.2)	
Gender				< 0.001
Female	41099 (41.0)	218 (27.6)	40,881 (41.1)	
Male	59,106 (59.0)	573 (72.4)	58,533 (58.9)	
Age (years)				< 0.001
≤ 14	5775 (5.8)	10 (1.3)	5765 (5.8)	
15-44	32354 (32.3)	149 (18.8)	32,205 (32.4)	
45-64	35121 (35.0)	266 (33.6)	34,855 (35.1)	
65-74	11408 (11.4)	122 (15.4)	11,286 (11.4)	
75-84	10970 (10.9)	149 (18.8)	10,821 (10.9)	
≥ 85	4577 (4.6)	95 (12.0)	4482 (4.5)	
ICISS				< 0.001
0.85-1	98182 (98.0)	359 (45.4)	97,823 (98.4)	
< 0.85	2023 (2.0)	432 (54.6)	1591 (1.6)	
Barthel Index at admission				< 0.001
> 60	46183 (53.2)	19 (2.8)	46,164 (53.6)	
≤ 60	40562 (46.8)	661 (97.2)	39,901 (46.4)	
mCCI				< 0.001
0	86984 (86.8)	536 (67.8)	86,448 (87.0)	
1-5	10251 (10.2)	186 (23.5)	10,065 (10.1)	
6-10	744 (0.7)	27 (3.4)	717 (0.7)	
> 10	2226 (2.2)	42 (5.3)	2184 (2.2)	
LOS (d)				< 0.001
1-7	47050 (47.0)	514 (65.0)	46,536 (46.8)	
8-30	48434 (48.3)	225 (28.4)	48,209 (48.5)	
>30	4721 (4.7)	52 (6.6)	4669 (4.7)	
ICU admission				< 0.001
yes	5523 (5.5)	547 (69.2)	4976 (5.0)	
no	94682 (94.5)	244 (30.8)	94,438 (95.0)	
Ventilator use				< 0.001
yes	3602 (3.6)	553 (69.9)	3049 (3.1)	
no	96603 (96.4)	238 (30.1)	96,365 (96.9)	

Abbreviation: ICISS = International Classification of Diseases based Injury Severity Score, mCCI = modified Charlson comorbidity index, LOS = length of hospital stay.

Table 2
Demographics and clinical features of unintentional injury hospitalizations by injury natures.

Unintentional injuries	Cases	Age (years)*	Sex ratio	Tertiary institution admission	Nonsurvivors	ICU admission	Ventilator use	LOS (d)*	ICISS < 0.85
Injuries to the head/neck	8675 (8.7)	47 (30-62)	2.62:1	6575 (75.8)	411 (4.7)	1399 (16.1)	836 (9.6)	8 (5-14)	1262 (14.5)
Injuries to the thorax	2407 (2.4)	57 (47-70)	1.97:1	1455 (60.4)	3 (0.1)	120 (5.0)	40 (1.7)	10 (7-14)	2 (0.1)
Injuries to the abdomen/lower back/pelvis	1476 (1.5)	48 (32-65)	1.35:1	986 (66.8)	6 (0.4)	131 (8.9)	90 (6.1)	9 (5-15)	4 (0.3)
Injuries to the spine/spinal cord	9335 (9.3)	68 (59-79)	1:1.84	6618 (70.9)	12 (0.1)	134 (1.4)	114 (1.2)	7 (4-12)	0 (0.0)
Injuries to the upper extremities	23363 (23.3)	43 (28-57)	1.85:1	12796 (54.8)	3 (< 0.1)	125 (0.5)	203 (0.9)	5 (3-9)	0 (0.0)
Injuries to the lower extremities	28726 (28.7)	56 (40-74)	1.11:1	20679 (72.0)	60 (0.2)	1281 (4.5)	754 (2.6)	10 (6-17)	2 (< 0.1)
Injuries to multiple injuries	22472 (22.4)	49 (35-61)	1.83:1	14798 (65.9)	267 (1.2)	2153 (9.6)	1474 (6.6)	11 (6-19)	681 (3.0)
Effects of foreign body entering through natural orifice	1639 (1.6)	3 (1-48)	1.38:1	1541 (94.0)	7 (0.4)	39 (2.4)	39 (2.4)	1 (1-3)	4 (0.2)
Burns and corrosions	1996 (2.0)	38 (6-55)	1.56:1	874 (43.8)	15 (0.8)	114 (5.7)	32 (1.6)	12 (7-20)	34 (1.7)
Other effects of external causes	116 (0.1)	36 (16.25-53)	5.11:1	71 (61.2)	7 (6.0)	27 (23.3)	20 (17.2)	8 (3-19)	34 (29.3)

Data are presented as N (%) unless otherwise indicated. * Presented as median and interquartile range.
Abbreviation: LOS = length of hospital stay, ICISS = International Classification of Diseases based Injury Severity Score.

injuries (29.3%) and in-hospital mortality (6.0%). Among injuries involving body regions, head/neck injuries had the highest rate of severe injury (14.5%) and in-hospital mortality (4.7%), followed by multiple injuries (3.0% and 1.2%).

With respect to injury mechanisms, exposure to natural forces led to the highest rate of severe injuries (92.9%) and in-hospital mortality (17.9%), followed by exposure to smoke, fire and flames (5.1% and 2.1%) and transport accidents (4.8% and 1.7%). No gender difference inhospital mortality was observed for patients caused by falls under 44 years old. In-hospital mortality following falls was higher for males than that for females in the age groups of 45–64 years (0.8% vs 0.2%, $\chi^2 = 42.8$, $P < 0.001$), 65–74 years (1.4% vs 0.3%, $\chi^2 = 33.4$, $P < 0.001$), 75–84 years (2.4% vs 0.7%, $\chi^2 = 48.2$, $P < 0.001$) and ≥ 85 years (3.6% vs 1.0%, $\chi^2 = 37.8$, $P < 0.001$). A similar

Table 3
Demographics and clinical features of unintentional injuries caused by different mechanisms.

Injury mechanisms	Cases	Age (years) *	Sex ratio	Tertiary institution admission	Nonsurvivors	ICU admission	Ventilator use	LOS (d)*	ICISS < 0.85
Transport accidents	19964 (19.9)	47 (32-59)	1.61:1	13611 (68.2)	346 (1.7)	1897 (9.5)	1349 (6.8)	11 (6-19)	967 (4.8)
Falls	57198 (57.1)	59 (42-74)	1.02:1	41331 (72.3)	399 (0.7)	3088 (5.4)	1875 (3.3)	8 (5-15)	922 (1.6)
Exposure to inanimate mechanical forces	16,417 (16.4)	40 (28-51)	4.05:1	7098 (43.2)	15 (0.1)	316 (1.9)	278 (1.7)	5 (2-9)	39 (0.2)
Exposure to animate mechanical forces	3647 (3.6)	39 (29-51)	3.24:1	2592 (71.1)	4 (0.1)	73 (2.0)	32 (0.9)	6 (3-10)	24 (0.7)
Accidental drowning and submersion	12 (< 0.1)	12 (5-28.25)	5.00:1	7 (58.3)	0 (0.0)	3 (25.0)	1 (8.3)	4.5 (1.5-9.8)	0 (0.0)
Other accidental threats to breathing	911 (0.9)	1 (1-3)	2.21:1	829 (91.0)	6 (0.7)	17 (1.9)	19 (2.1)	1 (1-3)	6 (0.7)
Exposure to electric current, radiation and extreme ambient air temperature and pressure	191 (0.2)	37 (25-49)	10.94:1	105 (55.0)	2 (1.0)	15 (7.9)	3 (1.6)	17 (7-35)	6 (3.1)
Exposure to smoke, fire and flames	570 (0.6)	45 (31-56)	2.20:1	210 (36.8)	12 (2.1)	83 (14.6)	25 (4.4)	14 (8-24)	29 (5.1)
Contact with heat and hot substances	1259 (1.3)	30 (1-55)	1.14:1	579 (46.0)	2 (0.2)	13 (1.0)	5 (0.4)	10 (6-17)	4 (0.3)
Contact with venomous animals and plants	8 (< 0.1)	4 (0-46)	3.00:1	7 (87.5)	0 (0.0)	1 (12.5)	0 (0.0)	1 (1-2)	0 (0.0)
Exposure to forces of nature	28 (< 0.1)	54 (43-64)	6.00:1	24 (85.7)	5 (17.9)	17 (60.7)	15 (53.6)	11 (3.0-19.8)	26 (92.9)

Data are presented as N (%) unless otherwise indicated. * Presented as median and interquartile range.
Abbreviation: LOS = length of hospital stay, ICISS = International Classification of Diseases based Injury Severity Score.

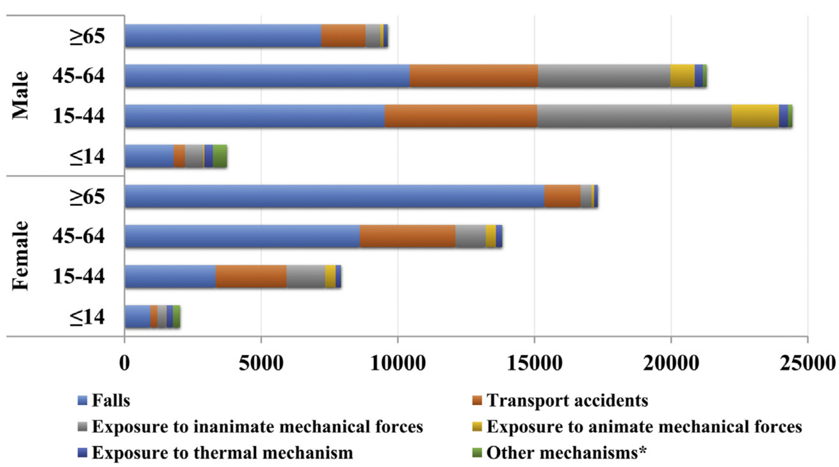

Fig. 1. Mechanisms of unintentional injury by sex and age group. * Other mechanisms include accidental drowning and submersion; other accidental threats to breathing; exposure to electric current, radiation and extreme ambient air temperature and pressure; contact with venomous animals and plants; and exposure to forces of nature.

pattern was observed inhospital mortality following transport accidents, with males dominating the number of deaths in the 45–64 (2.3% vs 1.3%, $\chi^2 = 10.6$, $P = 0.001$), 65–74 (4.2% vs 1.7%, $\chi^2 = 10.0$, $P = 0.002$) and 75–84 (4.7% vs 1.1%, $\chi^2 = 8.5$, $P = 0.004$) age groups.

Risk factors for in-hospital mortality

The pooled results of multivariate logistic regression of the imputed datasets are shown in Table 4. The most important influencing factors for in-hospital mortality of UI patients were male sex (OR: 1.50, 95% CI: 1.23–1.79), age 85 years and over (OR: 16.39, 95% CI: 7.46–36.00), a Barthel Index at admission ≤ 60 (OR: 25.78, 95% CI: 13.30–49.95), a mCCI ≥ 6 (OR: 2.60, 95% CI: 1.91–3.55), an ICISS < 0.85 (OR: 15.17, 95% CI: 12.57–18.30), sustaining injuries to the head/neck (OR: 23.20, 95% CI: 7.31–73.64), injuries caused by foreign body entering through natural orifice (OR: 34.00, 95%CI: 6.37–181.54) and injuries resulting from transport accidents (OR: 1.71, 95% CI: 1.41–2.07).

The median P value for the Hosmer-Lemeshow test was 0.120 (IQR: 0.084-0.156), which showed a good fit for the multivariate logistic regression model. The median AUC value was 0.950 (IQR: 0.950-0.951) for the model, demonstrating a significantly discriminant power of the model.

Discussion

Identifying the leading causes of hospitalization and describing the demographic features of UIs are key steps to providing evidence to reduce the disability and mortality caused by UIs. This study found that falls and transport accidents were the leading causes of UI hospitalization and in-hospital deaths in Beijing. Road traffic injuries and falls are also the two major UI-related causes of

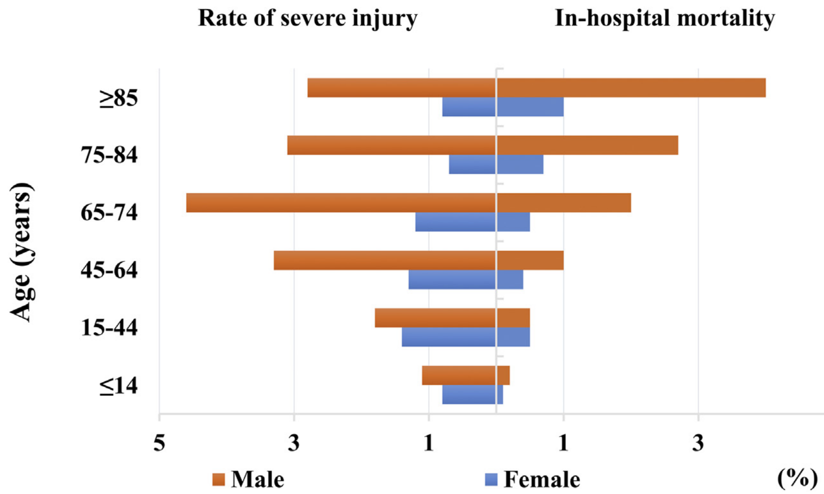

Fig. 2. Rates of severe injury and in-hospital mortality by sex and age group.

disability-adjusted life-years (DALYs) lost [1]. Thus, preventing falls and transport accidents should be assigned high priorities by policy makers.

Falls were the top cause of UI hospitalizations for all age groups, which is consistent with studies in India and Canada [25,26]. The annual prevalence of falls is reported to be 17.8%–18.0% among the elderly [27,28] and 41.5% among the frail elderly in Beijing [29]. Falls lead to a heavy economic burden to the Chinese elderly population, and the burden has increased in the past 30 years [30]. The number of males admitted to the hospital following falls is 2.9 times that of females in the 15–44 age group, which may be related to their exploratory and adventurous characteristics, as males are more likely to participate in outdoor and other social activities. Female patients accounted for 2/3 of the hospitalizations following falls in the elderly aged 65 years and over, similar to the data for New York [31]. Other than female predominance in the elderly population, postmenopausal biological changes of elderly women, such as osteoporosis [29,32] could explain the gender difference in UI hospitalizations following falls in the elderly because elderly women have higher chances of falling and increased possibilities of sustaining injuries that require admission after falling. Effective preventive interventions can reduce the prevalence of falls [33,34]; however, prevention of falls has not been given enough importance in China. Understand the underlying causes of falls in different sex and age groups is essential for future targeted actions toward health education, the improvement of living and working environments and intervention evaluation. Meanwhile, reducing in-hospital mortality for elderly men should not be neglected because the mortality rate is approximately 4 times that for elderly women.

Transport accidents are the second most common cause of UI hospitalization and in-hospital death. The rates of people wearing seatbelts, helmets and child restraints are reported to be 37%, 20% and < 1%, respectively, in China [35,36], which accounts for the high prevalence of transport accidents requiring admission. Legislation on seatbelt, helmet and child restraint use needs to be improved in China. The sex ratio of patients sustaining transport accidents was 1.61:1, which is lower than the ratios reported in Iran (2.2:1) and Romania (2.0:1) [9,37]. This difference may be explained by the more active participation of Chinese women in driving-related and outdoor activities than women in the other countries. The prevention of transport accidents by Chinese females should be given more attention. The in-hospital mortality of males aged 45–84 years following transport accidents is higher than that of females and may be related to the lack of safety awareness and dangerous driving behaviours of middle-aged and elderly men. Sustainable Development Goals include an ambitious aim of halving global deaths and injuries from road traffic accidents by 2020 [38]. China has also set a goal to reduce the number of deaths per 10,000 vehicles by 3.0% in the Healthy China

Table 4
Multivariate logistic regression for death during hospitalization.

Variables	*P*	OR (95% CI)
Male	< 0.001	**1.50 (1.23-1.79)**
Age (years)		
≤ 14	Ref	
15-44	0.011	2.71 (1.26-5.84)
45-64	0.001	**3.57 (1.67-7.63)**
65-74	< 0.001	**5.42 (2.50-11.77)**
75-84	< 0.001	**10.15 (4.68-21.98)**
≥ 85	< 0.001	**16.39 (7.46-36.00)**
Tertiary medical institution	0.715	0.97 (0.81-1.15)
Injury nature		
Upper extremities	Ref	
Head/neck	< 0.001	**23.20 (7.31-73.64)**
Thorax	0.282	2.42 (0.49-11.99)
Abdomen/lower back/pelvis	0.026	4.88 (1.21-19.74)
Spine/spinal cord	0.685	1.30 (0.36-4.67)
Lower extremities	0.276	1.92 (0.59-6.19)
Multiple injuries	< 0.001	**9.35 (2.95-29.64)**
Foreign body	< 0.001	**34.00 (6.37-181.54)**
Burns and Corrosions	0.050	12.72 (1.00-161.30)
Other effects of external causes	0.021	10.81 (1.43-82.07)
Injury mechanism		
Falls	Ref	
Transport accidents	< 0.001	**1.71 (1.41-2.07)**
Exposure to inanimate mechanical forces	0.169	0.66 (0.37-1.19)
Exposure to animate mechanical forces	0.008	**0.26 (0.10-0.71)**
Exposure to thermal mechanism	0.744	1.48 (0.14-15.68)
Other mechanisms*	0.493	1.66 (0.39-6.99)
Barthel Index at admission ≤ 60	< 0.001	**25.78 (13.30-49.95)**
ICISS < 0.85	< 0.001	**15.17 (12.57-18.30)**
mCCI		
0	Ref	
1-5	< 0.001	**1.64 (1.35-2.00)**
≥ 6	< 0.001	**2.60 (1.91-3.55)**

Abbreviation: OR: odds ratio, 95% CI: 95% confidential interval, ICISS = International Classification of Diseases based Injury Severity Score, CCI = Charlson comorbidity index.
Boldface indicates significance ($P < 0.01$).
* Other mechanisms include accidental drowning and submersion; other accidental threats to breathing; exposure to electric current, radiation and extreme ambient air temperature and pressure; contact with venomous animals and plants; and exposure to forces of nature.

2030 Planning Outline [39]. Improving the comprehensive quality of traffic participants through education should be considered to achieve these goals.

The multiple logistic regression identified the association of gender, aging, injury nature, injury mechanism, comorbid diseases, the Barthel Index at admission and ICISS with the in-hospital mortality of UIs, which could provide a reference to evaluate in-hospital mortality risks upon admission, guide medical practices and monitor the quality of medical care. The Barthel Index has been adopted as a measure of functional status for in-hospital mortality predictions in some clinical populations [40,41]. To the best of our knowledge, this study was the first to include the Barthel Index in predictions of in-hospital deaths among the trauma population. The in-hospital mortality increased by approximately 25 times in patients with a Barthel Index under 60 at admission, which implies that it is an important indicator for in-hospital mortality of UI patients.

It is worth noting that the rate of severe injuries and in-hospital mortality of patients under 75 years old increased with age; however, in-hospital mortality increased for patients aged 75 years and over even if the rate of severe injuries decreased. A significantly increased risk of death was found for patients aged 75 years and over after adjusting for confounders, which might be related to their poor physical status. Thus, elderly patients of UIs require more attention in the episode of care.

Head/neck injuries and multiple injuries were responsible for 85.7% of all the deaths caused by UIs before discharge, and ranked 2nd and 3rd in the in-hospital mortality among all the injury natures. The risk of death from injuries to the head/neck and multiple injuries increased by 23 and 9 times, compared with injuries to the upper extremities. Further investigations are warranted to clarify the contributors to the high in-hospital mortality for head/neck and multiple injuries, to help improve health resource allocation and save lives after the events of severe UIs.

Paediatric patients predominated in foreign body aspiration, which was also reported as a leading cause of accidents in children in other countries [42,43]. In our study, foreign body entering through natural orifice turned out to pose a significant risk of death before discharge. Similar to a study from Kenya [44], patients admitted for contact with heat and hot substances were mainly children. Public awareness should be raised to prevent the occurrence of these accidents. Studies on identifying influencing factors for a high risk of foreign body aspiration and burns during childhood are encouraged.

Many tools have been explored in injury severity measurement. Abbreviated Injury Scale (AIS) based tools, such as ISS, New ISS (NISS) and Trauma and Injury Severity Score (TRISS), are applicable usually in trauma registry center where AIS are coded by trained experts. Hospital DAD include ICD codes, but do not provide detailed information of the injuries. ICISS was introduced by Osler et al. as an alternative for measuring injury severity when hospital DAD can be accessed while AIS is unavailable [22]. It turns to be a well-performed and convenient tool in predicting the outcomes of trauma patients. Although ICD-AIS map created by the Association for the Advancement of Automotive Medicine enables the conversion between ICD-10 and AIS, charge of fees would limit its usage in LMICs. Pooled diagnosis-specific survival probabilities were generated from seven HICs by Gedeborg et al. [14], without validation in LMICs. Differences in injury epidemiology and resources allocated to trauma care between HICs and LMICs are probably enormous and should be taken into consideration. Thus, this study generates the diagnosis-specific SRRs from a large trauma population in China, which may be more applicable in injury severity estimation using ICISS in low and intermediate resources settings.

Coding guidelines using the ICD-10 for morbidity data have noted that coding both the nature of the injury and the external causes that give rise to the injury is important [16], which makes hospital DAD a good data source for epidemiological studies of UIs. Supplementary classifications that can be used as separate variables to identify the place of occurrence of the external cause and the activity of the injured person when the injury occurred are also provided in the ICD-10. However, these supplementary classifications have not yet been widely adopted in the ICD-10 coding for external causes in Beijing. Details of the circumstances under which an injury occurs are critical to epidemiological studies on UIs [45,46]. Collecting more specific information about UIs using these supplementary classifications can benefit future studies on preventive actions and the creation of a safer environment.

The present study has some limitations: (1) it was a retrospective study based on hospital DAD, and less specific information related to the injuries was available than when using questionnaire surveys and trauma registries; (2) SRRs of some infrequent injuries may be imprecise because of limited sample size; (3) the outcome of this study was defined as either survival or death at discharge, without any evaluation or analysis of the disability caused by the UIs; and (4) UIs requiring prehospital care and emergency department visits is another aspect at the nonfatal level in the injury pyramid, but they were not described in this study because of the unavailability of data.

Conclusions

Hospital DAD are an objective and cost-effective data source that provide a hospital-based view of UI epidemiology. This study demonstrated that sex, age, functional status at admission, comorbidities, injury nature, severity and mechanisms were significantly associated with in-hospital mortality of UIs in China. Diagnosis-specific SRRs of injuries are provided as reference to LMICs. The performance of this reference dataset warrants further validation. Supplementary classification of the detailed circumstances associated with the injury is suggested to be adopted in the ICD coding for morbidity data to benefit in-depth studies on UI prevention.

Conflict of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2019.01.029.

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