Risk Factors for Delayed Presentation Among Patients with Musculoskeletal Injuries in Malawi

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Background: The burden of injuries is high in low-income and middle-income countries such as Malawi, where access to musculoskeletal trauma care is limited. Delayed treatment can worsen trauma-related disability. Understanding risk factors for delayed hospital presentation will assist in guiding trauma system development.

Methods: We examined the records of 1,380 pediatric and adult patients with fractures who presented to the orthopaedic clinics of 2 urban referral hospitals and 2 rural district hospitals in Malawi. We used multivariate Poisson regression to evaluate the association between presentation to a hospital ≥ 2 days after the injury (delayed presentation) and 11 covariates: age, sex, education level, occupation, season of injury, day of injury, injury mechanism, injury type or extremity of injury, referral status, hospital of presentation, and estimated travel time.

Results: Twenty-eight percent of pediatric patients and 34% of adult patients presented late. In the pediatric cohort, fall (relative risk [RR], 1.40 [95% confidence interval (CI), 1.02 to 1.93]), sports injuries (RR, 1.65 [95% CI, 1.09 to 2.49]), tibial or fibular injuries (RR, 1.36 [95% CI, 1.05 to 1.77]), injury over the weekend (RR, 2.30 [95% CI, 1.88 to 2.80]), estimated travel time of ≥ 20 minutes (RR, 1.45 [95% CI, 1.16 to 1.81]), referral from another facility (RR, 1.46 [95% CI, 1.05 to 2.02]), and presentation to Kamuzu Central Hospital, Mangochi District Hospital, or Nkhata Bay District Hospital (RR, 1.34 [95% CI, 1.07 to 1.69]) independently increased the risk of delayed presentation. In the adult cohort, fall (RR, 1.85 [95% CI, 1.38 to 2.46]), injury over the weekend (RR, 1.80 [95% CI, 1.38 to 2.36]), estimated travel time ≥ 20 minutes (RR, 1.36 [95% CI, 1.03 to 1.80]), and presentation to Kamuzu Central Hospital (RR, 1.74 [95% CI, 1.30 to 2.33]) independently increased the risk of delayed presentation.

Conclusions: Delayed presentation to the hospital after a musculoskeletal injury is common in Malawi. Interventions are needed to improve access to musculoskeletal trauma care, especially for pediatric patients with tibial or fibular injuries, all patients after falls, patients injured over the weekend, and patients living far from health facilities.

Worldwide, trauma-related deaths exceed those from human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS), malaria, and tuberculosis combined and occur at disproportionately higher rates in low-income and middle-income countries¹⁻³. For every trauma-related death, many more nonfatal injuries occur^{4,5}. The resulting disability can be especially crippling for the poorest patients, who experience a vicious cycle of poverty from health-care costs and decreased productivity^{6,7}. Especially because of increasing road injuries, the incidence of musculoskeletal injury is increasing in low-income and middle-income countries^{4,8-11}. Delayed treatment worsens the burden of

trauma-related disability in low-resource settings^{12,13}. Quality surgical care is critical to reducing injury-related disability¹⁴.

Malawi is a low-income country in sub-Saharan Africa with 18 million residents¹⁵. With the world's fourth highest annual road injury mortality, 34.2 per 100,000¹⁵, Malawi has a high prevalence of musculoskeletal impairment¹⁶⁻²⁰. Hospital infrastructure, manpower, and essential equipment remain inadequate to effectively manage musculoskeletal trauma²¹. Barriers to care, particularly for the rural poor, include long travel distances, poor transportation, fear of a surgical procedure, lack of information, cultural barriers, and high costs of care²²⁻²⁴.

Disclosure: Two authors of this study (E.L. and J.N.K.) received funding from the National Institutes of Health (NIH) from grants AR-P30-0072577 and AR-K24-057827. One author of this study (L.C.C.) received a grant from the AO Alliance Foundation. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJS/F205>).

Understanding the characteristics of patients with fractures who present late to the hospital would help to guide efforts to strengthen and improve care for injured patients. We examined risk factors for delayed presentation in a cohort of patients with musculoskeletal injuries who presented at regional referral and rural district hospitals in Malawi.

Materials and Methods

Study Design and Sample

We performed a retrospective cohort study with data from the Malawi Fracture Care Registry. The registry includes adult and pediatric patients with isolated musculoskeletal injuries seen in outpatient orthopaedic clinics at 2 rural district hospitals (Nkhata Bay and Mangochi) and 2 urban referral centers (Kamuzu Central Hospital, Lilongwe, and Queen Elizabeth Central Hospital, Blantyre) (Fig. 1). Thirty percent of Malawians live in districts covered by these hospitals²⁵. However, catchment areas extend beyond hospital districts. Patients referred from other facilities typically receive no treatment besides improvised slings, bandages, or analgesia prior to referral. Few patients arrive via ambulance^{18,20}. Orthopaedic clinical officers (non-physician clinicians) at each hospital collected all registry data during a patient's clinic visit; no hospitalization or follow-up data were collected. We included subjects seen between September 2016 and May 2017. For additional details, see the Appendix.

Data Elements

Our outcome of interest was delayed presentation to the 4 hospitals included in the registry. We measured the time to presentation as the difference between the patient-reported date of the injury and the staff-recorded date of the hospital visit. This interval was measured in days, as no exact times were recorded to allow calculation in hours. We regarded time to presentation of ≥ 2 days as delayed¹².

We examined 11 covariates from the registry that had a plausible association with the outcome, based on a literature review^{12,19,20,23,24,26}. These included age, sex, education level, occupation, season of injury, day of injury, injury mechanism, injury type or extremity of injury, referral status, hospital of presentation, and estimated travel time.

We categorized age into 9 intervals. Pediatric patients were younger than 18 years of age. We categorized education as no schooling, primary grades 1 to 4, primary grades 5 to 8, secondary grades and above, and unknown. Occupation was recorded as unemployed, farmer, housewife, laborer, office worker, self-employed, small-scale business, student, and other. The mechanisms of injury were assault, fall, road traffic accident, sport, work-related, and other. We categorized the season of injury as dry (May to October) or rainy (November to April)²⁷. Data collection excluded 3 dry season months (June to August). We categorized day of injury as on a weekday (Monday through Thursday) or on a weekend (Friday through Sunday). We defined referral status as referred from another facility or self-referred.

Fig. 1
Map of Malawi by region: Northern, Central, and Southern regions. The Malawi Fracture Care Registry includes patients seen in the outpatient orthopaedic departments of Nkhata Bay District Hospital in the Northern region; Kamuzu Central Hospital, Lilongwe, in the Central region; and Mangochi District Hospital and Queen Elizabeth Central Hospital, Blantyre, in the Southern region.

Injury Classification

We categorized injuries by the body part affected: clavicle, shoulder, scapula, humerus, elbow, forearm, wrist, hand, pelvis, hip, femur, knee, tibia or fibula, ankle, foot, and unknown. Proximal humeral fractures were categorized as shoulder injuries, and supracondylar humeral fractures were categorized as elbow injuries. We categorized radial head fractures as elbow injuries, distal radial fractures as wrist injuries, and all other radial fractures as forearm injuries. Femoral neck, pertrochanteric, and subtrochanteric femoral fractures were recorded as hip injuries. Distal femoral and femoral condyle fractures were recorded as knee injuries. We recorded proximal and distal tibial fractures as tibial or fibular injuries. For

Fig. 2
Visualization of estimated travel (or transit) time (ETT) for Kamuzu Central Hospital. This is a map of Malawi, with color-coded visualization of the ETT from each pixel on the map to Kamuzu Central Hospital, which is indicated by the white circle. The callout window emphasizes the area around the city of Lilongwe. Scales for distance (in kilometers) and ETT (in minutes) are included. Calculation and visualization of ETT were performed using Redivis, which includes road location, type, and corresponding mean speed to estimate travel time between 2 GPS coordinates. For each pixel in this visualization, a corresponding GPS coordinate is assigned, ETT is calculated from that pixel to Kamuzu Central Hospital, and the pixel is then colored accordingly. Similar visualizations were constructed for the other hospitals of presentation: Nkhata Bay District Hospital, Mangochi District Hospital, and Queen Elizabeth Central Hospital. ETT was calculated for each patient in this study using the geocoded GPS coordinates of his or her hometown and a corresponding visualization for his or her hospital of presentation. Although ETT is not the actual travel time for particular patients, the ETT serves as a standardized, practical estimate of travel time from home to hospital.

1 patient with multiple injuries (femoral neck, tibia, and clavicle), the most severe injury (femoral neck) was used.

Estimated Travel Time

We calculated the estimated travel time for each patient from the recorded hometown to the hospital of presentation. We geocoded hometowns and all 4 hospitals with global positioning system (GPS) coordinates from Google Maps²⁸ or GeoNames²⁹. The Local Traditional Authority (a district subdivision) was geocoded if the hometown could not be found. We used Redivis (Redivis) to estimate the travel time for each patient with a geocoded hometown, an approach used in other research in low-income and middle-income countries^{30,31}. Rather than calculating straight-line distances, Redivis uses road location, type, and mean speed to estimate the travel time. Although estimated travel time is not the

actual travel time for particular patients, it serves as a standardized, practical estimate of travel time from home to hospital (Figs. 2 and 3). The estimated travel time was categorized in 20-minute intervals based on distribution. The estimated travel time was recorded as undetermined if a hometown could not be geocoded and as unknown if no hometown was listed.

Fig. 3
Geocoded hometown locations for all study patients. Each dot represents a patient from our study with a geocoded hometown, color-coded by estimated travel (or transit) time (ETT). Patients with undetermined or unknown ETTs are not plotted. Hospitals are indicated by white circles.

Fig. 4-A

Fig. 4-B

Figs. 4-A and 4-B Estimated travel (or transit) time (ETT) by hospital of presentation. Redivis was used to generate standardized, practical estimates of travel time from home to hospital for each patient in the study. **Fig. 4-A** Percentage of the combined cohort (pediatric and adult patients) in each ETT category (same scale as Figure 2) who presented to each of the 4 hospitals. **Fig. 4-B** The mean ETT, reported in minutes, for the pediatric and adult patients who presented to each of the 4 hospitals. The error bars represent the 95% CIs. Queen Elizabeth Central Hospital is a referral center in the large city of Blantyre, and Kamuzu Central Hospital is a referral center in the large city of Lilongwe. Mangochi District Hospital and Nkhata Bay District Hospital are rural district hospitals.

Statistical Analysis

Less than 5% of data were missing for all covariates except education level (7%), injury type (10%), and estimated travel time (11%). For these 3 covariates, we included an unknown category to preserve data completeness³². Separately for each cohort, we performed bivariate analyses using modified Poisson regression to examine the association between delayed

presentation and each covariate. Covariates with bivariate relative risks (RR)s of >1.25 or <0.8 , or with p values of <0.05 , were included in a multivariate analysis^{33,34}. We consolidated categories with similar RRs. In the final parsimonious model, we retained covariates with p values of <0.05 .

We used SAS 9.4 software (SAS Institute). The College of Medicine Research Ethics Committee (COMREC) in Malawi

Fig. 5

Percentage of cohort referred, by hospital of presentation. For each patient in the study, referral status was recorded in the registry as yes or no depending on whether the patient was referred to the hospital of presentation from another hospital. The percentage of patients who were referred was calculated separately for pediatric and adult patients at each of the 4 hospitals of presentation. The hospital of presentation is indicated on the x axis. Queen Elizabeth Central Hospital is a referral center in the large city of Blantyre, and Kamuzu Central Hospital is a referral center in the large city of Lilongwe. Mangochi District Hospital and Nkhata Bay District Hospital are rural district hospitals.

approved implementation of the Malawi Fracture Care Registry. The institutional review board at Brigham and Women's Hospital, Boston, Massachusetts, approved analysis of the de-identified data set.

Sensitivity Analysis

We examined the stability of our results by the introduction of the disposition from the clinic as a twelfth covariate and proxy for injury severity (see Appendix).

Results

The registry recorded 2,190 unique patients between September 1, 2016, and May 31, 2017. We excluded 3 international patients, 717 patients (33%) with missing dates of presentation and/or injury, and 90 patients (4%) without recorded age. The remaining 1,380 patients were included (68% children and 32% adults). Over 60% of patients who presented to the central hospitals lived nearby (estimated travel time, <20 minutes). The district hospitals had a greater proportion of patients who lived farther away (estimated travel time, ≥20 minutes) (Fig. 4-A). In both cohorts, the mean estimated travel time was shortest at Queen Elizabeth Central, followed by Kamuzu Central, Mangochi District, and then Nkhata Bay District Hospital (Fig. 4-B). Referral centers saw more referrals than district hospitals (Fig. 5).

Pediatric Cohort

Of the 932 pediatric patients, 262 (28% [95% confidence interval (CI), 25.2% to 31.0%]) were delayed. The mean

patient age was 8 years; 69% were male and 21% reported no schooling, 10% (20 of 194) of whom were school-age (>5 years of age). A fall was the most common mechanism of injury (73%), followed by sports (10%) and then assault (8%). More than 70% had upper-extremity injuries, mostly of the elbow, forearm, and wrist. The most common lower-extremity injury was of the tibia or fibula. On average, 13% of patients presented per rainy season month, and 7% presented per dry season month. Thirty percent of patients were injured over the weekend. Eighty-five percent of patients were referred from another facility (Table I).

Bivariate and multivariate regression results are presented in Table II. The final parsimonious multivariate model included mechanism of injury, injury type, day of injury, estimated travel time, referral status, and hospital of presentation. Patients who fell had a 40% increased risk of delayed presentation (RR, 1.40 [95% CI, 1.02 to 1.93]) and patients with sports injuries had a 65% increased risk (RR, 1.65 [95% CI, 1.09 to 2.49]) compared with other injury mechanisms. Tibial or fibular injury demonstrated a 36% increased risk (RR, 1.36 [95% CI, 1.05 to 1.77]) compared with other injury types. Injury over the weekend had a 130% increased risk compared with injury on a weekday (RR, 2.30 [95% CI, 1.88 to 2.80]). Relative to an estimated travel time of <20 minutes, an estimated travel time of ≥20 minutes was associated with a 45% increased risk (RR, 1.45 [95% CI, 1.16 to 1.81]). Patients referred from another facility had a 46% increased risk (RR, 1.46 [95% CI, 1.05 to 2.02]) compared with self-referred patients. Compared with Queen Elizabeth Central Hospital, seeking care at any of the other hospitals was associated

TABLE I Descriptive Statistics of the Cohorts*

Characteristic	Pediatric Cohort	Adult Cohort
Total	932 (67.5)	448 (32.5)
Delayed presentation	262 (28.1)	150 (33.5)
Age (yr)	8.4 ± 4.2	38.9 ± 15.7
Age groups		
0 to 5 years	255 (27.4)	—
6 to 10 years	364 (39.1)	—
11 to 17 years	313 (33.6)	—
18 to 25 years	—	102 (22.8)
26 to 35 years	—	115 (25.7)
36 to 45 years	—	105 (23.4)
46 to 55 years	—	61 (13.6)
56 to 65 years	—	25 (5.6)
≥66 years	—	40 (8.9)
Sex†		
Female	278 (30.8)	177 (39.6)
Male	626 (69.3)	270 (60.4)
Occupation†		
Unemployed	—	33 (7.4)
Farmer	—	102 (22.9)
Housewife	—	51 (11.5)
Laborer	—	45 (10.1)
Office worker	—	22 (4.9)
Self-employed	—	22 (4.9)
Small-scale business	—	67 (15.1)
Student	—	32 (7.2)
Other	—	71 (16.0)
Education level		
No schooling	194 (20.8)	46 (10.3)
Primary 1 to 4	348 (37.3)	49 (10.9)
Primary 5 to 8	264 (28.3)	159 (35.5)
Secondary or above	42 (4.5)	175 (39.1)
Unknown	84 (9.0)	19 (4.2)
Mechanism of injury†		
Assault	74 (8.1)	67 (15.3)
Fall	664 (73.0)	233 (53.2)
Road traffic accident	49 (5.4)	82 (18.7)
Sports	93 (10.2)	22 (5.0)
Work-related	0 (0)	20 (4.6)
Other	30 (3.3)	14 (3.2)
Injury type		
Clavicle	30 (3.2)	12 (2.7)
Scapula, shoulder, or humerus	10 (1.1)	15 (3.3)
Elbow	177 (19.0)	11 (2.5)
Forearm	252 (27.0)	51 (11.4)
Wrist	201 (21.6)	107 (23.9)

continued

TABLE I (continued)

Characteristic	Pediatric Cohort	Adult Cohort
Hand	5 (0.5)	12 (2.7)
Pelvis or hip	5 (0.5)	7 (1.6)
Femur	44 (4.7)	3 (0.7)
Knee	8 (0.9)	12 (2.7)
Tibia or fibula	82 (8.8)	48 (10.7)
Ankle	12 (1.3)	107 (23.9)
Foot	8 (0.9)	17 (3.8)
Unknown	98 (10.5)	46 (10.3)
Extremity of injury		
Upper	675 (72.4)	208 (46.4)
Lower	159 (17.1)	194 (43.3)
Unknown	98 (10.5)	46 (10.3)
Season of injury		
Dry season	189 (20.3)	119 (26.6)
Rainy season	743 (79.7)	329 (73.4)
Day of injury		
Weekday (Monday to Thursday)	650 (69.7)	264 (58.9)
Weekend (Friday to Sunday)	282 (30.3)	184 (41.1)
Estimated travel time		
<20 minutes	563 (60.4)	291 (65.0)
20 to 40 minutes	88 (9.4)	44 (9.8)
>40 to 60 minutes	65 (7.0)	30 (6.7)
>60 minutes	44 (4.7)	41 (9.2)
Undetermined	45 (4.8)	22 (4.9)
Unknown	127 (13.6)	20 (4.5)
Referrals	788 (84.6)	272 (60.7)
Hospital of presentation		
Kamuzu Central Hospital	178 (19.1)	116 (25.9)
Queen Elizabeth Central Hospital	602 (64.6)	241 (53.8)
Mangochi District Hospital	63 (6.8)	23 (5.1)
Nkhata Bay District Hospital	89 (9.6)	68 (15.2)

*The values are given as the number of patients, with the percentage in parentheses, except for age, which is given as the mean and the standard deviation. †These categories had missing data.

with a 34% increased risk of late presentation (RR, 1.34 [95% CI, 1.07 to 1.69]).

Adult Cohort

Of the 448 patients in the adult cohort, 150 (34% [95% CI, 29.1% to 37.9%]) were delayed. The mean patient age was 39 years, 60% of patients were male, and 10% reported no

TABLE II Pediatric Cohort: Bivariate and Multivariate Predictors of Delayed Presentation in Modified Poisson Regression Analyses

Variable	Rate of Delayed Presentation*	Bivariate†		Multivariate‡		Parsimonious Multivariate§	
		RR#	P Value**	RR#	P Value**	RR#	P Value**
Age group			0.031††		0.236		
0 to 10 years‡‡	25.9% (160 of 619)	1		1			
11 to 17 years	32.6% (102 of 313)	1.26 (1.02 to 1.55)		1.18 (0.90 to 1.56)			
Sex			0.167				
Female‡‡	24.5% (68 of 278)	1					
Male	28.9% (181 of 626)	1.18 (0.93 to 1.50)					
Education level			0.083		0.418		
No schooling‡‡	22.7% (44 of 194)	1		1			
Primary 1 to 4	30.5% (106 of 348)	1.34 (0.99 to 1.82)		1.03 (0.86 to 1.24)			
Primary 5 to 8	25.8% (68 of 264)	1.14 (0.82 to 1.58)		0.86 (0.69 to 1.07)			
Secondary or above	40.5% (17 of 42)	1.78 (1.14 to 2.80)		1.00 (0.73 to 1.36)			
Unknown	32.1% (27 of 84)	1.42 (0.95 to 2.12)		1.24 (0.95 to 1.62)			
Mechanism of injury			0.197		0.030††		0.032††
Road traffic accident‡‡	22.5% (11 of 49)	1		1§§		1§§	
Assault	18.9% (14 of 74)	0.84 (0.42 to 1.70)		1§§		1§§	
Other	26.7% (8 of 30)	1.19 (0.54 to 2.62)		1§§		1§§	
Fall	28.6% (190 of 664)	1.27 (0.75 to 2.17)		1.44 (1.03 to 2.01)		1.40 (1.02 to 1.93)	
Sports	34.4% (32 of 93)	1.53 (0.85 to 2.77)		1.64 (1.08 to 2.49)		1.65 (1.09 to 2.49)	
Injury type			0.014††		0.008††		0.003††
Elbow	21.5% (38 of 177)	0.75 (0.55 to 1.02)		0.69 (0.51 to 0.94)		0.72 (0.54 to 0.97)	
Tibia or fibula	42.7% (35 of 82)	1.49 (1.12 to 1.98)		1.35 (1.03 to 1.77)		1.36 (1.05 to 1.77)	
Other upper extremity‡‡	28.7% (143 of 498)	1		1		1§§	
Other lower extremity	24.7% (19 of 77)	0.86 (0.57 to 1.30)		0.95 (0.63 to 1.44)		1§§	
Unknown	27.6% (27 of 98)	0.96 (0.68 to 1.36)		0.78 (0.56 to 1.10)		1§§	
Season of injury			0.074				
Dry‡‡	33.3% (63 of 189)	1					
Rainy	26.8% (199 of 743)	0.80 (0.64 to 1.02)					
Day of injury			<0.001††		<0.001††		<0.001††
Weekday‡‡	19.5% (127 of 650)	1		1		1	
Weekend	47.9% (135 of 282)	2.45 (2.01 to 2.99)		2.26 (1.85 to 2.76)		2.30 (1.88 to 2.80)	
Estimated travel time			<0.001††		<0.001††		<0.001††
<20 minutes‡‡	24.9% (140 of 563)	1		1		1	
≥20 minutes	45.2% (89 of 197)	1.82 (1.47 to 2.24)		1.43 (1.14 to 1.79)		1.45 (1.16 to 1.81)	
Undetermined	31.1% (14 of 45)	1.25 (0.79 to 1.98)		1.33 (0.81 to 2.16)		1.30 (0.80 to 2.13)	
Unknown	15.0% (19 of 127)	0.60 (0.39 to 0.93)		0.60 (0.39 to 0.94)		0.57 (0.37 to 0.90)	
Referrals			0.151		0.010††		0.013††
Self-referred‡‡	23.1% (33 of 143)	1		1		1	
Referred from other facility	28.9% (228 of 788)	1.25 (0.91 to 1.72)		1.48 (1.06 to 2.06)		1.46 (1.05 to 2.02)	
Hospital of presentation			<0.001††		0.009††		0.013††
Queen Elizabeth Central Hospital‡‡	23.8% (143 of 602)	1		1		1	
Mangochi District Hospital	34.9% (22 of 63)	1.47 (1.02 to 2.12)		1.39 (1.09 to 1.76)§§		1.34 (1.07 to 1.69)§§	
Nkhata Bay District Hospital	41.6% (37 of 89)	1.75 (1.32 to 2.33)		1.39 (1.09 to 1.76)§§		1.34 (1.07 to 1.69)§§	
Kamuzu Central Hospital	33.7% (60 of 178)	1.42 (1.10 to 1.82)		1.39 (1.09 to 1.76)§§		1.34 (1.07 to 1.69)§§	

*The values are given as the percentage of patients, with the number of patients in parentheses, who had a delay in presentation of >1 day. †Bivariate analysis was performed for each covariate with delayed presentation as the outcome measure. ‡The multivariate model included categories with RR > 1.25, RR < 0.8, or p < 0.05. §The parsimonious model was constructed by excluding covariates with p > 0.05. #The values are given as the RR, with the 95% CI in parentheses. **Type-III p values are shown for categorical variables. ††Significant. ‡‡Reference. §§These categories were combined in the analysis.

schooling and 46% reported primary school only. Seven percent were unemployed. Farming was the most common occupation (23%), followed by small-scale business (15%).

Falls accounted for 53% of injuries, followed by road traffic accidents (19%) and assault (15%). Wrist and ankle injuries were most common. On average, 12% of patients presented per

TABLE III Adult Cohort: Bivariate and Multivariate Predictors of Delayed Presentation in Modified Poisson Regression Analyses

Variable	Rate of Delayed Presentation*	Bivariate†		Multivariate‡		Parsimonious Multivariate§	
		RR#	P Value**	RR#	P Value**	RR#	P Value**
Age group			0.029††		0.047††		
18 to 45 years‡‡	30.4% (98 of 322)	1		1			
≥46 years	41.3% (52 of 126)	1.36 (1.04 to 1.77)		1.32 (1.01 to 1.71)			
Sex			0.269				
Female‡‡	30.5% (54 of 177)	1					
Male	35.6% (96 of 270)	1.17 (0.89 to 1.53)					
Occupation			0.032††		<0.001††		<0.001††
Farmer‡‡	40.2% (41 of 102)	1		1§§		1§§	
Unemployed	36.4% (12 of 33)	0.90 (0.54 to 1.51)		1§§		1§§	
Office worker	45.5% (10 of 22)	1.13 (0.68 to 1.89)		1§§		1§§	
Student	37.5% (12 of 32)	0.93 (0.56 to 1.55)		1§§		1§§	
Other	31.7% (65 of 205)	0.79 (0.58 to 1.08)		1§§		1§§	
Housewife	15.7% (8 of 51)	0.39 (0.20 to 0.77)		0.39 (0.21 to 0.72)		0.38 (0.20 to 0.72)	
Education level			0.975				
No schooling‡‡	37.0% (17 of 46)	1					
Primary 1 to 4	34.7% (17 of 49)	0.94 (0.55 to 1.61)					
Primary 5 to 8	32.7% (52 of 159)	0.88 (0.57 to 1.37)					
Secondary or above	32.6% (57 of 175)	0.88 (0.57 to 1.36)					
Unknown	36.8% (7 of 19)	1.00 (0.50 to 2.01)					
Mechanism of injury			0.018††		<0.001††		<0.001††
Road traffic accident‡‡	24.4% (20 of 82)	1		1§§		1§§	
Assault	23.9% (16 of 67)	0.98 (0.55 to 1.74)		1§§		1§§	
Other	30.4% (17 of 56)	1.24 (0.72 to 2.16)		1§§		1§§	
Fall	39.5% (92 of 233)	1.62 (1.07 to 2.45)		1.79 (1.34 to 2.38)		1.85 (1.38 to 2.46)	
Injury type			0.602				
Upper extremity‡‡	35.6% (74 of 208)	1					
Lower extremity	30.9% (60 of 194)	0.87 (0.66 to 1.15)					
Unknown	34.8% (16 of 46)	0.98 (0.63 to 1.51)					
Season of injury			0.105		0.301		
Dry‡‡	39.5% (47 of 119)	1		1			
Rainy	31.3% (103 of 329)	0.79 (0.60 to 1.04)		0.84 (0.61 to 1.16)			
Day of injury			<0.001††		<0.001††		<0.001††
Weekday‡‡	24.2% (64 of 264)	1		1		1	
Weekend	46.7% (86 of 184)	1.93 (1.48 to 2.51)		1.80 (1.37 to 2.35)		1.80 (1.38 to 2.36)	
Estimated travel time			0.003††		0.036††		0.017††
<20 minutes‡‡	27.8% (81 of 291)	1		1			
≥20 minutes	40.9% (47 of 115)	1.47 (1.10 to 1.96)		1.33 (0.99 to 1.79)		1.36 (1.03 to 1.80)	
Undetermined	45.5% (10 of 22)	1.63 (1.00 to 2.68)		1.72 (0.99 to 2.96)		1.75 (1.04 to 2.94)	
Unknown	60.0% (12 of 20)	2.16 (1.44 to 3.22)		1.83 (1.23 to 2.72)		1.86 (1.26 to 2.76)	
Referrals			0.312				
Self-referred‡‡	30.7% (54 of 176)	1					
Referred from other facility	35.3% (96 of 272)	1.15 (0.87 to 1.51)					
Hospital of presentation			0.121		0.008††		<0.001††
Queen Elizabeth Central Hospital‡‡	28.6% (69 of 241)	1		1		1§§	
Mangochi District Hospital	34.8% (8 of 23)	1.21 (0.67 to 2.20)		1.01 (0.54 to 1.89)		1§§	
Nkhata Bay District Hospital	41.2% (28 of 68)	1.44 (1.02 to 2.03)		0.97 (0.68 to 1.38)		1§§	
Kamuzu Central Hospital	38.8% (45 of 116)	1.35 (1.00 to 1.84)		1.79 (1.29 to 2.48)		1.74 (1.30 to 2.33)	

*The values are given as the percentage of patients, with the number of patients in parentheses. †Bivariate analysis was performed for each covariate with delayed presentation as the outcome measure. ‡The multivariate model included categories with RR > 1.25, RR < 0.8, or p < 0.05. §The parsimonious model was constructed by excluding covariates with p > 0.05. #The values are given as the RR, with the 95% CI in parentheses. **Type-III p values are shown for categorical variables. ††Significant. ‡‡Reference. §§These categories were combined in the analysis.

rainy season month, and 9% of patients presented per dry season month. Forty-one percent of patients were injured over the weekend. Sixty-one percent of patients were referred from another facility (Table I).

Bivariate and multivariate regression results are presented in Table III. The final parsimonious multivariate model included occupation, mechanism of injury, day of injury, estimated travel time, and hospital of presentation. Relative to all other occupations, housewives demonstrated a 62% reduced risk of late presentation (RR, 0.38 [95% CI, 0.20 to 0.72]). Patients who fell had an 85% increased risk (RR, 1.85 [95% CI, 1.38 to 2.46]) compared with all other injury mechanisms. Injury over the weekend was associated with an 80% increased risk compared with injury on a weekday (RR, 1.80 [95% CI, 1.38 to 2.36]). Relative to patients with estimated travel time of <20 minutes, those with an estimated travel time of ≥20 minutes had a 36% increased risk (RR, 1.36 [95% CI, 1.03 to 1.80]). Compared with all other hospitals, seeking care at Kamuzu Central Hospital was associated with a 74% increased risk of late presentation (RR, 1.74 [95% CI, 1.30 to 2.33]).

Sensitivity Analysis

The disposition from the clinic was not associated with delay in the pediatric cohort. Adult patients who were treated and then sent home had a 63% increased risk of delayed presentation (RR, 1.63 [95% CI, 0.96 to 2.76]) in the multivariable model. Full details appear in the Appendix.

Discussion

We performed a retrospective cohort study of 932 children and 448 adults who presented to 2 referral centers and 2 rural district hospitals in Malawi. We examined associations between 11 covariates and presentation ≥2 days after injury. Pediatric patients who fell or had sports injuries, tibial or fibular injuries, injuries over the weekend, estimated travel time of ≥20 minutes, or referrals from another facility and those who presented at Kamuzu Central, Mangochi District, or Nkhata Bay District Hospital had an increased risk of delay. Adult patients who fell, were injured over the weekend, had an estimated travel time of ≥20 minutes, or presented at Kamuzu Central Hospital had an increased risk of delay.

Our reported rates of delay for the pediatric cohort (28%) and the adult cohort (34%) were higher than the 19% (95% CI, 17.7% to 19.4%) of patients with trauma who presented >24 hours after injury as derived from Eaton et al.²⁶. We report high rates of assault, consistent with prior work^{19,20}. However, we report lower rates of road injuries and higher rates of falls^{19,20}. These differences likely result from our examination of patients with isolated musculoskeletal injuries seen in clinics, whereas prior studies examined patients with trauma presenting to accident and emergency departments.

In the pediatric cohort, tibial or fibular injury was associated with a 36% increased risk of delayed presentation. This is concerning, as one-third of tibial shaft fractures may result in compartment syndrome, a complication worsened by delay³⁵. In both cohorts, patients who fell had an increased risk

of delay. Falls may have resulted in fewer severe injuries, contributing to delay if the need for formal medical care went unrecognized. Of all occupations, housewives had reduced risk of delay. As family caretakers, housewives perhaps have a greater incentive to get well sooner and can mobilize support to reach a hospital promptly.

In both cohorts, injury over the weekend was associated with increased risk of delay, perhaps due to limited transportation services and relative unavailability of orthopaedic outpatient services over the weekend (see Appendix). Patients living farther from a hospital were more likely to present late. In the adult cohort, patients with undetermined and unknown estimated travel times had an increased risk of delay. Undetermined estimated travel times may represent remote villages unidentifiable in geocoding databases, and unknown estimated travel times may represent locations unrecognizable to the staff completing the registry forms. In contrast, pediatric patients with unknown estimated travel times had a decreased risk of delay, suggesting that children with unknown estimated travel times perhaps lived close to a hospital.

All patients presenting to Kamuzu Central Hospital and pediatric patients presenting to both district hospitals had an increased risk of delay. Although public health care is free, differing transportation costs, prevalence of corruption, long wait times, hospital reputation, and availability of non-governmental hospitals may affect delayed presentation^{22,23,36-38}.

This study had several limitations. First, we excluded 33% of registry patients missing dates of presentation and/or injury. A separate examination of these patients revealed similar distributions in all covariates except referral status: 61% of children and 82% of adults were self-referred, compared with 15% and 39% in the included study cohorts. The exclusion of more self-referred patients perhaps exaggerated the association between referral status and delay. Patients with long delays may have forgotten the date of the injury or may have been reluctant to admit how long that they waited. Therefore, we may have underestimated the frequency of delay.

Second, as we defined delay as presentation ≥2 days after the injury, our results may not pertain to patients with particular delays substantially longer than 2 days. Unfortunately, sample size limitations preclude assessment of risk factors for alternative definitions of delay. Third, injuries were categorized using limited descriptions in the registry. Injury severity was also unknown. As all patients presented to clinics, they were likely less severely injured than patients presenting to accident and emergency departments. Thus, our findings may not be generalizable to patients with severe or multiple injuries, who should be examined in future studies. However, we observed that adults treated in a clinic and sent home, who were presumably less severely injured, had an increased risk of delay compared with those admitted for treatment. Our observed associations remained stable with the inclusion of the disposition from the clinic as a proxy for injury severity.

Fourth, income level and employment details were not recorded, precluding differentiation, for example, between commercial farmers and subsistence farmers. Limited financial

resources may increase the risk of late presentation. Fifth, injuries could have occurred in locations other than the patients' hometowns. However, as the majority of injuries in Malawi occur in or near the home²⁰, we assumed that the estimated travel time from the patient's hometown was an appropriate approximation. Moreover, the estimated travel time most accurately estimates travel by private vehicle, which is not the case for all patients^{18,20}. However, the estimated travel time still captures the effective distance from hometown to hospital, albeit in units of minutes rather than kilometers. Sixth, although the registry included referral status, the type of referring facility was unknown. Patients referred from rural hospitals may have an increased risk of late presentation compared with those referred from urban health centers.

Enhanced registry data collection could address several study limitations. Improved documentation of the time of injury and presentation would permit more precise determination of delay. Improved documentation of the location of injury would allow better characterization of the cohort of patients presenting to each hospital. Standardized documentation of the injury type and severity would be valuable for clinical and research purposes. The registry should be expanded to other hospitals and to accident and emergency departments to capture data on more severely injured patients.

We demonstrated that delayed presentation to a clinic is common in Malawi for patients with fractures regardless of age, sex, education level, or occupation. This warrants further investigation, as delayed treatment can worsen trauma-related disability^{12,13}. We identified subsets involving specific mechanisms or types of injuries with an increased risk of delay. Further research is needed to understand the perceptions of injury and when patients typically seek formal treatment. An increased risk of delay among patients injured over the weekend demonstrates a need to extend availability and to improve community awareness of outpatient orthopaedic services. The increased risk of delay for patients living farther from a hospital and for patients referred from facilities incapable of managing fractures demonstrates a need to improve access for rural populations. We should investigate the health system navigation by patients and the geospatial access to musculoskeletal trauma care³⁹. This would guide the future expansion of outreach services, transportation infrastructure, and possibly provision of financial support for patients at the greatest risk of late presentation after fracture in Malawi and other low-resource contexts.

Appendix

Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJS/F206\)](http://links.lww.com/JBJS/F206). ■

NOTE: The authors thank the Orthopaedic Departments at Mangochi and Nkhata Bay District Hospitals and Queen Elizabeth and Kamuzu Central Hospitals for their help with this study and their tireless care of patients with trauma. They also thank Foster Mbomuwa for his help in collecting and managing the registry data and geocoding hometowns, Swastina Shrestha for her help with data management and advice on statistical analysis, and Sean Meador for his help creating Figure 3. They especially thank all their patients in Malawi, who put their faith in the community of health-care providers to heal their injuries.

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