

# A multicenter observational study on the distribution of orthopaedic fracture types across 17 low- and middle-income countries

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## Abstract

**Objectives:** To describe the regional distribution of fractures sustained by women and health care system characteristics across 17 low- and middle-income countries (LMICs).

**Methods:** The International Orthopaedic Multicentre Study in fracture care (INORMUS) is an observational study collecting data on patients in LMICs who sustained a fracture or musculoskeletal injury. As a planned analysis for the INORMUS study, we explored differences in fracture locations and demographics reported among 9878 female patients who sustained a fracture within 17 LMICs in 5 regions (China, Africa, India, Other Asia, and Latin America).

**Results:** Half of our study population (49.6%) was  $\geq 60$  years of age. Across all regions, 58.3% of patients possessed health insurance. Latin America possessed the highest proportion (88.8%) of health insurance, while in Africa, patients possessed the lowest (18.0%). Falls from standing were the most prevalent mechanism of injury (51.7%) followed by falls from height (12.8%) and motorcycle-related road traffic injuries (9.7%). The majority of the fractures (65.6%) occurred in patients aged 50 and older. Hip fractures were the most common fracture (26.8%), followed by tibia/fibula (12.6%) and spine fractures (9.7%). Open fractures accounted for 7.6% of fractures and were most commonly tibia/fibula fractures (35.1%). Despite these severe injuries, less than one-third (28.8%) of patients were transported for care after sustaining a fracture by ambulance. Regionally, a majority of female patients in Africa were working age and suffered tibia/fibula (21.6%) and femur fractures (14.0%). Patients in the regional category Other Asia, suffered the highest frequencies of open fractures (9.6% low grade, 7.1% high grade), and disproportionately from motorcycle road traffic injuries (29.9%).

**Conclusion:** Across all regions, the most significant source of fracture burden was in the elderly, and included common fragility fractures, such as hip fractures. Notable regional deviations in fracture distributions were observed within Africa, and Other Asia. Across all studied LMICs, ambulance usage was low, and health insurance coverage was particularly low in Africa and India.

**Abbreviations:** DALYs = disability-adjusted life years, GDP = gross domestic product, INORMUS = International Orthopaedic Multicenter Study in Fracture Care, LMICs = low- and middle- income countries, RTIs = road traffic injuries.

**Keywords:** Global health, low- and middle-income countries, orthopaedic injury, trauma, Women's health

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## 1. Background

Injuries, broadly originating from traffic accidents, falls, drowning, and violence, among others, are a leading cause of disability-adjusted life years (DALYs) globally,<sup>[1]</sup> and account for over 5 million deaths annually worldwide. Over 90% of injury burden occurs within low- and middle-income countries (LMICs).<sup>[2]</sup> International institutions, including the United Nations through the Decade of Action on Road Safety (2011–2020), have recognized a global need to reduce the health and economic burdens associated with injuries.<sup>[2]</sup>

Worldwide, road traffic injuries (RTIs) result in 1.25 million fatalities per year, 90% of which occur in LMICs.<sup>[3]</sup> As a result of rising motor vehicle usage, by 2020, road traffic mortalities are expected to increase to 2 million per year.<sup>[4]</sup> Addressing injury burden requires improvements in global surgery. It has been estimated that worldwide approximately 2 million lives could be saved from all injuries through improvements in access to trauma care.<sup>[5]</sup> Improvements are further needed in prehospital care through increased access to ambulance services and first responders.<sup>[5]</sup>

An emerging challenge for LMICs is addressing an aging population.<sup>[6]</sup> An estimated 70% of world's aging population

resides within LMICs, and this number is expected to grow.<sup>[6,7]</sup> Fragility fractures result from low-trauma falls in the elderly, and are especially common among women.<sup>[8]</sup> Surgically caring for fragility fractures can be complex, often requiring critical care, and prolonged hospitalization.<sup>[9]</sup>

The health burden associated with injuries strongly intersects with sustainable development. Mortality and long-term disabilities incurred by orthopaedic trauma can exacerbate poverty.<sup>[10]</sup> Overall, an estimated 2.5% of GDP will be lost in LMICs by 2030 due to a lack of surgical services.<sup>[11]</sup> While men suffer greater levels of injury-related DALYs,<sup>[11]</sup> ensuring women receive equitable surgical care is an important priority for achieving global sustainability efforts.<sup>[12]</sup> Women suffer greater levels of all-cause disease burden,<sup>[11]</sup> and in LMICs, women have reduced autonomy to make health care decisions.<sup>[13]</sup> Within LMICs, women fulfill important household duties including retrieving water, which can increase the risk of head, neck, and spine fractures.<sup>[14]</sup> Understanding the orthopaedic fracture distribution in women within LMICs will support their long-term health, enable their participation within society, and consequently, support sustainable development efforts.

In this work, we provide prospective, observational data on the distribution of orthopaedic fractures in females across 17 LMICs as part of the International Orthopaedic Multicenter Study in fracture care (INORMUS). We build on international monitoring efforts including the Global Burden of Disease study<sup>[15]</sup> and Study on global AGEing and adult health.<sup>[6]</sup> Our primary objective was to describe the regional distribution of fractures sustained by female patients, in addition to regional trends of demographic and health care system characteristics across 17 LMICs.

## 2. Methods

INORMUS is a multicenter, observational study to evaluate and assess global trends in fracture burden and how they relate to demographics. A comprehensive list of objectives and study methods have been published previously.<sup>[15,16]</sup> In this secondary study, we analyzed all female patients enrolled before December 2017. We included five regions defined as China, Africa (Uganda, Kenya, Nigeria, Botswana, Ghana, South Africa, and Tanzania), India, Other Asia (Pakistan, Nepal, Vietnam, Thailand, The Philippines, and Iran), and Latin America (Venezuela, and Mexico).

### 2.1. Ethics

The INORMUS study was approved by the Hamilton Integrated Research Ethics Board, and each clinical site's ethics committee. Data were collected with informed consent, and aggregated as de-identified data, with participants identified through coded identification numbers.

### 2.2. Selection criteria and data collection

Eligible patients were those 18 years of age and older, who were admitted to a participating hospital within 3 months of sustaining an orthopaedic trauma. Specifically, trauma included a fracture, dislocation, fracture dislocation of the appendicular skeleton (i.e., upper and lower extremities, shoulder girdle, and pelvic girdle) or spine. Patients were enrolled through a direct emergency department referral. If patients met the eligibility criteria, study personnel obtained informed consent, and collected demographic and clinical data.

### 2.3. Selection of factors

For this study, we analyzed only the most severe orthopaedic fracture sustained by an enrolled patient. In addition, we included data for 11 variables (age, urban vs rural, income, education level, occupation, health insurance status, transportation to hospital, location administered from, fracture location). Hip fractures include fractures of the proximal femur. Foot fractures also include talus, and calcaneus fractures. Wrist fractures include fractures of the distal ulna, and distal radius. Arm fractures include fractures of the midshaft humerus, middle radius, and middle ulna. Elbow fractures include fractures of the distal humerus, olecranon, proximal radius, and proximal ulna. Other upper extremity fractures include clavicle, scapula, and other fractures. Low-grade open fractures are defined as Gustillo I or II, while high grade fractures include Gustillo-III. Demographic and injury fracture characteristics were selected a priori based on previous literature findings, and a pilot study.<sup>[16,17]</sup>

### 2.4. Estimating catchment area

For each hospital, we extrapolated an estimated patient catchment population by dividing the number of in-patient hospital beds by an estimate of the average number of hospital beds/1000 people. The number of in-patient hospital beds was reported by administrative staff at each hospital site based on internal data. We were unable to collect hospital bed numbers for the All-India Institute of Medical Sciences (AIIMS) in India, and data were retrieved from their website: <https://www.aiims.edu>. For each country, figures for the average number of hospital beds/1000 people, and total population, was collected from the World Bank Data Bank available from <https://data.worldbank.org>. The most recent available values were used in all cases.

### 2.5. Statistical analysis

We report region disaggregated proportions for all variables measured. To determine the age-specific fracture burden, we performed a chi-square analysis comparing age with fracture location, and mechanism of injury. To identify which fracture locations were associated with open fractures, we performed chi-square analysis comparing fracture location with open-fractures. All analysis was conducted using SPSS version 25.

## 3. Results

We included 9878 female patients who reported information regarding their orthopaedic fractures, and hospital admission. Patients were included from 47 participating hospitals across 17 LMICs in Asia, Africa, and Latin America. We estimated a capture population of approximately 5.5 million (0.40%), 10.0 million (2.33%), 19.1 million (1.43%), 5.5 million (1.11%), and 2.5 million (1.53%) in China, Africa, India, Other Asia, and Latin America respectively. A list of hospitals, regions, and countries that were included in the study is described in Table A1, and a visual representation of regional categories is illustrated in Figure A1.

We examined demographic, health systems, and fracture characteristics disaggregated by region in Table 1. A summary of the most common fracture locations by region is included in Figure 1. Across all regions, the top 3 fracture locations were hip (26.8%), tibia/fibula (12.6%), and spine fractures (9.7%). The top 3 mechanisms of injury were fall from standing (51.7%), fall

**Table 1**  
**Baseline demographics, health care, and fracture characteristics of female fracture patients disaggregated by region.**

Total	China 4449	Africa 1869	India 1678	Other Asia 1304	Latin America 578	Total 9878
Age, years						
18–29	224 (5.0%)	398 (21.3%)	269 (16.0%)	180 (13.8%)	82 (14.2%)	1153 (11.7%)
30–39	248 (5.6%)	375 (20.1%)	215 (12.8%)	139 (10.7%)	68 (11.8%)	1045 (10.6%)
40–49	438 (9.8%)	321 (17.2%)	211 (12.6%)	155 (11.9%)	77 (13.3%)	1202 (12.2%)
50–59	768 (17.3%)	278 (14.9%)	248 (14.8%)	206 (15.8%)	81 (14.0%)	1581 (16.0%)
≥60	2771 (62.3%)	496 (26.6%)	735 (43.8%)	624 (47.9%)	270 (46.7%)	4896 (49.6%)
Is urban (vs rural)	3428 (77.1%)	1235 (66.1%)	1064 (63.4%)	645 (49.5%)	496 (85.8%)	6868 (69.5%)
Annual household income (USD)						
Unknown	864 (19.4%)	1022 (54.7%)	723 (43.1%)	109 (8.4%)	338 (58.5%)	3056 (30.9%)
<2000	590 (13.3%)	508 (27.2%)	634 (37.8%)	272 (20.9%)	196 (33.9%)	2200 (22.3%)
2001–6000	667 (15.0%)	223 (11.9%)	132 (7.9%)	460 (35.3%)	38 (6.6%)	1520 (15.4%)
6001–10000	1159 (26.1%)	65 (3.5%)	106 (6.3%)	223 (17.1%)	5 (0.9%)	1558 (15.8%)
>10,000	1169 (26.3%)	51 (2.7%)	83 (4.9%)	240 (18.4%)	1 (0.2%)	1544 (15.6%)
Education						
No education	529 (11.9%)	207 (11.1%)	480 (28.6%)	180 (13.8%)	83 (14.4%)	1479 (15.0%)
Up to elementary	953 (21.4%)	617 (33.0%)	369 (22.0%)	296 (22.7%)	244 (42.2%)	2479 (25.1%)
Up to secondary	2077 (46.7%)	700 (37.5%)	421 (25.1%)	512 (39.3%)	164 (28.4%)	3874 (39.2%)
Postsecondary	890 (20.0%)	344 (18.4%)	406 (24.2%)	316 (24.2%)	87 (15.1%)	2043 (20.7%)
Occupation						
Agriculture	660 (14.8%)	249 (13.3%)	122 (7.3%)	216 (16.6%)	5 (0.9%)	1252 (12.7%)
Service	302 (6.8%)	133 (7.1%)	178 (10.6%)	123 (9.4%)	47 (8.1%)	783 (7.9%)
Business	239 (5.4%)	503 (26.9%)	35 (2.1%)	98 (7.5%)	27 (4.7%)	902 (9.1%)
Homemaker/unemployed	2208 (49.6%)	576 (30.8%)	1175 (70.1%)	494 (37.9%)	438 (75.8%)	4891 (49.5%)
Student	53 (1.2%)	117 (6.3%)	97 (5.8%)	36 (2.8%)	7 (1.2%)	310 (3.1%)
Industrial	249 (5.6%)	53 (2.8%)	4 (0.2%)	70 (5.4%)	8 (1.4%)	384 (3.9%)
Education	101 (2.3%)	70 (3.7%)	25 (1.5%)	42 (3.2%)	5 (0.9%)	243 (2.5%)
Other*	637 (14.3%)	168 (9.0%)	41 (2.4%)	225 (17.3%)	41 (7.1%)	1112 (11.3%)
Health insurance						
Private insurance	191 (4.3%)	23 (1.2%)	186 (11.1%)	72 (5.5%)	41 (7.1%)	513 (5.2%)
Government insurance	3646 (82.0%)	313 (16.7%)	162 (9.7%)	649 (49.8%)	472 (81.7%)	5242 (53.1%)
No insurance	612 (13.8%)	1533 (82.0%)	1330 (79.3%)	583 (44.7%)	65 (11.2%)	4123 (41.7%)
Transportation to hospital						
Ambulance	1455 (32.7%)	348 (18.7%)	298 (17.9%)	662 (50.9%)	72 (12.5%)	2835 (28.8%)
Private vehicle	2467 (55.5%)	789 (42.3%)	1219 (73.2%)	476 (36.6%)	474 (82.0%)	5425 (55.0%)
Public transportation	428 (9.6%)	598 (32.1%)	74 (4.4%)	110 (8.5%)	28 (4.8%)	1238 (12.6%)
Other†	98 (2.2%)	129 (6.9%)	74 (4.4%)	53 (4.1%)	4 (0.7%)	358 (3.6%)
Location administered From						
Injury site	1699 (38.2%)	829 (44.5%)	556 (33.4%)	243 (18.7%)	97 (16.8%)	3424 (34.7%)
Home	1894 (42.6%)	344 (18.5%)	580 (34.8%)	448 (34.4%)	185 (32.0%)	3451 (35.0%)
Other hospital	812 (18.3%)	619 (33.2%)	335 (20.1%)	582 (44.7%)	261 (45.2%)	2609 (26.5%)
Other‡	43 (1.0%)	72 (3.9%)	196 (11.8%)	28 (2.2%)	35 (6.1%)	374 (3.8%)
Fracture location						
Hip	1290 (29.1%)	254 (14.5%)	463 (28.4%)	415 (32.7%)	165 (28.9%)	2587 (26.8%)
Femur	182 (4.1%)	245 (14.0%)	113 (6.9%)	135 (10.6%)	24 (4.2%)	699 (7.2%)
Tibia/fibula	333 (7.5%)	378 (21.6%)	206 (12.6%)	236 (18.6%)	59 (10.4%)	1212 (12.6%)
Ankle malleolus	268 (6.0%)	190 (10.9%)	85 (5.2%)	47 (3.7%)	113 (19.8%)	703 (7.3%)
Ankle plafond	27 (0.6%)	26 (1.5%)	5 (0.3%)	3 (0.2%)	13 (2.3%)	74 (0.8%)
Foot	118 (2.7%)	46 (2.6%)	114 (7.0%)	38 (3.0%)	12 (2.1%)	328 (3.4%)
Patella/other lower	219 (4.9%)	44 (2.5%)	84 (5.2%)	28 (2.2%)	15 (2.6%)	390 (4.0%)
Proximal humerus	213 (4.8%)	42 (2.4%)	68 (4.2%)	40 (3.2%)	26 (4.6%)	389 (4.0%)
Arm	80 (1.8%)	118 (6.8%)	72 (4.4%)	68 (5.4%)	20 (3.5%)	358 (3.7%)
Elbow	182 (4.1%)	103 (5.9%)	98 (6.0%)	59 (4.6%)	31 (5.4%)	473 (4.9%)
Wrist	375 (8.5%)	191 (10.9%)	166 (10.2%)	79 (6.2%)	74 (13.0%)	885 (9.2%)
Other upper§	226 (5.1%)	45 (2.6%)	68 (4.2%)	57 (4.5%)	9 (1.6%)	405 (4.2%)
Spine	839 (18.9%)	20 (1.1%)	45 (2.8%)	30 (2.4%)	5 (0.9%)	939 (9.7%)
Pelvic	82 (1.8%)	45 (2.6%)	42 (2.6%)	34 (2.7%)	4 (0.7%)	207 (2.1%)
Open fracture						
Closed	4292 (96.8%)	1560 (89.3%)	1488 (91.2%)	1057 (83.3%)	523 (91.8%)	8920 (92.4%)
Low-grade open	104 (2.3%)	125 (7.2%)	112 (6.9%)	122 (9.6%)	15 (2.6%)	478 (5.0%)
High-grade open	38 (0.9%)	62 (3.5%)	31 (1.9%)	90 (7.1%)	32 (5.6%)	253 (2.6%)
Mechanism of injury						
Fall from standing	2850 (64.1%)	664 (35.5%)	658 (39.2%)	551 (42.3%)	386 (66.8%)	5109 (51.7%)

(continued)

**Table 1**  
(continued).

Total	China 4449	Africa 1869	India 1678	Other Asia 1304	Latin America 578	Total 9878
Fall from height	422 (9.5%)	277 (14.8%)	355 (21.2%)	155 (11.9%)	74 (12.8%)	1283 (13.0%)
RTI—pedestrian	441 (9.9%)	265 (14.2%)	122 (7.3%)	66 (5.1%)	17 (2.9%)	911 (9.2%)
RTI—motorcycle	116 (2.6%)	186 (10.0%)	242 (14.4%)	389 (29.9%)	21 (3.6%)	954 (9.7%)
RTI—other motor vehicle <sup>†</sup>	101 (2.3%)	264 (14.1%)	63 (3.8%)	34 (2.6%)	17 (2.9%)	479 (4.9%)
RTI—other <sup>‡</sup>	151 (3.4%)	21 (1.1%)	70 (4.2%)	34 (2.6%)	4 (0.7%)	280 (2.8%)
Other <sup>#</sup>	368 (8.3%)	192 (10.3%)	168 (10.0%)	73 (5.6%)	59 (10.2%)	860 (8.7%)

\* Includes entertainment, military/police, healthcare, and public servant.  
 † Includes on-foot, rickshaw, or other.  
 ‡ Includes local doctor, nursing home, and other.  
 § Includes clavicle, scapula, and other.  
 || Includes truck/bus, automobile.  
 ¶ Includes rickshaw/similar non-motorized, rail, animal, animal-drawn cart, bicycle, other.  
 # Includes struck/lifting, intentional, or other.

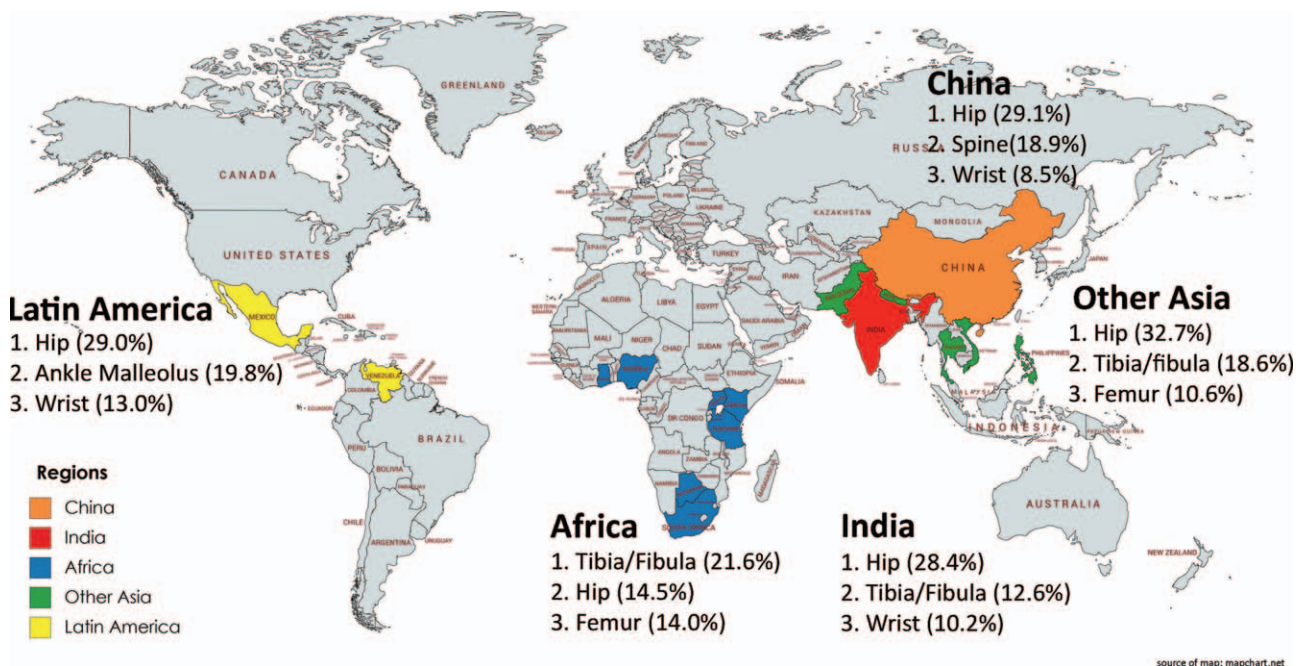
from height (13.0%), and motorcycle RTIs (9.7%). Notably, demographic and injury features varied substantially by region.

**China:** Of 4449 female patients in China, 62.3% of female patients were ≥60 years old, and 77.1% inhabited urban areas. Compared with other regions, patients in China reported the highest household income, with 26.3% of women reporting incomes >\$10,000. The percentage of patients who were unemployed or homemakers was 49.6%. Most patients possessed health insurance (86.3% insured). Around 32.7% of patients were brought to the hospital by ambulance. Most commonly, patients suffered hip fractures (29.1%), and spine fractures (18.9%). Open fractures were uncommon (2.3% low grade, 0.9% high grade). Predominantly, fractures were a result of a fall from standing (64.1%).

**Africa:** The age distribution of 1869 patients analyzed from Africa was younger; only 26.6% of patients were ≥60 years old. Patients lived in urban settings (65.6%). Only 2.7% of patients possessed household incomes > \$10,000. Patients in Africa had

the highest levels of employment (69.2%), most commonly working in the business sector (26.9%). Patients possessed a dearth of insurance (82.0% uninsured). Ambulance usage was low (18.7%), and usage of public transportation to the hospital was disproportionately high (32.1%). Patients in Africa most frequently sustained tibia/fibula fractures (21.6%), and disproportionately sustained femur fractures (14.0%), with a notably low frequency of hip fractures (14.5%). One in ten fractures were open (7.2% low grade, 3.5% high grade). Falls from standing was the top mechanism of injury (35.4%); however, falling from height (14.7%), pedestrian-related RTIs (14.2%), and other motor vehicle RTIs (14.1%) were also common.

**India:** Around 1678 patients were included from India. A total of 43.8% of women were ≥60 years old, and 61.8% lived in urban areas. Patients were of particularly low socioeconomic status (SES), only 4.9% held annual household incomes > \$10,000, and only 29.9% were employed. Few patients possessed medical insurance coverage (21.7%). Only one in five used an



**Figure 1.** The top 3 fracture locations sustained by patients across China, India, Africa, Other Asia, and Latin America.

**Table 2**  
Fracture locations and mechanism of injury disaggregated by age.

	Age, years				
	18–29	30–39	40–49	50–59	≥60
<b>Fracture location</b>					
Hip	37 (3.4%)	36 (3.7%)	70 (6.0%)	232 (15.0%)	2212 (45.6%)
Femur	137 (12.4%)	66 (6.7%)	76 (6.5%)	101 (6.5%)	319 (6.6%)
Tibia/fibula	209 (18.9%)	239 (24.2%)	232 (20.0%)	251 (16.2%)	280 (5.8%)
Ankle malleolus	128 (11.6%)	121 (12.3%)	136 (11.7%)	150 (9.7%)	168 (3.5%)
Ankle plafond	16 (1.4%)	16 (1.6%)	10 (0.9%)	13 (0.8%)	19 (0.4%)
Foot	75 (6.8%)	60 (6.1%)	80 (6.9%)	46 (3.0%)	67 (1.4%)
Patella/other lower	32 (2.9%)	42 (4.3%)	66 (5.7%)	91 (5.9%)	159 (3.3%)
Proximal humerus	25 (2.3%)	21 (2.1%)	31 (2.7%)	69 (4.5%)	243 (5.0%)
Arm	87 (7.9%)	59 (6.0%)	63 (5.4%)	66 (4.3%)	83 (1.7%)
Elbow	88 (8.0%)	68 (6.9%)	76 (6.5%)	93 (6.0%)	148 (3.1%)
Wrist	94 (8.5%)	112 (11.4%)	119 (10.2%)	188 (12.1%)	372 (7.7%)
Other upper*	87 (7.9%)	64 (6.5%)	89 (7.7%)	75 (4.8%)	90 (1.9%)
Spine	50 (4.5%)	43 (4.4%)	77 (6.6%)	141 (9.1%)	628 (13.0%)
Pelvic	39 (3.5%)	39 (4.0%)	37 (3.2%)	33 (2.1%)	59 (1.2%)
<b>Mechanism of injury</b>					
Fall from standing	226 (19.6%)	253 (24.2%)	381 (31.7%)	745 (47.1%)	3504 (71.6%)
Fall from height	167 (14.5%)	181 (17.3%)	195 (16.2%)	217 (13.7%)	523 (10.7%)
RTI—pedestrian	156 (13.5%)	116 (11.1%)	155 (12.9%)	158 (10.0%)	325 (6.6%)
RTI—motorcycle	266 (23.1%)	210 (20.1%)	169 (14.1%)	167 (10.6%)	142 (2.9%)
RTI—other motor vehicle†	121 (10.5%)	91 (8.7%)	85 (7.1%)	94 (5.9%)	88 (1.8%)
RTI—other‡	38 (3.3%)	45 (4.3%)	44 (3.7%)	65 (4.1%)	88 (1.8%)
Other§	179 (15.5%)	149 (14.3%)	173 (14.4%)	135 (8.5%)	224 (4.6%)

Fracture location vs age; chi-square: 2814.1,  $P < .001$ .

Mechanism of Injury vs Age; chi-square: 2088.7,  $P < .001$ .

\*Includes clavicle, scapula, or other.

†Includes truck/bus, automobile.

‡Includes rickshaw/similar non-motorized, rail, animal, animal-drawn cart, bicycle, other.

§Includes struck/lifting, intentional, or other.

ambulance (17.9%). Patients most frequently suffered hip fractures (28.4%). Open fractures were similar to the global average (6.9% low grade, 1.9% high grade). Notable mechanisms of injury included falls from standing (39.2%), falling from height (21.2%), and motorcycle related RTIs (14.4%).

**Other Asia:** Around 1304 patients were analyzed within Other Asia, of which 47.9% were ≥60 years old. Half of patients lived in urban settings. Patients were of higher SES with 18.4% of patients having annual household income >\$10,000; 62.1% were employed. 55.3% of patients possessed insurance. Of all regions, patients in Other Asia had the highest usage of ambulances (50.9%). The most common fractures included hip (32.7%), tibia/fibula (18.6%), and femur fractures (10.6%). Across all regions, patients suffered the highest frequencies of open fractures (9.6% low grade, 7.1% high grade). Falls from standing (42.3%) was the most common mechanism of injury; however, motorcycle RTIs (29.9%) were nearly threefold more frequent than in India, the next highest region.

**Latin America:** Half of 578 patients were ≥60 years old, and were highly urbanized (85.8%). Patients were the lowest SES in our study with 0.17% of patients possessing annual household income >\$10,000, and 75.8% being unemployed. Patients had the highest level of insurance (88.8%); yet, the lowest frequency of ambulance use (12.5%). Hip fractures were the most common (29.0%), while malleolus ankle fractures were disproportionately high (19.8%). 2.6%, and 5.6% sustained low-grade and high-grade open fractures respectively. Falls from standing were the predominant mechanism of injury (66.8%).

We found that age played a significant role in defining fracture locations, and mechanisms of injury ( $P < .001$ ) (Table 2). As expected, hip fractures were uncommon until ages 50 to 59 years

old (15.0%), and they were the most frequent fracture in patients ≥60 years old (45.6%). Tibia/fibula fractures were the most frequent fractures in patients aged 18 to 59 years old accounting for 1 in 5 patients. The frequency of falls from standing increased with age, from 19.6% in patients aged 18 to 29 years old to the most common mechanism of injury (71.6%) in patients ≥60 years old. Motorcycle RTIs were the most common mechanism of injury in patients aged 18 to 29 years old (23.1%), decreasing with age.

**Table 3**  
Open fracture types disaggregated by fracture location

	Closed fracture	Low-grade open	High-grade open
<b>Fracture location</b>			
Hip	2579 (28.9%)	3 (0.6%)	4 (1.6%)
Femur	628 (7.0%)	35 (7.3%)	36 (14.2%)
Tibia/fibula	955 (10.7%)	155 (32.4%)	102 (40.3%)
Ankle malleolus	648 (7.3%)	39 (8.2%)	16 (6.3%)
Ankle plafond	68 (0.8%)	4 (0.8%)	2 (0.8%)
Foot	259 (2.9%)	47 (9.8%)	22 (8.7%)
Patella/other lower	345 (3.9%)	34 (7.1%)	10 (4.0%)
Proximal humerus	383 (4.3%)	4 (0.8%)	2 (0.8%)
Arm	315 (3.5%)	29 (6.1%)	14 (5.5%)
Elbow	434 (4.9%)	28 (5.9%)	11 (4.3%)
Wrist	836 (9.4%)	29 (6.1%)	20 (7.9%)
Other upper*	322 (3.6%)	69 (14.4%)	14 (5.5%)
Spine	939 (10.5%)	0 (0.0%)	0 (0.0%)
Pelvic	205 (2.3%)	2 (0.4%)	0 (0.0%)
Total	8916 (100.0%)	478 (100.0%)	253 (100.0%)

Fracture location vs open fracture; chi-square: 929.6,  $P < .001$ .

\*Includes clavicle, scapula, and other.

In Table 3 we assessed the distribution of open fractures by fracture location. The three most common low-grade fractures were tibia/fibula (32.4%), other upper extremity (14.4%), and foot (9.8%). We found tibia/fibula (40.3%), femur (14.2%) and foot fractures (8.7%) were the most common high-grade fractures.

## 4. Discussion

This study reports descriptive results of the first large scale, clinical observational study describing the distribution of fractures in women in 17 LMICs.

### 4.1. Fracture trends across all 17 LMICs

We observed a previously identified role of aging in injuries among women across LMICs, adding additional quantification from prospective clinical data.<sup>[18]</sup> Nearly two-third of patients were  $\geq 50$  years old. Falls from standing accounted for the most common mechanism of injury, and sharply increased with age, indicative of fragility fractures.<sup>[8]</sup> Across 17 LMICs, hip fractures, commonly associated with osteoporosis and aging, were the most frequent, occurring within 3 in 10 patients. The frequency of hip fractures we observed was two- to fourfold higher than previous multiregional estimates of fragility fracture incidence.<sup>[19,20]</sup> Hip fractures carry a high risk of mortality, with a reported one-year postoperative mortality rate of 27%.<sup>[21,22]</sup> Consequently, compared to less serious fragility fractures, we suspect a higher proportion of hip fracture patients will seek care for their treatment, which may explain our higher measurements of frequency.

Among younger populations (18–49 years old), RTIs accounted for 4 in 10 fractures, while tibia/fibula were the most common fracture location. This is consistent with previous reports whereby tibia/fibula fractures are associated with RTIs.<sup>[23]</sup> Within the subset of RTIs, being hit as a pedestrian, or, motorcycle related injuries were major sources of fractures, aligning with previous data, and demonstrating a need for improving road safety procedures.<sup>[24–27]</sup> Among female patients, we determined that 7.5% of fractures were open, with tibia/fibula fractures, and foot representing common locations. This is consistent with lower-extremity fractures accounting for the majority of treated open fractures.<sup>[28]</sup>

## 5. The regional distribution of fractures across 17 LMICs

### 5.1. Africa: working-age fractures

To contrast the global trend of fragility fracture burden in women, patients in Africa sustained high frequencies of tibia/fibula, femur, and open fractures. Mechanistically, patients suffered the highest frequencies of pedestrian related RTIs, and RTIs resulting from nonmotorcycle motorized vehicles. We suspect this trend coincides with women in Africa being younger, and employed (e.g., business sector); thus, increasing their exposure to RTIs due to necessarily travelling outside the home.

Our results are comparable to a pilot surveillance study in South Africa, which found 77% of female patients were between the ages 20 to 59 years old, a similar distribution to our data.<sup>[29]</sup> By contrast our data suggest a greater role for RTIs (~40% of injury burden), among African women than a previous comprehensive report from Cape Town which reported 13.7%.<sup>[30]</sup> Differences could result from our inclusion criteria, which consisted of patients who sustained orthopaedic fractures,

instead of trauma more generally. Additionally, the inclusion of data from more African countries may contribute to differences. Nevertheless, the finding that more working age-women in Africa are sustaining RTI-related fractures has implications on indirect costs (e.g., from lost work), and poverty.<sup>[31]</sup>

### 5.2. Other Asia: disproportionate high impact fractures

Across 17 LMICs, female patients within Other Asia sustained the highest levels of motorcycle related RTIs, and open fractures. Correspondingly, 1 in 5 female patients sustained a tibia/fibula fracture. Motorcycle accidents are particularly serious, resulting in a high mortality rate.<sup>[30]</sup> We speculate this high frequency of motorcycle accidents reflects a noted rise in motorcycle taxi usage, and ownership within southeast Asia including in Thailand and Vietnam, which is included within Other Asia in our study.<sup>[30]</sup> Our data shed preliminary insight into a need to address the burden of RTIs among women within this region, for example, through improved traffic regulations.

### 5.3. China, India, Latin America: commonly fragility fractures

Patients in China, India, and Latin America mirrored the global trend, most commonly sustaining hip fractures, and fractures due to falls from standing. Regionally, spine fractures were high in China (18.9%), and virtually absent from other regions. Malleolus ankle fractures were common in Latin America (19.8%). As we did not sample all hospitals, these trends must be interpreted cautiously. Spine fractures may be clinically silent, resulting in patients not seeking treatment. Additionally, the treatment of spine fractures may require special trauma facilities outside of the hospitals included within our study. Patients sustaining ankle fractures likewise may not seek treatment. Interestingly, patients in India disproportionately sustained falls from height. This finding is consistent with a pilot study which suggests urban Indian households create numerous falling risks including the use of wooden ladders instead of staircases, and rooftop dwellings.<sup>[32]</sup>

## 6. Regional differences in prehospital admission

### 6.1. The need for improved hospital transportation services

Most fatalities following an orthopaedic trauma occur before a patient reaches the hospital.<sup>[33]</sup> Consistently, we found that across all 17 LMICs, approximately one-third of female patients used ambulance services. Patients in Other Asia utilized ambulances at the highest rate (50.9%). While there are no global indicators of appropriate ambulance usage, a lack of ambulance services within LMICs has been emphasized.<sup>[34]</sup> Previous measures of ambulance usage by emergency department patients have ranged from 4% in Pakistan to 67.3% within tertiary hospitals in India.<sup>[35,36]</sup> Previous analysis of orthopaedic neurotrauma patients by INORMUS investigators measured 36.5% of patients used ambulance services in India.<sup>[17]</sup> Early operation increases survival rates,<sup>[37]</sup> and these data provide preliminary benchmarks to assess ambulance usage by female fracture patients.

### 6.2. Health Insurance

In our study, health insurance was highly stratified across LMICs, with 9 in 10 insured in China, and Latin America to 2 in 10 insured in Africa, and India. In LMICs, the high cost of care

combined with an inability to work creates a fear of financial insecurity, and a barrier to receiving care.<sup>[38]</sup> In Uganda, over half of adults who received care for trauma experienced financial catastrophe as a result of their treatment.<sup>[39]</sup> A lack of insurance also impedes efficient emergency medical services, such as interhospital referrals.<sup>[34,40,41]</sup> As a result, within LMICs, a lack of insurance may prevent care, and exacerbate poverty in patients who recover.

## 7. Strengths and limitations

Our data provide observational prospective clinical data continuously collected from 47 hospitals in 17 LMICs providing high-volume data over a 3-year period. The extensiveness of this dataset provides added demographic, and injury characteristics from LMICs. Our research approach was not designed to be epidemiological sampling of the fracture burden over the entire population within each region. Our estimates of catchment area rely on estimates of hospital beds per person as reported by the World Bank DataBank. This approach does not account for differences in population density, and relies on estimates from public data sources, which may not be current. Therefore, we emphasize our analysis cannot reliably generalize to patients who do not seek treatment for their injuries, and therefore does not purport to estimate fracture incidence within different regions. Instead, our cross-sectional analysis provides a description of the fracture burden of female patients who seek treatment at hospitals; thereby, reflects the clinical manifestations of fracture burden within these regions. Our conclusions may not be generalizable to women who do not seek treatment for their injuries or seek treatment from non-major hospitals (e.g., traditional healers).

## 8. Conclusion

Across all regions, a majority of female patients were over the age of 50 years old, coinciding with a high proportion of fragility fractures, and nearly one in three patients sustained a hip fracture. Patients in Africa, however, were primarily working age, sustained a higher proportion of tibia/fibula and femur fractures. Motorcycle RTIs and open fractures were especially common within Other Asia. Notable deficiencies in health care systems include a low frequency of ambulance use, and low health insurance coverage among women in Africa, India, and Other Asia. Our research provides preliminary insight into baseline fracture and demographic trends across marginalized women living in 17 LMICs, and we hope future research will build upon our analysis.

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**Table A1****List of participating hospitals and estimated capture population disaggregated by country and region.**

Hospital	Country	Enrolment period, years	Total no. of inpatient hospital beds	No. of hospital beds (/1000 <sup>*</sup> )	Data source year <sup>*</sup>	Estimated capture population (Thousands)	Country population (Millions) <sup>†</sup>	Percent Capture
China						<b>5540.8</b>	<b>1386.4</b>	<b>0.40</b>
Beijing Chaoyang Hospital	China	3.7	1396	3.8	2012	367.4	1386.4	0.026
Langfang People's Hospital	China	3.7	1002	3.8	2012	263.7	1386.4	0.019
Langfang Aidebao General Hospital	China	3.4	568	3.8	2012	149.5	1386.4	0.011
Second Bethune Hospital of Jilin University	China	2.0	1623	3.8	2012	427.1	1386.4	0.031
Tianjin Hospital	China	2.0	1427	3.8	2012	375.5	1386.4	0.027
Beijing Anzhen Hospital	China	2.2	1650	3.8	2012	434.2	1386.4	0.031
Harbin Medical University Second hospital	China	2.2	5000	3.8	2012	1315.8	1386.4	0.095
Shenyang Orthopaedic Hospital	China	2.2	848	3.8	2012	223.2	1386.4	0.016
Hanzhong People's Hospital	China	2.2	874	3.8	2012	230.0	1386.4	0.017
Shanghai No.10 People's Hospital	China	1.6	1500	3.8	2012	394.7	1386.4	0.028
Xiamen University affiliated First Hospital	China	1.8	2500	3.8	2012	657.9	1386.4	0.047
The 2nd affiliated hospital of Wenzhou Medical University	China	2.1	2667	3.8	2012	701.8	1386.4	0.051
Africa						<b>9993.3</b>	<b>428.6</b>	<b>2.33</b>
Mulago Hospital	Uganda	3.6	1500	0.5	2010	3000.0	42.9	7.00
Rift Valley Provincial General Hospital	Kenya	3.6	850	1.4	2010	607.1	49.7	1.22
Kenyatta National Hospital	Kenya	2.9	2000	1.4	2010	1428.6	49.7	2.87
Kiambu District Hospital	Kenya	2.5	382	1.4	2010	272.9	49.7	0.55
AIC Kijabe Hospital	Kenya	2.4	328	1.4	2010	234.3	49.7	0.47
Ondo State Trauma and Surgical Centre	Nigeria	2.4	100	0.5	2004	200.0	190.9	0.10
National Orthopedic Hospital, Enugu	Nigeria	1.5	211	0.5	2004	422.0	190.9	0.22
Princess Marina Hospital	Botswana	1.8	750	1.8	2010	416.7	2.3	18.18
KATH, Kumasi	Ghana	1.0	854	0.9	2011	948.9	28.8	3.29
Chris Hani Baragwanath Hospital	South Africa	2.6	2680	2.8	2005	957.1	56.7	1.69
Charlotte Maxeke Johannesburg Academic Hospital	South Africa	2.6	1080	2.8	2005	385.7	56.7	0.68
Helen Joseph Hospital	South Africa	2.6	616	2.8	2005	220.0	56.7	0.39
KCMC—Kilimanjaro Christian Medical Centre	Tanzania	1.4	630	0.7	2010	900.0	57.3	1.57
India						<b>19130.0</b>	<b>1339.2</b>	<b>1.43</b>
Sancheti Institute of Orthopaedics	India	3.1	160	0.7	2011	228.6	1339.2	0.02
Noble Hospital	India	3.2	325	0.7	2011	464.3	1339.2	0.03
Bharati Vidyapeeth University Medical College	India	2.1	831	0.7	2011	1187.1	1339.2	0.09
Datta Meghe Institute of Medical Sciences	India	2.9	1525	0.7	2011	2178.6	1339.2	0.16
AIIMS	India	2.1	2362	0.7	2011	3374.3	1339.2	0.25
CMC Vellore	India	1.2	2249	0.7	2011	3212.9	1339.2	0.24
CMC Ludhiana	India	1.2	720	0.7	2011	1028.6	1339.2	0.08
Indian Institute for Spinal Care	India	1.6	185	0.7	2011	264.3	1339.2	0.02
IGMC & RI	India	2.0	850	0.7	2011	1214.3	1339.2	0.09
St. John's Medical College	India	1.8	1100	0.7	2011	1571.4	1339.2	0.12
Post Graduate Institute of Medical Education and Research	India	0.6	1749	0.7	2011	2498.6	1339.2	0.19
Baptist Christian Hospital	India	0.8	135	0.7	2011	192.9	1339.2	0.01
NHL Medical College	India	0.3	1200	0.7	2011	1714.3	1339.2	0.13
Other Asia						<b>5485.2</b>	<b>495.8</b>	<b>1.11</b>
Northwest General Hospital & Research	Pakistan	3.3	503	0.6	2012	838.3	197.0	0.43
Lumbini Medical College	Nepal	3.1	600	5	2005	120.0	29.3	0.41
Cho Ray Hospital	Vietnam	2.0	2757	2	2010	1378.5	95.5	1.44
Viet Duc Hospital	Vietnam	2.2	1671	2	2010	835.5	95.5	0.87
Ramathibodi Hospital	Thailand	1.7	1400	2.1	2010	666.7	69.0	0.97
Khon Kaen Hospital	Thailand	1.5	1000	2.1	2010	476.2	69.0	0.69
Philippine General Hospital	The Philippines	0.8	1170	1	2011	1170.0	104.9	1.12
Latin America						<b>2466.7</b>	<b>161.1</b>	<b>1.53</b>
Hospital Civil de Guadalajara	Mexico	2.7	1200	1.5	2011	800.0	129.2	0.62
Hospital Universitario de Caracas	Venezuela	1.3	1500	0.9	2011	1666.7	32.0	5.21

\* Data were obtained from World Bank DataBank. Data for the most recent year where data were available were used.

† Data were obtained from World Bank DataBank. Population estimates correspond to 2017 figures.

The values bolded in Table A1, reflect the summarized regional values.

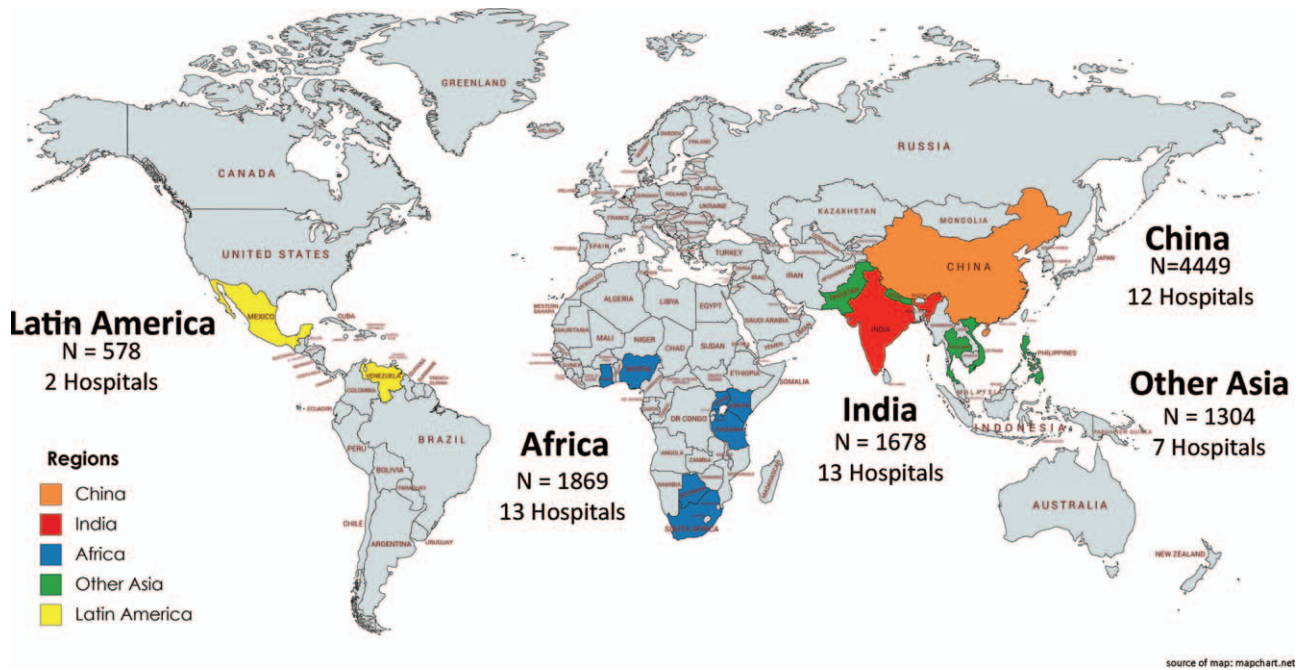


Figure A1. Visual representation of the regional categories and distribution of hospitals.