5-1-2020

Delays in hospital admissions in patients with fractures across 18 low-income and middle-income countries (INORMUS): a prospective observational study

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Delays in hospital admissions in patients with fractures across 18 low-income and middle-income countries (INORMUS): a prospective observational study

*Panthea Pouramin, Chuan Silvia Li, Jason W Busse, Sheila Sprague, P J Devereaux, Jagnoor Jagnoor, Rebecca Ivers, Mohit Bhandari, on behalf of the INORMUS investigators**

Summary

Background The *Lancet* Commission on Global Surgery established the Three Delays framework, categorising delays in accessing timely surgical care into delays in seeking care (First Delay), reaching care (Second Delay), and receiving care (Third Delay). Globally, knowledge gaps regarding delays for fracture care, and the lack of large prospective studies informed the rationale for our international observational study. We investigated delays in hospital admission as a surrogate for accessing timely fracture care and explored factors associated with delayed hospital admission.

Methods In this prospective observational substudy of the ongoing International Orthopaedic Multicenter Study in Fracture Care (INORMUS), we enrolled patients with fracture across 49 hospitals in 18 low-income and middle-income countries, categorised into the regions of China, Africa, India, south and east Asia, and Latin America. Eligible patients were aged 18 years or older and had been admitted to a hospital within 3 months of sustaining an orthopaedic trauma. We collected demographic injury data and time to hospital admission. Our primary outcome was the number of patients with open and closed fractures who were delayed in their admission to a treating hospital. Delays for patients with open fractures were defined as being more than 2 h from the time of injury (in accordance with the *Lancet* Commission on Global Surgery) and for those with closed fractures as being a delay of more than 24 h. Secondary outcomes were reasons for delay for all patients with either open or closed fractures who were delayed for more than 24 h. We did logistic regression analyses to identify risk factors of delays of more than 2 h in patients with open fractures and delays of more than 24 h in patients with closed fractures. Logistic regressions were adjusted for region, age, employment, urban living, health insurance, interfacility referral, method of transportation, number of fractures, mechanism of injury, and fracture location. We further calculated adjusted relative risk (RR) from adjusted odds ratios, adjusted for the same variables. This study was registered with ClinicalTrials.gov, NCT02150980, and is ongoing.

Findings Between April 3, 2014, and May 10, 2019, we enrolled 31 255 patients with fractures, with a median age of 45 years (IQR 31–62), of whom 19 937 (63·8%) were men, and 14 524 (46·5%) had lower limb fractures, making them the most common fractures. Of 5256 patients with open fractures, 3778 (71·9%) were not admitted to hospital within 2 h. Of 25 999 patients with closed fractures, 7141 (27·5%) were delayed by more than 24 h. Of all regions, Latin America had the greatest proportions of patients with delays (173 [88·7%] of 195 patients with open fractures; 426 [44·7%] of 952 with closed fractures). Among patients delayed by more than 24 h, the most common reason for delays were interfacility referrals (3755 [47·7%] of 7875) and Third Delays (cumulatively interfacility referral and delay in emergency department: 3974 [50·5%]), while Second Delays (delays in reaching care) were the least common (423 [5·4%]). Compared with other methods of transportation (eg, walking, rickshaw), ambulances led to delay in transporting patients with open fractures to a treating hospital (adjusted RR 0·66, 99% CI 0·46–0·93). Compared with patients with closed lower limb fractures, patients with closed spine (adjusted RR 2·47, 99% CI 2·17–2·81) and pelvic (1·35, 1·10–1·66) fractures were most likely to have delays of more than 24 h before admission to hospital.

Interpretation In low-income and middle-income countries, timely hospital admission remains largely inaccessible, especially among patients with open fractures. Reducing hospital-based delays in receiving care, and, in particular, improving interfacility referral systems are the most substantial tools for reducing delays in admissions to hospital.

Funding National Health and Medical Research Council of Australia, Canadian Institutes of Health Research, McMaster Surgical Associates, and Hamilton Health Sciences.

Lancet Glob Health 2020; 8: e711–20

See **Comment** page e623

*Listed in the appendix

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See **Online** for appendix

Research in context

Evidence before this study

We searched PubMed, with no specified start date, for publications until Oct 5, 2019, using the search terms "hospital admission delay" or "hospital delay" or admission delay" combined with "injury" or fracture", which provided 21 results. No studies directly assessed the frequency of delays in hospital admission in patients with fractures in low-income and middle-income countries. Two studies that retrospectively analysed trauma-related deaths in India and Ghana showed that delay in hospital admission was a clinically significant factor in preventable deaths. Five studies linked morbidity and mortality resulting from non-fracture injuries to delays in hospital admission in a single country. Through reading of the literature, we identified three further studies that broadly measured access to surgical services in low-income and middle-income countries using statistical modelling, and generally suggested that access to care that was both timely and affordable was deficient. Given the paucity of clinical data to inform on observed trends in timely access to hospital admission and the lack of studies focused on identifying the reasons for delay, a comprehensive clinical perspective of timely access to hospital admission is needed.

Added value of this study

To our knowledge, this is the largest prospective observational study to date to investigate delays in hospital admission among orthopaedic fracture patients, and to apply the *Lancet* Commission on Global Surgery's Three Delays framework to understand the main reasons for these delays in low-income and middle-income countries. Given the global target for 80% of a population to have access to surgical care within 2 h of an injury, our study shows that hospitals failed to admit approximately 70% of patients with open fractures in this time frame. Among those with closed fractures, approximately 27% were delayed by more than 24 h. In assessing hospital admission delays of more than 24 h among all patients with fractures, delays in receiving care (ie, Third Delays)—in particular, interfacility referrals—accounted for approximately 50% of delays. Thus, our analysis provides a clinically observed assessment of gaps in the prehospital network and the state of global targets in fracture care in low-income and middle-income countries.

Implications of all the available evidence

Low-income and middle-income countries are falling behind in achieving global targets for accessing orthopaedic care and are failing at the first step of the emergency-care system—ie, transporting patients to a treating hospital in a timely manner. Developing and improving interfacility referral protocols and systems is a particularly crucial hospital-based tool for decreasing delays in admissions.

Introduction

Globally, injuries account for over 10% of disability-adjusted life-years, 90% of which occur in low-income and middle-income countries.[1,2] Deficiencies in the prehospital networks (ie, access to an ambulance, health insurance coverage), contribute substantially to mortality and morbidity due to injuries,[3] and approximately 80% of injury-related deaths occur before patients are admitted to a hospital.[4] Annually, approximately 24 million (53%) of 45 million all-disease premature deaths in low-income and middle-income countries can be addressed by improving emergency care systems.[5] The *Lancet* Commission on Global Surgery determined that essential facilities for surgical care should be available within 2 h for patients with severe injuries, including open fractures. Passing this benchmark time increases the risk of complications and mortality.[3] Thresholds for treatment timing for closed fractures range broadly from 6 h for fractures in long bones to 24 h or longer for closed hip fractures.[6]

The *Lancet* Commission on Global Surgery developed the Three Delays framework for categorising delays in accessing timely surgical care.[3] The First Delay is the delay in seeking care, which occurs when a patient waits to seek formal health-care treatment due to, for example, a lack of finances, distrust of the health-care system, or geographical restrictions.[3,7] The Second Delay is the delay in reaching care, which occurs when patients who have a desire to seek hospital care are impeded from doing so. Such delays could result from travelling long distances to find a hospital with sufficient resources or a lack of transportation.[3] The Third Delay is the delay in receiving care, which is the result of hospital-based deficiencies, such as a lack of capacity to provide care.[8]

As highlighted by WHO[9] and The World Bank,[10] in low-income and middle-income countries, data on emergency care systems are lacking and prospective studies to address crucial gaps in understanding delays in fracture care are needed. In response to the need for clinical data, the international multicentre orthopaedic study of fracture care (INORMUS) is, to date, the largest prospective observational study to quantify delays in hospital admissions in patients with fractures. Similar to previous work,[11] we assessed time from injury to admission to a treating hospital as a prerequisite and a surrogate for timely care. To identify priorities for improving access to care, our objectives were to determine the frequency of 2 h delays in admission for patients with open fractures and 24 h delays for patients with closed fractures, to apply the Three Delays framework to categorise delays in admission of more than 24 h by First, Second, and Third Delays; and to identify risk factors of delayed admission to hospital.

Methods

Study design and participants

INORMUS is an ongoing, multicentre, observational study, assessing global trends in musculoskeletal injury and health-care systems. In this substudy, we used data from the patients enrolled between April 3, 2014, and May 10, 2019. Patients were recruited from 49 hospitals with orthopaedic units (appendix pp 7–8) in 18 countries, which were grouped into five regions: China, Africa (Uganda, Kenya, Nigeria, Ghana, South Africa, Tanzania, Cameroon, and Ethiopia), India, south and east Asia (Pakistan, Nepal, Vietnam, Thailand, Philippines, Iran), and Latin America (Venezuela and Mexico).

Patients were eligible for inclusion in INORMUS if they had been admitted to a participating hospital within 3 months of an orthopaedic trauma and were aged 18 years or older. Trauma was defined as a fracture, dislocation, or fracture dislocation of the appendicular skeleton (ie, upper and lower extremities, shoulder girdle, and pelvic girdle) or spine. At each admitting hospital, eligible patients were identified through direct emergency department referrals. Patients were approached by study personnel (eg, nurses, physicians, residents, and research coordinators) to acquire written and informed consent, which was provided by all included patients. Patient data were then aggregated and de-identified. Generally, patient enrolment was done consecutively; however, in eight hospitals patients were consecutively enrolled, but only on specific days of the week (at least 3 days per week) due to restricted hospital resources. The scheduled enrolment days were consistent throughout the entire enrolment period. Specifically, four hospitals enrolled patients only on Monday–Friday; one hospital enrolled on Monday–Saturday; and three other hospitals enrolled on specific days of the week (eg, all of Monday, Wednesday, and Friday). In this substudy, only patients who sustained a fracture were analysed.

The protocol was approved by the McMaster University Research Ethics Board and each clinical site's ethics committee. The protocol has been published elsewhere.[12]

Data collection

On inclusion, the orthopaedic team at the hospital did a history and physical examination of each patient and recorded their findings via a paper case report form that was subsequently manually entered into an electronic database; further details of the study methods have been previously published.[12,13] During the clinical assessment, both inpatients and outpatients were asked when their injury occurred, from which the time to admission at the treating hospital was determined.

For all patients who were delayed in their admission by more than 24 h, we collected data on the primary reason for delay from a list of ten options. We categorised the reasons using the Three Delays framework: First Delays were fear of hospitals, treated by a traditional healer, concern of costs, believing the injury would heal itself, not wanting to go to hospital; Second Delays were unavailable transportation and distance to hospital; and Third Delays were interfacility referral and delay in emergency department. The final category was other reasons. These categories are in accordance with the *Lancet* Commission on Global Surgery.[3] In alignment with previous research, because interfacility referrals occur when the transferring hospital is unable to provide care, we defined this reason as a Third Delay.[8,14,15] Assessing the time to treatment was beyond the scope of this analysis.

We only report the most severe fracture sustained by a patient, as determined by the treating surgeon on the basis of their clinical experience. Fractures were categorised as hip, lower limb, upper limb, spine, and pelvic. The lower limb includes the femur, tibia, fibula, ankle, foot, patella, or other lower bone. The upper limb includes the humerus, arm (radius and ulna), clavicle, scapula, or other.

Outcomes

For this substudy, the primary outcome was to assess the number of patients with open and closed fractures who were delayed in admission to a treating hospital. In accordance with the *Lancet* Commission on Global Surgery framework, a delay in admitting patients with an open fracture to a treating hospital was defined as taking more than 2 h from the time of injury.[3] A delay in admission in patients with closed fractures was defined as being admitted to a treating hospital more than 24 h after time of injury. The delay threshold of more than 24 h is a conservative timepoint beyond which many closed fractures are at an increased risk of adverse outcomes and has been previously used as a benchmark for hospital admissions.[6,16,17]

Our secondary outcomes were the reasons for delay in hospital admission inclusively among patients with open and closed fractures, stratified by First, Second, and Third Delays of more than 24 h.

Statistical analysis

We analysed demographic (age, sex, level of education, occupation, income, living location, region), prehospital network (health insurance coverage, method of transportation, location transported from), and injury-related factors (fracture location, mechanism of injury, grade of open fracture [categorised as either Gustilo-Anderson grade I or II, or Gustilo-Anderson grade III], number of fractures sustained). We selected variables a priori on the basis of previous qualitative and quantitative literature, themes derived from the *Lancet* Commission on Global Surgery and the WHO Emergency Medical Services model, and our pilot studies.[3,5,15,17–20] Demographic and socioeconomic factors affect patients' willingness or financial capacity to access hospital care. Indicators of the prehospital network, including access to transportation and interfacility referrals, affect the timeliness of hospital admission. Finally, the type and severity of a fracture can affect a patient's impetus to seek treatment, the mobility of the patient, and the capacity of hospitals to provide treatment.[3,5,15,17–20]

INORMUS was originally powered for 40 000 patients for the primary outcome of quantifying mortality among patients with orthopaedic trauma.[12,13] This study size resulted in this substudy being overpowered. Considering the frequency of an admission time of more than 2 h among all patients is more than 50% (based on a high-powered study in a low-income country),[20] and the frequency of an open fracture among all fractures is 15%,[19] we estimated a minimum sample size of 2400 patients with fractures was needed to obtain the 360 patients with open fractures required to model delay of more than 2 h among patients with open fractures.[21] Because a sixth of patients were delayed by more than 24 h in our previous work,[19] we estimated that a robust regional model of a delay of more than 24 h among patients with closed fractures would require a minimum sample size of 1341 patients overall.[21]

	Patients with open fractures (n=5256)	Patients with closed fractures (n=25 999)	Total cohort (n=31 255)
Age, years	36 (26–48)	47 (32–64)	45 (31–62)
Sex			
Men	4269 (81·2%)	15 668 (60·3%)	19 937 (63·8%)
Women	987 (18·8%)	10 331 (39·7%)	11 318 (36·2%)
Education			
No education	362 (6·9%)	2616 (10·1%)	2978 (9·5%)
Up to elementary school	1320 (25·1%)	5852 (22·5%)	7172 (22·9%)
Up to secondary school	2301 (43·8%)	10 570 (40·7%)	12 871 (41·2%)
Post-secondary school	1273 (24·2%)	6958 (26·8%)	8231 (26·3%)
Data missing	0	3 (<0·1%)	3 (<0·1%)
Income, US$			
Unknown	1531 (29·1%)	8013 (30·8%)	9544 (30·5%)
≤2000	2025 (38·5%)	7199 (27·7%)	9224 (29·5%)
2001–6000	897 (17·1%)	3866 (14·9%)	4763 (15·2%)
6001–10 000	517 (9·8%)	3568 (13·7%)	4085 (13·1%)
>10 000	286 (5·4%)	3350 (12·9%)	3636 (11·6%)
Data missing	0	3 (<0·1%)	3 (<0·1%)
Occupation			
Agriculture	852 (16·2%)	3698 (14·2%)	4550 (14·6%)
Service	1143 (21·7%)	3710 (14·3%)	4853 (15·5%)
Business	839 (16·0%)	3655 (14·1%)	4494 (14·4%)
Homemaker or unemployed	674 (12·8%)	7414 (28·5%)	8088 (25·9%)
Student or working in the education sector	470 (8·9%)	2095 (8·1%)	2565 (8·2%)
Industrial	730 (13·9%)	2343 (9·0%)	3073 (9·8%)
Other*	548 (10·4%)	3081 (11·9%)	3629 (11·6%)
Data missing	0	3 (<0·1%)	3 (<0·1%)
Living location			
Rural	2412 (45·9%)	8286 (31·9%)	10 698 (34·2%)
Urban	2844 (54·1%)	17 711 (68·1%)	20 555 (65·8%)
Data missing	0	2 (<0·1%)	2 (<0·1%)
Region			
China	650 (12·4%)	8471 (32·6%)	9121 (29·2%)
Africa	1485 (28·3%)	6290 (24·2%)	7775 (24·9%)
India	1735 (33·0%)	7001 (26·9%)	8736 (28·0%)
South and east Asia	1191 (22·7%)	3285 (12·6%)	4476 (14·3%)
Latin America	195 (3·7%)	952 (3·7%)	1147 (3·7%)

Data are median (IQR) or n (%). *Including entertainment, military or police, health care, and public servant.

Table 1: **Demographic characteristics of patients with fractures included in analyses**

To identify risk factors of delayed admission to hospital admission, we constructed two separate, adjusted, binary logistic regression models to determine the risk of delays in hospital admission of more than 2 h in patients with open fractures (model 1) or more than 24 h in patients with closed fractures (model 2), adjusted by the identified independent variables. For both models, the independent variables were region, age, employment, urban living, health insurance, interfacility referral, method of transportation, number of fractures, mechanism of injury, and fracture location. However, for model 1, spine and pelvic fractures were aggregated into a single category of other fracture, due to their low frequency in patients with open fractures. To more generally delineate factors for 2-h and 24-h delay, as a post-hoc analysis we constructed two additional binary logistic regression models to predict delays of more than 2 h and 24 h collectively across patients with open fractures and closed fracture combined. We adjusted these models for region, age, employment, urban living, health insurance, interfacility referral, method of transportation, number of fractures, the mechanism of injury, fracture location, and open fracture. Previous literature has quantitatively or qualitatively ascribed the contribution of the included demographic, health-systems, and fracture variables towards delay or adverse surgical outcomes.[3,5,15,17–20] We did not include income as an independent factor, because more than 10% of participants did not report their income.[22] A table of hypothesised associations is included in the appendix (pp 12–14). For all models, we entered independent variables using forced simultaneous entry. We calculated odds ratios (ORs) from the logistic regression model, adjusted for each independent variable (ie, region, age, employment, urban living, health insurance, interfacility referral, method of transportation, number of fractures, mechanism of injury, and fracture location), but converted these to adjusted risk ratios (RRs) by estimating a baseline risk of delay in admission (appendix p 1). Adjusted ORs and RRs are presented with 99% CIs to facilitate interpretation.

We present categorical variables as an absolute number and proportion and continuous variables as the median (IQR) due to non-normal distributions. We assessed between-group differences in categorical variables using the χ^2 test, and in continuous variables using the Kruskal-Wallis test when comparing more than two groups, and the Mann-Whitney U test when comparing two groups. Given the exploratory nature of this study and our large dataset, and to avoid spurious associates, we considered p values of less than 0·01 to be significant. Missing cases were infrequent (<1%) and we excluded them from analyses.

This study was registered with ClinicalTrials.gov, NCT02150980.

Role of the funding source

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

Results

Between April 3, 2014, and May 10, 2019, 35 716 patients were approached for inclusion, of whom 3415 (9·6%) refused to participate or did not meet inclusion criteria. Furthermore, 1027 patients sustained a dislocation, but not a fracture, and another 19 had missing fracture data, and so were not included in our analysis. 31 255 patients were enrolled, of whom 19 937 (63·8%) were men and 11 318 (36·2%) were women. Regionally, 9121 (29·2%) patients were from China, 7775 (24·9%) were from Africa, 8736 (28·0%) were from India, 4476 (14·3%) were from south and east Asia, and 1147 (3·7%) were from Latin America (table 1). Participating men were of working age (median 39 years [IQR 28–53]) and commonly had tibia or fibula (4735 [23·7%] of 19 937), hip (2573 [12·9%]), and femur (2504 [12·6%]) fractures. Participating women were older than participating men (median age 58 years [IQR 41–72]) and commonly had hip (2946 [26·0%] of 11 318), tibia or fibula (1607 [14·2%]), and wrist (993 [8·8%]) fractures (appendix p 2).

Of 5256 patients with open fractures, with a median time to hospital admission of 5 h (IQR 2–14), 3778 (71·9%) were delayed by more than 2 h. Of 25 999 patients with closed fractures, with a median time to hospital admission of 7 h (3–36), 7141 (27·5%) were delayed by more than 24 h. Overall, patients in Latin America had the greatest proportions of delayed hospital admissions (173 [88·7%] of 195 patients with open fractures and 426 [44·7%] of 526 with closed fractures). Among patients with open fractures, proportionally fewer patients in China (399 [61·4%] of 650) had delays than in other regions, and among patients with closed fractures, fewer in Africa (1396 [22·2%] of 6287) had delays than in other regions (figure 1). For patients with open fractures, all pairwise comparisons between regions with respect to delays in admission to hospital were significantly different (Kruskall-Wallis test p<0·001) except for between India and Africa (p=0·167), India and south and east Asia (p=0·022), and Africa and south and east Asia (p=0·336). For patients with closed fractures, all pairwise comparisons were significantly different between all regions (Kruskall-Wallis test p<0·01). Ambulances were the form of transportation to reach the hospital for 2382 (45·3%) patients with open fractures and 7966 (30·6%) patients with closed fractures (table 2). In seven (39%) of 18 countries, 50% or more of patients with open fracture used an ambulance (appendix pp 3–4).

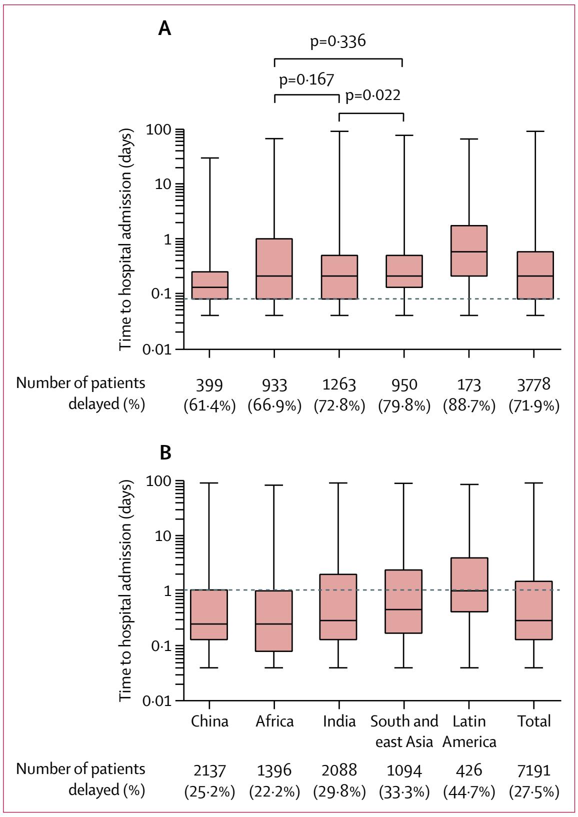

Figure 1: **Time from injury to admission to a treating hospital for patients with fractures, by region**
(A) Patients with open fractures, with dotted line showing 2 h delay. (B) Patients with closed fractures, with dotted line showing 24 h delay. Box plots show median and IQR, with whiskers showing the full range. The proportion of patients delayed is reported in square brackets. Non-significant pairwise comparisons are shown in the figure, with all other pairwise comparisons being significantly different (p<0·01).

For the 7875 patients who had a delay in admission to hospital of more than 24 h and who reported a reason for this delay (792 [15·1%] patients with an open fracture, 7083 [27·2%] with a closed fracture), interfacility referrals (3755 [47·7%]) and believing the injury would heal itself (1832 [23·2%]) were the most common primary reasons for delay. 1056 (48·9%) of 2158 patients in China who reported a reason for delay believed the injury would heal itself (figure 2). Reasons for delay significantly differed by region (overall χ^2 test p<0·001). Notably, only 388 (4·3%) of 7875 patients who reported a reason for delay of more than 24 h indicated concerns about cost as the primary reason for their delay. After aggregating all reasons for delays, Third Delays were the most common (3974 [50·5%] of 7875 reasons given) followed by First Delays (3093 [39·3%]) and Second Delays (423 [5·4%]). First Delays were the

	Patients with open fractures (n=5256)	Patients with closed fractures (n=25 999)	Total cohort (n=31 255)
Health insurance			
Private	252 (4·8%)	1584 (6·1%)	1836 (5·9%)
Government	1586 (30·2%)	10 599 (40·8%)	12 185 (39·0%)
No insurance	3418 (65·0%)	13 814 (53·1%)	17 232 (55·1%)
Data missing	0	2 (<0·1%)	2 (<0·1%)
Transportation to hospital			
Ambulance	2382 (45·3%)	7966 (30·6%)	10 348 (33·1%)
Private vehicle	2155 (41·0%)	13 388 (51·5%)	15 543 (49·7%)
Public transport	548 (10·4%)	3640 (14·0%)	4188 (13·4%)
Other*	159 (3·0%)	977 (3·8%)	1136 (3·6%)
Data missing	12 (0·2%)	28 (0·1%)	40 (0·1%)
From where they were transported to hospital			
Injury site	2128 (40·5%)	9884 (38·0%)	12 012 (38·4%)
Home	235 (4·5%)	6835 (26·3%)	7070 (22·6%)
Other hospital	2603 (49·5%)	8124 (31·2%)	10 727 (34·3%)
Other†	276 (5·3%)	1123 (4·3%)	1399 (4·5%)
Data missing	14 (0·3%)	33 (0·1%)	47 (0·2%)
Open fractures			
Low-grade open (Gustilo-Anderson grade I and II)	3284 (62·5%)	..	3284 (10·5%)
High-grade open (Gustilo-Anderson grade III)	1968 (37·4%)	..	1968 (6·3%)
Data missing	4 (0·1%)	..	4 (<0·1%)
Mechanism of injury			
Standing fall	182 (3·5%)	8784 (33·8%)	8966 (28·7%)
Fall from height	371 (7·1%)	4244 (16·3%)	4615 (14·8%)
Pedestrian road traffic injury	521 (9·9%)	2416 (9·3%)	2937 (9·4%)
Other road traffic injury‡	2822 (53·7%)	8103 (31·2%)	10 925 (35·0%)
Struck or lifting	333 (6·3%)	1268 (4·9%)	1601 (5·1%)
Other§	1026 (19·5%)	1183 (4·6%)	2209 (7·1%)
Missing	1 (<0·1%)	1 (<0·1%)	2 (<0·1%)
Fractures			
Hip	75 (1·4%)	5444 (20·9%)	5519 (17·7%)
Lower limb			
Femur	609 (11·6%)	2821 (10·9%)	3430 (11·0%)
Tibia or fibula	2099 (39·9%)	4243 (16·3%)	6342 (20·3%)
Ankle malleolus	244 (4·6%)	1544 (5·9%)	1788 (5·7%)
Ankle plafond	54 (1·0%)	208 (0·8%)	262 (0·8%)
Foot	548 (10·4%)	1031 (4·0%)	1579 (5·1%)
Patella or other lower bone	202 (3·8%)	921 (3·5%)	1123 (3·6%)
Upper limb			
Wrist	55 (1·0%)	909 (3·5%)	964 (3·1%)
Proximal humerus	281 (5·3%)	1312 (5·0%)	1593 (5·1%)
Arm	263 (5·0%)	1322 (5·1%)	1585 (5·1%)
Elbow	220 (4·2%)	2055 (7·9%)	2275 (7·3%)
Other upper limb bone¶	564 (10·7%)	1419 (5·5%)	1983 (6·3%)
Spine	9 (0·2%)	1953 (7·5%)	1962 (6·3%)
Pelvic	28 (0·5%)	810 (3·1%)	838 (2·7%)
Data missing	5 (0·1%)	7 (<0·1%)	12 (<0·1%)
Number of fractures			
One fracture	3725 (70·9%)	22 651 (87·1%)	26 376 (84·4%)
More than one fracture	1531 (29·1%)	3348 (12·9%)	4879 (15·6%)

(Table 2 continues in next column)

(Continued from previous column)

Data are n (%). *Includes walking, rickshaw, motorcycle, or other methods of transport. †Includes local doctor, nursing home, or other location. ‡Includes motorcycle, truck, bus, automobile, rickshaw or similar non-motorised vehicle, rail, animal, animal-drawn cart, bicycle, or other traffic vehicle. §Includes intentional or other mechanism. ¶Includes clavicle, scapula, or other upper limb bone not listed.

Table 2: **Injury characteristics of patients with fractures**

lengthiest of all delay categories (median of 6 days [IQR 3–13]), with seeking treatment from a traditional healer incurring the longest delays (median 8 days [IQR 4–17]; appendix p 10).

We delineated risk factors for a delay in hospital admission of more than 2 h for patients with open fractures and a delay of more than 24 h for patients with closed fractures (table 3). Increasing age increased the risk of delay for both patients with open fractures and those with closed fractures. Delay was strongly associated with region. In Latin America, patients with open fractures and closed fractures were more likely to be delayed in admission to hospital than both groups in China, whereas those with closed fractures in Africa were less likely to have delays than those in China (table 3). Sex was not a risk factor for delays in either fracture group; however, when subcategorising by First and Third delays, women with open or closed fractures were at increased risk of Third Delays of more than 24 h (adjusted RR 1·15, 99% CI 1·05–1·26; appendix p 5).

Among injury-related factors, in patients with open fractures, upper limb fractures were associated with a lower risk of delays of more than 2 h versus those with lower limb fractures (table 3). Closed spine and pelvis fractures were associated with a greater risk of delays of more than 24 h than were closed lower limb fractures. Patients with closed fractures who had standing fall injuries were also at higher risk of a delay of more than 24 h than any other form of injury. Subcategorising by the type of delay in all patients who were delayed by more than 24 h, spine fractures increased the risk of First Delays (adjusted RR 3·21, 99% CI 2·70–3·81) and pelvic fractures decreased the risk of First Delays (0·56, 0·35–0·91) compared with lower limb fractures (appendix p 5). Moreover, spine (1·67, 1·44–1·94), pelvic (1·74, 1·46–2·06), and hip (1·22, 1·08–1·38) fractures increased the risk of Third delays compared with lower limb fractures. Indeed, of all fracture types, patients with pelvic fractures were most often referred to another hospital (449 [53·6%] of 837; appendix p 11)

The health-care network of the patients also influenced likelihood of delay. Health insurance reduced the risk of delays for both patients with open and closed fractures (table 3). Subcategorising by the type of delay in all patients who had a delay of more than 24 h, health insurance reduced the risk of Third Delays (adjusted RR 0·79, 99% CI 0·72–0·87), but not First Delays (0·88, 0·77–1·00; appendix p 5). For patients with closed fractures, ambulances were associated with a lower risk of a delay of more than 24 h than private vehicles, public transport, and other modes of transportation (table 3). However, other modes of transportation (eg, walking, rickshaw) reduced the risk of a delay of more than 2 h in patients with open fractures compared with ambulances. Indeed, 1834 (77·0%) patients with open fractures who used an ambulance were delayed by more than 2 h compared with 67 (42·1%) who used other methods of transportation (p<0·0001; appendix p 9). This trend extended to delays of more than 2 h in general. When analysing patients with open fractures and closed fractures together (post hoc), other modes of transportations reduced the risk of a delay of more than 2 h compared with ambulances (adjusted RR 0·73, 99% CI 0·63–0·84; appendix p 6). Interfacility referrals were associated with a greater risk of delay for both patients with open fractures and those with closed fractures than transportation by an ambulance (table 3).

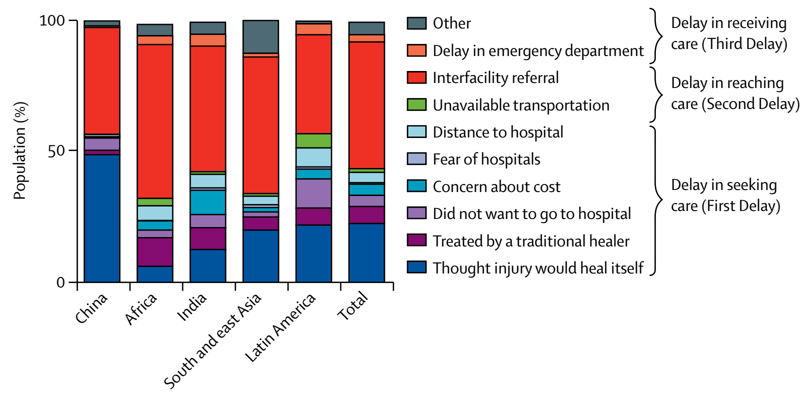

Figure 2: **Reasons for a delay in hospital admission of more than 24 h including both patients with open or closed fractures, disaggregated by region**
Each reason for delay provided by a patient has been recategorised according to the *Lancet* Commission on Global Surgery 2030 Three Delays framework.

Discussion

We found a substantial proportion of patients with both open and closed fractures were delayed in reaching a treating hospital. Approximately 70% of patients with open fractures did not reach the *Lancet* Commission on Global Surgery target of hospital admission within 2 h, and approximately 27% with closed fractures were delayed by more than 24 h. In the regions assessed, patients in China and Africa were the least delayed in their admission to a treating hospital, while those in Latin America were the most delayed. Two-thirds of patients did not use ambulances, with almost half travelling by private vehicle. Half of all patients with fractures were delayed in their admission by more than 24 h due to Third Delays, which was largely a result of interfacility referrals—the most common reason for delay. First Delays accounted for 39% of patient delays of more than 24 h, and were the lengthiest delays recorded.

This study was strengthened by primarily using prospective consecutive sampling. However, in rare cases where hospital resources were lacking, a systematic sampling approach was used instead. Limitations include that hospitals were not evenly distributed and were mostly larger trauma centres; consecutive sampling might under-represent minority populations; and because we only observed patients who attended a hospital, our analysis has Berkson's bias, and thus the magnitude of First and Second Delays are likely to be underestimated. Additionally, our threshold for assessing the reasons for delays of more than 24 h is conservative and might not be clinically suitable for all fractures. Furthermore, different reasons for delays, some of which might not have been included in our sample, might predominate over different timescales. Another factor to consider is that, despite the fact that more than 90% of included patients were admitted within 1 week, their report might be subject to recall bias. Also, we were unable to consider the total distance travelled by patients and we cannot quantify the time it took patients to be admitted to an initial referring hospital. Finally, because of the high frequency of delays in hospital admission (>10%), we converted ORs to RRs to more appropriately interpret the magnitude of the risk; however, these calculated RRs represent approximate measures.[23,24] Nevertheless, this study addresses a large knowledge gap in fracture epidemiology in low-income and middle-income countries and, to our knowledge, is the largest study to date to determine sources of delay in hospital admissions using the Three Delays framework.

Because of a lack of clinical registry data in low-income and middle-income countries, current measurements of health-care access use modelling strategies. Estimates have ranged from 2·2 billion people lacking access to surgical theatres in low-income and middle-income countries,[25] to 4·8 billion people lacking access to timely and affordable care globally.[26] By contrast, Ouma and colleagues[11] estimated that 71% of patients in sub-Saharan Africa live within 2 h of a hospital, implying theoretical access to timely care. Because only 5% of delays in our study were Second Delays, our findings support that proximity is not the primary barrier to access to care.[27]

We found that interfacility referrals were the greatest contributor towards delays in admission to hospital. Interfacility referrals are often precipitated by a lack of

	Delay of more than 2 h in patients with open fractures			Delay of more than 24 h in patients with closed fractures		
	Odds ratio (99% CI)	Risk ratio (99% CI)	p value	Odds ratio (99% CI)	Risk ratio (99% CI)	p value
Demographics						
Increasing age	1·01 (1·00–1·02)	1·00 (1·00–1·01)	0·001	1·01 (1·01–1·01)	1·01 (1·01–1·01)	<0·0001
Female *vs* male	0·87 (0·69–1·11)	0·92 (0·78–1·07)	0·16	1·00 (0·92–1·10)	1·00 (0·92–1·09)	0·89
Employed *vs* unemployed	0·90 (0·68–1·20)	0·94 (0·78–1·11)	0·35	0·87 (0·79–0·97)	0·88 (0·80–0·97)	0·0005
Health insurance *vs* no insurance	0·80 (0·64–0·99)	0·87 (0·74–0·99)	0·0080	0·87 (0·79–0·96)	0·88 (0·80–0·96)	0·0002
Urban *vs* rural	0·77 (0·64–0·93)	0·85 (0·75–0·95)	0·0003	0·95 (0·87–1·03)	0·95 (0·88–1·03)	0·11
Region						
China	1 (ref)	1 (ref)	..	1 (ref)	1 (ref)	..
Africa	0·77 (0·56–1·07)	0·85 (0·67–1·04)	0·039	0·84 (0·74–0·97)	0·85 (0·75–0·97)	0·0012
India	1·02 (0·75–1·40)	1·01 (0·83–1·21)	0·85	1·45 (1·28–1·64)	1·42 (1·27–1·59)	<0·0001
South and east Asia	1·45 (1·05–2·00)	1·24 (1·03–1·44)	0·0027	1·91 (1·67–2·18)	1·83 (1·62–2·06)	<0·0001
Latin America	3·27 (1·68–6·33)	1·74 (1·33–2·07)	<0·0001	1·95 (1·60–2·37)	1·87 (1·56–2·23)	<0·0001
Transportation factors						
Transportation to hospital						
Ambulance	1 (ref)	1 (ref)	..	1 (ref)	1 (ref)	..
Private vehicle	1·08 (0·88–1·33)	1·05 (0·92–1·18)	0·32	2·83 (2·56–3·14)	2·61 (2·39–2·85)	<0·0001
Public transport	0·77 (0·57–1·05)	0·85 (0·68–1·03)	0·028	2·45 (2·12–2·82)	2·29 (2·01–2·60)	<0·0001
Other*	0·55 (0·34–0·88)	0·66 (0·46–0·93)	0·0012	1·59 (1·23–2·05)	1·54 (1·22–1·95)	<0·0001
Referred from another hospital	7·89 (6·40–9·74)	2·15 (2·07–2·22)	<0·0001	3·66 (3·36–4·00)	3·25 (3·02–3·50)	<0·0001
Injury factors						
More than one injury	0·92 (0·75–1·12)	0·95 (0·83–1·07)	0·27	0·94 (0·83–1·06)	0·94 (0·84–1·05)	0·17
Standing fall *vs* other injury	1·54 (0·93–2·56)	1·27 (0·95–1·60)	0·029	1·47 (1·34–1·62)	1·44 (1·32–1·57)	<0·0001
Fracture location						
Lower limb	1 (ref)	1 (ref)	..	1 (ref)	1 (ref)	..
Hip	1·44 (0·62–3·34)	1·23 (0·73–1·75)	0·26	1·15 (1·03–1·30)	1·15 (1·02–1·28)	0·0017
Upper limb	0·79 (0·64–0·97)	0·86 (0·75–0·98)	0·0036	1·16 (1·05–1·27)	1·15 (1·05–1·26)	0·0001
Spine	..	..	..	2·67 (2·30–3·09)	2·47 (2·17–2·81)	<0·0001
Pelvis	..	..	..	1·38 (1·10–1·72)	1·35 (1·10–1·66)	0·0002
Other†	1·34 (0·42–4·30)	1·18 (0·54–1·89)	0·52	..	..	..

Adjusted for egion, age, employment, urban living, health insurance, interfacility referral, method of transportation, number of fractures, mechanism of injury, and fracture location. *Includes walking, rickshaw, motorcycle, or other method of transport. †In 2-h delay regression, spine and pelvic fractures were combined.

Table 3: **Adjusted binary logistic regression analysis associating demographic and injury characteristics with delays in hospital admission by fracture type**

facility resources and specialist capacity. Nkurunziza and colleagues[15] showed that across three district hospitals in Rwanda, half of referred patients were delayed by more than 2 days before being transferred due to a lack of resources and protocols. Moreover, inadequate triage protocols and poor communication with ambulances result in the transportation of patients to ill-equipped hospitals, resulting in poor clinical outcomes.[10,15,28,29] We echo others who call for a strengthening of district hospital resources, referral protocols, and centralising emergency medical service dispatches.[10,15,29]

Reducing delays of more than 2 h will require improvement in the timeliness of ambulances. Previous estimates on ambulance use in low-income and middle-income countries have ranged widely from 4% to 67%.[8,18,30] We found that approximately 45% of patients with open fractures and 33% of all patients used an ambulance. WHO determined that ambulances transported the majority (≥50%) of seriously injured patients in 37% of low-income and middle-income countries.[31] Similarly, we found that in seven (39%) of 18 countries analysed, ambulances transported 50% or more of patients with open fractures. We found that other methods of transportation, including walking and rickshaws, resulted in a lower risk of a delay in admission of more than 2 h than did use of an ambulance. Also, patients who had an upper limb open fracture were at lower risk of delay, suggesting a role for patient mobility in reducing the likelihood of delay. Additionally, patients who used other methods of transportation could have travelled shorter distances than an ambulance would have done, and ambulance transportation might disproportionately have unmeasured confounders, such as congestion or poor infrastructure. Nevertheless, our data align with previous descriptive field work showing how taxis and rickshaws often supplant ambulances as a first line of transportation[17,32] and highlight a need to improve ambulance dispatch services.[10]

Notably, patients who had hip, spine, and pelvic fractures were at an increased risk of delays of more than 24 h and Third Delays. Clinically, in low-income and middle-income countries, spine and pelvic fractures are difficult to diagnose because of a lack of x-ray facilities and trained personnel. Thus, our data might reflect a deficiency of facilities to diagnose these fractures.[17] Additionally, although sex did not affect risk of delays of more than 2 h or 24 h, women were at higher risk of Third Delays of more than 24 h than were men. This finding suggests a sex bias in the health-care system in low-income and middle-income countries that can potentiate long-term consequences for women's human development (socio-economic, social, societal). Thus, hospitals should take active measures to mitigate these inequities.

Universal health insurance is a commonly cited solution for increasing access to care in low-income and middle-income countries.[3] Although we found that health insurance overall reduced delays in admission to hospital, it did not reduce First Delays. Consistent with this finding, fewer than 5% of all patients reported concerns about cost as their primary reason for their delay. Instead, health insurance reduced the risk of Third Delays, supporting a previously described role of health insurance in reducing bureaucratic hospital barriers to care.[15,17] Nevertheless, we acknowledge that patients who cannot afford care might not be represented in our sample. Furthermore, admitted patients might still have financial difficulties due to treatment costs.

Although sub-Saharan Africa is traditionally viewed as among the most marginalised regions for surgical access,[33] we found that patients in Africa had some of the least delays. This discrepancy can, in part, be attributed to the fact that six of eight African countries included in our study met the *Lancet* Commission on Global Surgery benchmark that more than 80% of patients live within 2 h distance of a hospital.[11] Our data instead emphasise a need for improving access to care in Latin America, a region that is under-represented in global studies.[34] For instance, Mexico is an urbanised country with a high frequency of road traffic injuries, yet it has an underfunded and understaffed emergency medical service system.[35] Regionally, we also found that a high proportion of patients in China believed their injuries would heal on their own; thus, consideration of regional nuances is important when shaping future health-care policies.

In summary, to address the *Lancet* Commission on Global Surgery and WHO targets for global access to surgical care, here we have shown that across 18 low-income and middle-income countries, 71·9% of patients with open fractures and 27·5% of those with closed fractures were delayed in their admission to hospital. To ameliorate delays of more than 2 h for patients with open fractures, ambulatory services must be improved. Additionally, reducing delays associated with interfacility referrals is crucial. Improving the capacity for hospitals to diagnose and admit patients with hip, spine, and pelvic fractures, who were at an increased risk of delays of more than 24 h and Third Delays, should be a priority. Our data affirm that improving the prehospital network in low-income and middle-income countries is an important tool for improving access to fracture care.

Contributors

PP, CSL, and MB designed the analysis plan for this substudy. PP, CSL, SS, JWB, and MB contributed to the statistical analysis. PP and MB drafted the manuscript. CSL and MB provided overall management and support throughout the project. MB, RI, PJD, SS, CSL, and JJ contributed to the design and management of INORMUS. CSL, SS, and JJ contributed to overseeing the collection and management of the clinical data. PJD, RI, JJ, JWB, SS, and CSL contributed to the second draft of the manuscript, providing input and critical review. All authors reviewed and approved the manuscript.

Declaration of interests

MB reports receiving consulting fees from AgNovos Healthcare, and Pendopharm, and receives grant support from DJ Orthopedics and Acumed. PJD reports receiving grant support from Abbott Laboratories, Boehringer Ingelheim, Philips Healthcare, Roche Diagnostics, and Siemens. SS is employed by Global Research Solutions and reports receiving grant support from the Medical Research Council of Australia, Canadian Institutes of Health Research, McMaster Surgical Associates, and Hamilton Health Sciences. MB and CSL report receiving grant support from the Medical Research Council of Australia, Canadian Institutes of Health Research, McMaster Surgical Associates, and Hamilton Health Sciences. JJ and RI are funded by the National Health and Medical Research Council, Australia. All other authors declare no competing interests.

Data sharing

Data dictionaries pertaining to individual patient data will not be made available for sharing on publication.

Acknowledgments

This research was funded by the National Health and Medical Research Council of Australia (APP1084967), Canadian Institutes of Health Research (MOP133609), McMaster Surgical Associates, and Hamilton Health Sciences. We thank Diane Heels-Ansdell for her valuable contribution and advice regarding statistical analyses. And we thank Behnam Sadeghirad and Li Wang for their expertise and insights.

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