Cost of orthopaedic injuries sustained during unsanctioned crossings of the U.S.-Mexico border treated at a single level 1 trauma center.

Tyler C Nicholson MD[1,2], Michael Polmear MD[1,2], Richard VanTienderen MD[1,2], Adam Adler MD[1,2], James Blair MD[3]

1) William Beaumont Army Medical Center TX 2) Texas Tech Health Science Center El Paso 3) Augusta Health & Medical College of Georgia

Objectives: The purpose of this study is to report the incidence and patterns of injuries, surgical interventions performed, and healthcare costs associated with unlawful border crossings.

Design: Retrospective Review

Setting: Level 1 Trauma center on US-Mexico Border

Main outcome measurement: Demographic and treatment data

Results and conclusions: 111 patients were identified with an average age of 32 ± 12 years (range 6-60), and 56% were males. Monthly frequency of admissions was 0.75 in 2017, 1.33 in 2018, and 7.1 in 2019 ($p<0.001$). Median length of stay was 4 days (interquartile range 2-8). There was a total of 178 orthopaedic injuries (24 upper extremity, 123 lower extremity, 10 acetabular and pelvic ring, 21 spine). Pilon fractures were the most common injury pattern noted (N=33, 19%). Injuries resulted in 146 operative events, 231 procedures, 344 hours of operative room time, and 711 hospital days. 98 patients (88%) received definitive fixation, 13 (12%) had further surgery recommended without ability to follow-up. 92% of patients had no outpatient follow up. Total estimated cost of trauma utilization, diagnostic imaging, operating room utilization, implant costs, inpatient services, and Department of Homeland Security agent supervision was nearly $13.5M over the three-year study period. Injuries associated with unlawful border crossings are complex, costly, and challenging to treat. This is the first study that attempts to quantify the rates of orthopaedic-related hospital admissions, costs, types of injuries sustained, and orthopaedic surgeries being performed on this patient population.

Level of Evidence: IV

Keywords: Trauma, Pilon, Plateau, Border

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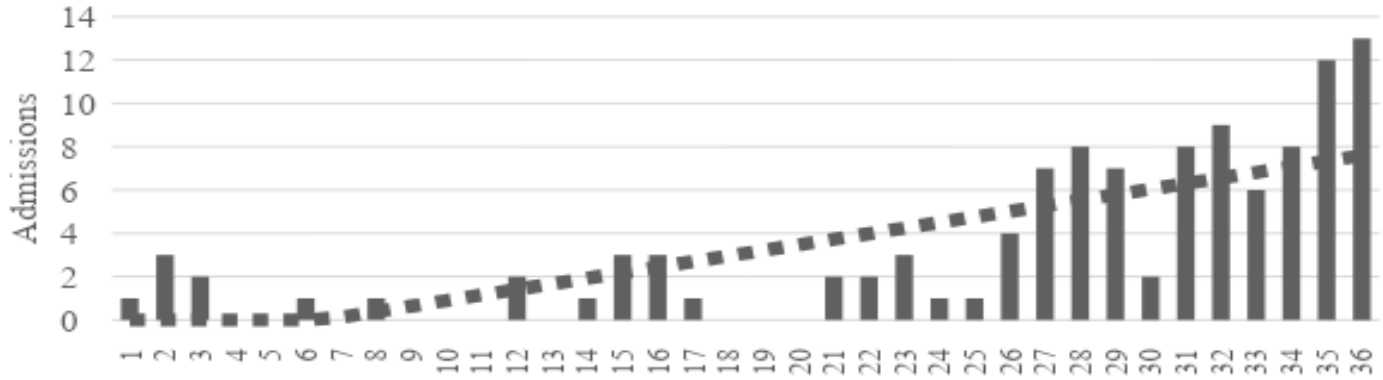
Figure 1. Monthly admissions of patients with orthopaedic injuries from January 2017 through December 2019. Trend is a three-month moving average (dotted line).



INTRODUCTION

The United States (U.S.)-Mexico border sees nearly one billion documented crossings per year, with a prevalence of additional crossings throughout the nearly 2000-mile border. Unlawful crossings are hazardous and healthcare costs for this population have been estimated at an annual cost of $4.3B by local, state, and federal governments.[1] Recent media attention has focused on the increased volume of these crossings with the United States Department of Homeland Security reporting 977,509 apprehensions during fiscal year 2019.[2]

Often, individuals involved in illegal border crossings sustain orthopaedic injuries that require emergency treatment. There are considerable social barriers to obtaining health care for illegal immigrants. Immigration apprehension policies have resulted in family separation[3] and oftentimes, individuals

Table 1. Presenting orthopaedic injuries

Region	Total	Open Fracture	(GA Type)			Closed Fracture	Soft Tissue Only	Operative (%)	Total (%)
			I	II	III				
Upper Extremity	24	5	1	1	3	16	3	17 (71%)	13
Lower Extremity	123	22	4	7	11	91	7	113 (91%)	69
Pelvic Ring and Acetabular	10	0	0	0	0	10	0	5 (50%)	6
Spine	21	0	0	0	0	21	0	3 (14%)	12
Total	178	27	5	8	14	138	10	138 (78%)	100

crossing have little to no financial means for food and subsidies, let alone healthcare costs. The majority do not speak English which complicates communication between healthcare provider and patient. There can be exacerbation of pre-existing health conditions and deviation from typical treatment plans, placing additional strain on emergency facilities.[4] A recent cost analysis of undocumented immigrants brought to a trauma center in southern Texas reported costs of $4.5M with reimbursements of only $0.99M.[5]

Although recent literature explores the healthcare costs associated with illegal immigration, there is little known about the healthcare implications directly associated with unlawful border crossings into the United States. The purpose of this study is to investigate the orthopaedic healthcare impact and quantify the regional healthcare charges and costs around El Paso, TX associated directly with undocumented border crossings.

METHODS

After local institutional review board approval, our orthopaedic trauma registry was queried from January 2017 through December 2019 to identify all patients admitted due to injuries sustained during undocumented border crossing. Our institution is a county hospital situated on the U.S.-Mexico border and is the only level one trauma center for over a 280-mile radius and treats the majority of patients sustaining injuries along the New Mexico and West Texas border, including those apprehended by the Department of Homeland Security.

A retrospective analysis was performed on all identified patients. Demographic parameters and clinical variables were extracted. Charts were reviewed to identify mechanism of injury, acuity of care upon presentation to the emergency department, services consulted during the inpatient stay, length of inpatient stay, ICU admissions, injury characteristics for both orthopaedic and non-orthopaedic injuries sustained. Surgical data were extracted to include orthopaedic procedures performed, length of operating room utilization, and estimated implant costs. Hospital data was queried to determine overall economic impact.

Cost Analysis

Total estimates for patient care included charges associated with trauma team activation, diagnostic imaging, operating room utilization, and implant and material costs for each procedure, inpatient services and Department of Homeland Security Border Patrol monitoring. These costs were derived from the Chargemaster[6] for our institution to estimate orthopaedic surgical care from the emergency department through operative management. Trauma activation codes at our institution follow the American College of Surgeons' Committee on Trauma guidelines[7] with emergency physician discretion. Inpatient costs were derived from Texas Hospital Price Point, a service provided by the Texas Hospital Association, a non-profit organization that tracks billable inpatient costs associated with major diagnostic categories and diagnosis related groups for each hospital in Texas. The most severe injury for each patient was used in the query with further sub-categorization for complication or comorbidity as applicable.

Statistical Analysis

Continuous variables were described using means with standard deviations or medians with ranges, and categorical variables were described using frequencies and percentages. A 2-tailed independent-samples Student's t-test was used to compare means between groups of continuous parametric data. Significant independent predictors were determined to be those that maintained p-values < 0.05.

Source of funding

There was no funding source for this study.

RESULTS

Demographics

111 patients were identified having sustained an orthopaedic injury due to an undocumented border crossing. Patients were an average age of 32.2 ± 12.0 years old (range 6-60). There were 62 males and 49 females. Average body mass index (BMI) was 27.9 ± 5.8 (range 13-45). Ethnicity of the patients were identified as 110 Hispanic and one Chinese. Of note, injuries to the spinal column are treated solely by our hospital's neurosurgical team and not included in this study.

Emergency Department and Hospital Admission Data

Of these patients, acuity level by trauma team activation criteria upon presentation to the emergency department included 13 level one, 35 level two, and 63 level three. All 111 patients presented through the emergency department. Twenty-five (22.5%) patients required ICU admission. Frequency of hospital admissions demonstrated a significant increase with 0.75 admissions per month in 2017, 1.33 admissions per month in 2018, and 7.10 admissions per

Table 2. Costs associated with hospitalization and operative intervention.

	Trauma Activation ($)	Diagnostic Imaging ($)	OR Utilization Time ($)	Ortho Implant and Material Cost ($)	*Ortho Costs ($)*	*Inpatient ($)*	Total ($)
Subtotal	674,954	263,059	619,260	756,518	*2,313,791*	*8,457,152*	10,770,943
n	111 patients	111 patients	106 patients, 231 procedures	164 implants, 225 procedures	*111 patients*	*111 patients*	111 patients
Per Patient	6,080	1,169	5,842	3,362	*20,845*	*76,190*	97,035

month in 2019 (p=0.0001, Figure 1). For the patients in this cohort, additional specialty service consults included 85 general surgery trauma, 21 neurosurgery, four hospitalist/internal medicine, four oral and maxillofacial surgery, four pediatric, two obstetrics/gynecology, two infectious disease, one vascular surgery, and one cardiology. Median hospital length of stay was four days (interquartile range 2-8, range 1-39), for a total of 711 hospital days. Nine (8.1%) patients had outpatient clinic follow-up at an average of 27.2 ± 14.8 days post-operatively. A total of eighteen patients had further surgery recommended at the time of their initial discharge. Five (28%) of those patients were able to follow up for definitive surgery, whereas thirteen (72%) did not follow up for definitive care. One patient had a second admission/procedure scheduled from clinic follow-up and four patients were able to be directly admitted for a second admission for further treatment.

There was 5.4% rate of repeat emergency department visits after hospital discharge resulting in an additional seven emergency department visits, for a total of 118 emergency department visits. These visits occur under Department of Homeland Security (DHS) custody. One of these return visits was for unrelated medical evaluation and treatment, and another one was for admission due to acute renal failure in the setting of rhabdomyolysis. The remaining five of these visits were utilized as a form of post-discharge follow up for either post-op pain, wound check/suture removal, or to ask questions about the post-operative plan.

Injury characteristics

In total, there were 178 orthopaedic injures with 138 (78%) of those injuries requiring surgical intervention. There were 36 open injuries (27 open fractures and 9 open wounds with no underlying fracture) with 5 Gustilo-Anderson (GA) Type 1 (18.5%), 8 GA Type 2 (29.6%) and 14 GA Type 3 (51.9%) fractures. There were 24 (13.4%) upper extremity, 123 (69.1%) lower extremity, 10 (5.6%) pelvic ring and acetabular, and 21 (11.8%) spine injuries. Ankle/pilon fractures were the most common injury pattern noted (N=52, 29%). Non-orthopaedic injuries in this patient cohort included 15 head/brain injuries, five facial injuries, and three abdominal injuries. Injury characteristics may be found in Table 1 and supplemental Table 1.

Table 2a. Trauma activation costs

	n	Per Activation ($)	Total ($)
Level I	13	37,338	485,394
Level II	35	3,634	127,190
Level III	63	990	62,370
Total	111	6,080	674,954

The most common mechanism of injury was fall from height (N=100, 90%). Other mechanisms of injury included seven ground level falls, one motor vehicle collision, two patients hit by a train, and one automobile versus pedestrian collision. These injuries resulted in 146 separate operative events (142 orthopaedic, four non-orthopaedic) with 231 total procedures performed. Operating room utilization time totaled 335 hours for orthopaedic procedures and 9 hours for non-orthopaedic procedures for a total of 344 operative hours.

Complications

Four patients (4%) had a total of nine (8% incidence) complications during hospitalization (supplemental Table 3). There was one unexpected return to the operating room for a revision posterior pelvic fixation.

Cost/Charge analysis

Total orthopaedic estimates for triage, diagnostic, and operative costs derived from charges associated with trauma team activation ($674,954), diagnostic imaging ($263,059), operating room utilization with an estimated cost at our facility of $30/minute ($619,260), and orthopaedic implant and material costs for each procedure ($756,518) for a total estimate of over $2.3 million or $20,845 per patient (Table 2, supplemental Table 2). Inpatient services were calculated separately based on the most severe injury and presence of comorbidity or complication for each patient for a total of over $8.4 million or $76,190 per patient. All patients were supervised 24 hours per day by a DHS officer while in-patient. At an average of $24 per hour, this cost was $409,536 or $3,690 per patient. These three major costs together were nearly $13.5M or over $121,570 per patient. Annual charges increased proportionally with admissions with over $1.2M in 2017, $1.9M in 2018, and $10.3M in 2019.

DISCUSSION

These results demonstrate that injuries sustained by these types of border crossings increased in frequency over the study period, resulted in complex injuries often requiring surgical intervention, and resulted in approximately $13.5M in healthcare costs. These are unique patients in a unique

Table 2b. Diagnostic imaging, implant, and material costs for each procedure. ex-fix: external fixator; fx: fracture; IMN: intramedullary nail; ORIF: open reduction internal fixation; TTC: tibiotalocalcaneal

			Unit cost	Total	Cost per case	Total
Ankle-spanning ex-fix	30	13	1,371	41,130	5,500	165,000
Spine posterior instrumentation and fusion	3	1	4,996	14,988	46,000	138,000
Ankle fusion TTC nail	2	1	1,637	3,274	21,000	42,000
Knee-spanning ex-fix	6	3	1,617	9,702	6,000	36,000
Ankle-spanning ex-fix multiplanar	2	1	1,371	2,742	16,000	32,000
Tibia IMN	12	5	1,430	17,160	2,600	31,200
Pilon ORIF	17	8	1,371	23,307	1,700	28,900
Ankle ORIF	18	8	1,034	18,612	1,400	25,200
Tibial plateau ORIF	8	4	1,451	11,608	2,700	21,600
Calcaneus ORIF	5	2	1,283	6,415	3,000	15,000
Femur CMN	5	2	1,203	6,015	3,000	15,000
Femur IMN	5	2	1,203	6,015	2,800	14,000
Fibula IMN	4	2	1,034	4,136	3,000	12,000
Ankle-spanning ex-fix revision	2	1	1,034	2,068	5,500	11,000
Ankle syndesmotic suspensory fixation	3	1	1,034	3,102	3,200	9,600
Midfoot ORIF	2	1	1,283	2,566	4,000	8,000
Distal Femur ORIF	2	1	1,540	3,080	3,600	7,200
Acetabular ORIF	2	1	4,675	9,350	3,000	6,000
Knee-spanning ex-fix revision	1	0	1,451	1,451	6,000	6,000
Distal radius ORIF	3	1	1,157	3,471	1,900	5,700
Femur reconstruction IMN	2	1	1,203	2,406	2,800	5,600
Distal humerus ORIF	1	0	1,541	1,541	4,300	4,300
Humerus ORIF	1	0	1,541	1,541	4,300	4,300
Talus ORIF	3	1	1,283	3,849	1,400	4,200
Sacral fx percutaneous fixation	3	1	4,279	12,837	1,100	3,300
Radial head arthroplasty	1	0	1,528	1,528	3,245	3,245
Ankle ligamentous reconstruction	1	0	946	946	3,000	3,000
Phalanx ORIF	1	0	765	765	1,800	1,800
Tibia ORIF	1	0	1,371	1,371	1,700	1,700
CRPP of calcaneus	2	1	1,690	3,380	800	1,600
Monteggia ORIF	1	0	1,528	1,528	1,600	1,600
Patella ORIF	3	1	1,114	3,342	530	1,590
Pubic symphysis ORIF	2	1	4,675	9,350	675	1,350
Sacral fx percutaneous fixation revision	1	0	4,675	4,675	1,100	1,100
Ankle percutaneous screw fixation	2	1	1,371	2,742	530	1,060
Ankle syndesmotic screw fixation	3	1	1,034	3,102	300	900
Scaphoid ORIF	2	1	1,530	3,060	450	900
Femur flexible IMN	1	0	1,203	1,203	800	800
Perilunate CRPP	1	0	765	765	800	800
I&D	35	16	-	-	1,500	52,500
Below knee amputation	1	0	680	680	1,500	1,500
Below knee amputation revision	1	0	354	354	1,500	1,500
Closed reduction metatarsal fxs	2	1	946	1,892	311	622
Closed reduction tarsal-metatarsal dislocations	1	0	1,283	1,283	311	311
Closed treatment ankle fx	1	0	718	718	740	740
Closed treatment calcaneus fx	1	0	1,283	1,283	700	700
Ex-fix removal	7	3	-	-	300	2,100
Finger ray resection	2	1	765	1,530	2,000	4,000
Finger revision amputation	3	1	368	1,104	2,000	6,000
Free radial forearm flap	1	0	375	375	2,000	2,000
Patella advancement	2	1	1,114	2,228	2,000	4,000
Patellar tendon repair	1	0	1,114	1,114	2,000	2,000
Reverse radial forearm flap	1	0	375	375	2,000	2,000
STSG	2	1	-	-	2,000	4,000
Total	225	100	1,169	263,059	3,362	756,518

Table 3. Comparative analysis of present study with others describing similar border injuries

	Present study 2020	Burk, et al. 2017	Kelada, et al. 2010
Demographics			
Male (%)	56	47	61.8
Female (%)	44	53	48.2
Study time range	Jan 2017 - Dec 2019	2004-2010	2000-2007
No. individuals	111	174	238
No. occurrences of musculoskeletal injury types			
Extremity	157	193	197
Spine	21	72	N/A
Hospital course			
No. admitted patients	111	166	N/A
Length of stay (days)	4	3.5	N/A
Musculoskeletal surgical interventions per patient	1.3	0.75	N/A

socioeconomic circumstance that deserve medical care that is no different from any other patient in this country. However, they are not entirely similar to other underserved patient populations in the United States in that follow up care is minimal while repeat visits to the Emergency Department is very low making any type of wound or fracture healing monitoring extremely difficult. Therefore, alternative methods of soft tissue and osseous treatment must be considered. While the total volume of these patients may be considered minimal at an average of approximately three patients per month for the totality of the study, it is important to note the recent marked increase in admission rate during the latter half of the study period. Though these results are from a single trauma center along the U.S.-Mexico Border and underestimate the true number of orthopaedic injuries and hospital admissions associated with undocumented border crossings, they are likely commensurate with the experience of other trauma centers along the Southwest U.S. border. The overall healthcare impact is likely far greater than what is reported in the current study when taking all medical specialties into consideration.

Prior literature on this topic is sparse. Sapkota, et al. used cross-sectional medical examiner's data to determine the most frequent causes of death associated with illegal border crossings in 2002-2003 and found that environmental heat exposure was the most common cause, followed by vehicle crashes and drownings.[8] Kelada, et al. published a time-trend analysis on the rate of border-crossing injuries from 2000-2007

and reported that although there was a decrease in apprehensions during that time period, the number of injuries significantly increased.[9] Burk, et al. published a retrospective review of injuries sustained by unlawful border crossings from 2004-2010.[10] The demographics and injury patterns they reported were similar due to predominant mechanism of fall from the border wall fence with height ranging from 18 to 27 feet, except for a slightly higher female to male ratio and a higher predominance of spine injuries in their study. This difference can be attributed to our institution's neurosurgical service treating patients with spine injuries, and isolated spine injuries were not in our orthopaedic trauma registry. Our study also demonstrated a much higher incidence of injury over a much shorter study period. This could be indicative of an increasing trend in unauthorized migrant crossing and apprehension and therefore higher incidence of traumatic injury. These studies were also performed in geographically distinct regions of the U.S.-Mexico border indicating that the variations in injury pattern as well as incidence of traumatic injury could be due to variations in terrain, migrant crossing techniques, physical barriers that must be traversed, etc. Patient demographics and injury characteristics are compared to Burk, et al. and Kelada, et al. in Table 3.

The financial impact of these injuries was notable. Consistent with prior studies, the largest proportion of cost was due to inpatient services and hospitalization.[11-12] (Table 2) While hospital charges and costs are not interchangeable, they can be used as surrogate markers. Charges associated with trauma team activation, operating room utilization, and orthopaedic implants also occupied a large portion of the overall expenditure. While imaging and other diagnostic procedures accounted for a relatively small portion of the cost, this cost was still sizable at over $250,000 dollars for the period of this study. Limited follow-up necessitated prolonged hospitalization to facilitate definitive treatment. Over two-thirds of the injuries reported in this study were lower extremity injuries with only an 8% outpatient clinic follow up rate. While several studies have identified lower extremity injuries that can be treated with early definitive fixation,[13-15] early treatment of high energy pilon or tibial plateau fractures can result in increased complications.[16-17] Therefore, in order to ensure appropriate definitive management for patients with these injuries, the decision was often made to keep the patients hospitalized for prolonged periods of time to allow for sufficient soft tissue rest prior to safe definitive fracture fixation, further increasing the healthcare cost of treating this unique patient population. Additionally, every effort was made to avoid definitive fixation utilizing any type of external fixation due to the poor likelihood of outpatient follow up.

While noncompliance with orthopaedic trauma follow up is common[18], limited follow-up in this study was

multifactorial and largely attributed to social circumstances following hospital discharge.[19] In these circumstances, patients are typically under the custody of the DHS during hospitalization and following discharge until the patient sees an immigration judge at which point the patient will either be deported or released. The timeline of this process can vary from days to months. A 5.4% return visit rate to the emergency department is lower than previously reported emergency department utilization trends in orthopaedic trauma patients[20]. An outpatient clinic follow up rate of 8.1% is also much lower than previously reported rates.[21] In our cohort, the majority of patients who followed up post-discharge, both in the clinic and emergency department, had undergone operative intervention for their orthopaedic injuries during admission. This is consistent with previous evaluations of follow up trends in other at-risk populations.[22]

Policies related to detention, deportation, and release of undocumented immigrants have changed throughout the history of our country and continued to be fluid even during the period of our study.[23] Detention, deportation, and transfer limited return access to our clinic. Multiple patients were released to their family members living in various parts of the U.S. and were unable to return to our facility due to proximity. It is the authors' hope that these patients were all able to follow up and receive appropriate care at their final destination, but this cannot be confirmed. Detailed discharge information defining weight bearing status, range of motion and activity restrictions, physical therapy instructions, discharge medications, signs and symptoms of infections and other post-discharge considerations are essential.

This study has multiple limitations as a single level one trauma center along the U.S.-Mexico border analyzing orthopaedic injuries and far underestimates the healthcare impact of undocumented border crossings within the U.S. Anecdotally, the acute rise in border crossing injuries has affected other community hospitals in our region, further underestimating our figures within the El Paso, TX, area. This study does not include patients presenting with non-orthopaedic injuries, injuries to the spinal column acute medical issues such as dehydration, those discharged from the emergency department, nor does it include injuries from other medical specialties, which further underestimates the total healthcare impact. The charges listed are generalized and not the true cost billed for each patient encounter, and it does not include funds reimbursed by the federal and state level. The sources used also reflect current costs as of the end of 2019 and may not reflect changes in costs from prior years. However, the associated charges were procured and analyzed in a manner that conferred accuracy to the treated injuries. Additionally, the generalized costs for orthopaedic implants, the cost of inpatient hospitalization, advanced imaging, and operating room expenses lends generalizability. Another limitation is the relatively short study period during which data were collected, as there is a time-trend relationship to border crossings.

Due to the unique nature of these patient injuries and known poor follow up with minimal repeat visits to the Emergency Department, the authors suggest the following treatment considerations for a patient injured during an undocumented border crossing:

- Strongly consider definitive treatment and early total care as soon as clinically safe and feasible to avoid prolonged hospital stays.
- For patients requiring prolonged hospitalization, provide clear documentation for the medical and surgical reasons to continue hospitalization prior to definitive care, such as compartment monitoring, soft tissue amenability for staged procedures, and wound healing for open fractures.
- Assume that once a patient is discharged, they will not be able to follow up in a clinic within the United States.
- Consider the use of absorbable sutures and skin closure techniques that do not require the removal of staples or stitches.
- Be cautious with multi-stage procedures, such as definitive fracture treatment in an external fixator, anticipated need for bone grafting, and bone transport, if patient discharge is going to be attempted.
- Provide patients with detailed verbal and written wound care and rehabilitation plans along with weightbearing restrictions in their native language.
- Provide medical records upon discharge to facilitate follow-up at other locations.
- Recognize that patient circumstances may not allow for certain weightbearing restrictions, such as nonweightbearing of a lower extremity.
- Strongly consider techniques that will allow for immediate weightbearing such as plate over nail constructs for extreme metaphyseal distal femur or tibia fractures.[24-25]

CONCLUSION

In conclusion, this is a challenging patient population to treat with complex injuries and unique social circumstances who are entitled to the same quality of care as any citizen of this country. Patient care may be further challenged by a lack of immediate family and social support, extreme financial limitations of those injured, and language barriers. Treatments can be costly and outcomes are unknown due to poor follow up. Increased attention should be placed on protocols that emphasize early appropriate care, immediate weightbearing, and discharge as early as clinically feasible, which should mitigate prolonged hospital stays, return visits to the emergency department, and improve patient care.

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