

# Border-fence falls versus domestic falls at a South Texas trauma center

Muhammad Darwish <sup>1</sup>, Constance McGraw,<sup>2</sup> Christopher W Foote <sup>1</sup>,  
Chaoyang Chen,<sup>1</sup> Vidhur Sohini,<sup>1</sup> David Bar-Or <sup>2</sup>, Carlos H Palacio<sup>1</sup>

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/tsaco-2022-001020>).

<sup>1</sup>Trauma Services Department, South Texas Health System, McAllen, Texas, USA

<sup>2</sup>Trauma Research, Injury Outcomes Network, Englewood, Colorado, USA

## Correspondence to

Dr David Bar-Or; [davidbme49@gmail.com](mailto:davidbme49@gmail.com)

Received 27 September 2022  
Accepted 11 February 2023

## ABSTRACT

**Objectives** Falling from height may lead to significant injuries and time hospitalized; however, there are few studies comparing the specific mechanism of fall. The purpose of this study was to compare injuries from falls after attempting to cross the USA-Mexico border fence (intentional) with injuries from domestic falls (unintentional) of comparable height.

**Methods** This retrospective cohort study included all patients admitted after a fall from a height of 15–30 ft to a level II trauma center between April 2014 and November 2019. Patient characteristics were compared by falls from the border fence with those who fell domestically. Fisher's exact test,  $\chi^2$  test and Wilcoxon Mann-Whitney U test were used as appropriate. A significance level of  $\alpha < 0.05$  was used.

**Results** Of the 124 patients included, 64 (52%) were falls from the border fence while 60 (48%) were domestic falls. Patients sustaining injuries from border falls were on average younger than patients who had domestic falls (32.6 (10) vs 40.0 (16),  $p=0.002$ ), more likely males (58% vs 41%,  $p<0.001$ ), fell from a significantly higher distance (20 (20–25) vs 16.5 (15–25),  $p<0.001$ ), and had a significantly lower median injury severity score (ISS) (5 (4–10) vs 9 (5–16.5),  $p=0.001$ ). Additionally, compared with domestic falls, border falls had fewer injuries to the head (3% vs 25%,  $p=0.004$ ) and chest (5% vs 27%,  $p=0.007$ ), yet more extremity injuries (73% vs 42%,  $p=0.003$ ), and less had an intensive care unit (ICU) stay (30% vs 63%,  $p=0.002$ ). No significant differences in mortality were found.

**Conclusion** Patients sustaining injuries from border crossing falls were slightly younger, and although fell from higher, had a lower ISS, more extremity injuries, and fewer were admitted to the ICU compared with patients sustaining falls domestically. There was no difference in mortality between groups.

**Level of evidence** Level III, retrospective study.

## INTRODUCTION

Injuries sustained from jumps or falls at the USA-Mexico border account for a significant proportion of admissions at trauma centers in border states.<sup>1–6</sup> Although previous studies on falls from heights have demonstrated that an increase in the height fallen has been associated with worse outcomes and a higher rate of mortality,<sup>7–10</sup> most of the focus was on the difference in height as opposed to the difference in mechanism of fall. Additionally, the literature is scarce when it comes to evaluating the difference between domestic versus border crossing-related falls. Previous studies evaluated the different types of injuries sustained by immigrants crossing

the border but did not address similar falls domestically, which can also lead to significant morbidity and mortality at trauma centers.<sup>1–10</sup>

This study took place at an American College of Surgeons (ACS)-verified level II trauma center located approximately 15 miles from the Texas-Mexico border in the Rio Grande Valley Sector. The purpose of this retrospective study was to describe the difference in characteristics and outcomes between falls from a height at the border wall fence versus domestic falls.

## METHODS

This retrospective cohort study included patients admitted after a fall from height to an ACS-verified level II trauma center between April 2014 and November 2019. The primary inclusion criterion was a fall from a height of 15–30 ft. Patients that were transferred out on arrival were excluded. Patients were then primarily grouped as 'border falls', defined as falls that occurred while attempting to cross the USA-Mexico border wall versus 'domestic falls', defined as all other unintentional falls from height, not related to crossing the USA-Mexico border.

Covariates collected on each patient from the trauma registry included sex, age, injury severity score (ISS, 1–15,  $\geq 16$ ), admission Glasgow Coma Scale (GCS, 3–8, 9–12, 13–15), hospital length of stay (LOS), ICU admission, number of days on mechanical ventilation, number of surgical interventions (0 vs 1 vs  $\geq 2$ ), and the available comorbid conditions (history of smoking, hypertension, diabetes mellitus, dyslipidemia, alcohol abuse). In addition, the pattern of injuries was collected and analyzed and included intracranial bleeds, soft tissue injuries, fractures, thoracic injuries, intra-abdominal injuries, and compartment syndromes. Outcome measures included an ICU stay and in-hospital mortality. Data are presented as average mean  $\pm$  (SD), median (IQR), or percentage.

Categorical variables were analyzed with  $\chi^2$  test and Fisher's exact test and continuous data were analyzed using Wilcoxon Mann-Whitney U test and Kruskal-Wallis test, as necessary. A significance level of  $\alpha=0.05$  and SAS V.9.4 (Cary, North Carolina, USA) were used to conduct all statistical analyses.

## RESULTS

During the study period, 1073 patients presented to our trauma center after sustaining a fall from height and of those, 124 (12%) patients were falls from a height of 15–30 ft. Sixty-four patients (52%) were a fall from the border fence, while 60 (48%) were

© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

**To cite:** Darwish M, McGraw C, Foote CW, et al. *Trauma Surg Acute Care Open* 2023;**8**:e001020.

**Table 1** Baseline differences between border-fence falls and domestic falls

Characteristics, n (%)	Border, n=64 (52%)	Domestic, n=60 (48%)	P value
Sex			<0.001
Female	26 (41%)	2 (3%)	
Male	38 (58%)	58 (97%)	
Age, mean (SD) years	32.6 (10)	40.0 (16)	0.002
Injury severity score, median (IQR)	5 (4–10)	9 (5–16.5)	0.001
1–9	46 (72%)	32 (53%)	0.07
10–15	9 (14%)	10 (17%)	
≥16	9 (14%)	18 (30%)	
ED GCS			0.11
3–8	1 (2%)	5 (8%)	
9–12	0 (0%)	0 (0%)	
13–15	63 (98%)	55 (92%)	
Comorbid conditions			
Hypertension	5 (8%)	20 (34%)	0.003
Diabetes mellitus	0 (0%)	10 (17%)	0.004
Dyslipidemia	1 (2%)	6 (10%)	0.05
Tobacco use	17 (27%)	21 (36%)	0.28
Alcohol abuse	8 (13%)	27 (46%)	<0.001
Fall height, median (IQR) ft	20 (20–25)	16.5 (15–20)	<0.001
Fall height, ft			<0.001
15–19	11 (18%)	32 (53%)	
20–24	36 (56%)	23 (38%)	
25–30	17 (27%)	5 (8%)	
Hospital LOS, median (IQR) days	5 (4–8)	5 (3–8)	0.07
Number of surgeries			0.001
0	9 (14%)	22 (37%)	
1	49 (77%)	27 (45%)	
≥2	6 (9%)	11 (18%)	
ICU stay	19 (30%)	38 (63%)	0.002
ICU LOS	4 (3–7)	3 (2–6)	0.63
MV used	1 (2%)	8 (13%)	0.01
In-hospital mortality	0 (0%)	3 (5%)	0.11

Bold p values indicate statistical significance at  $p < 0.05$ . ED, emergency department; GCS, Glasgow Coma Scale; ICU, intensive care unit; LOS, length of stay; MV, mechanical ventilation.

domestic falls. Overall, the mean age of patients was 36 (13.4) years, most were males (77%) who had a median ISS of 9 (4–13), spent 5 (3–8) days hospitalized on average, and fell from a median height of 20 (15–20) ft. On arrival to the trauma center, the most reported mechanisms of fall for domestic patients were falls from ladders (30%), falls from roofs (25%), and falls from trees (16%).

Table 1 reports any differences by fall type. Compared with domestic falls, patients sustaining injuries after a border-fence fall were more likely males compared with female patients (58% vs 41%,  $p < 0.001$ , table 1), were significantly younger on average (32.6 (SD 10) vs 40 (16),  $p = 0.002$ ), and had a lower median (IQR) ISS score (5 (4–10) vs 9 (5–16.5),  $p = 0.001$ ). When reporting medical history, compared with domestic falls, border-fence falls had a significantly lower proportion with hypertension (8% vs 34%,  $p = 0.004$ ), diabetes mellitus (0% vs 17%,  $p = 0.004$ ), and fewer suffered from alcohol abuse (13% vs 46%,  $p < 0.001$ ).

Interestingly, although injury severity was lower in the border falls group, they fell from a significantly higher height, on average (20 (20–25) vs 16.5 (15–20),  $p < 0.001$ , table 1) compared with domestic falls. Additionally, both hospital and ICU LOS were similar between groups, but compared with domestic falls, significantly

**Table 2** Differences in injury locations by fall type

Characteristics, n (%)	Border, n=64 (52%)	Domestic, n=60 (48%)	P value
Head	2 (3%)	15 (25%)	0.004
Face	1 (2%)	7 (12%)	0.03
Chest	3 (5%)	16 (27%)	0.007
Abdomen	0 (0%)	4 (7%)	0.05
Spine	23 (36%)	21 (35%)	0.91
Pelvis	4 (6%)	6 (10%)	0.44
Extremities	47 (73%)	25 (42%)	0.003

Bold p values indicate statistical significance at  $p < 0.05$ .

fewer border falls had two or more surgeries (9% vs 18%,  $p < 0.001$ ), fewer had an ICU stay (30% vs 63%,  $p = 0.002$ ), and fewer were put on mechanical ventilation (2% vs 13%,  $p = 0.01$ ). No patients in the border-fence falls group died compared with three deaths in the domestic falls group, although it was not statistically different between groups (0% vs 5%,  $p = 0.11$ ).

Table 2 reports on any differences in injury locations by fall type. Patients sustaining border-fence falls had a lower rate of head injuries (3% vs 25%,  $p = 0.004$ ), facial injuries (2% vs 12%,  $p = 0.03$ ), and chest injuries (5% vs 27%,  $p = 0.007$ ) compared with domestic falls. On the other hand, border falls had a higher rate of extremity injuries (73% vs 42%,  $p = 0.003$ ), particularly the lower extremities. The border falls group also had less abdominal injuries (0% vs 7%,  $p = 0.05$ ) and less pelvic injuries (6% vs 10%,  $p = 0.44$ ) than domestic falls, but differences were not significantly different between groups. Both groups had a similar percentage of injuries related to the spine (36% and 35%, respectively). Please refer to online supplemental table 1 to see more specific differences in injury by fall type.

## DISCUSSION

This study found that patients sustaining injuries from border-fence falls tended to be younger, have less comorbidities, and a lower ISS on admission, which in turn places them at a lower risk of a longer ICU stay compared with domestic falls. Additionally, border-fence falls sustained injury patterns that were different from domestic falls, which is consistent with the deliberate and possibly more controlled nature of border-fence falls as opposed to the accidental nature of domestic falls. Although overall mortality rates were not different between domestic and border-fence falls, there were significantly fewer ICU admissions for the border-fence falls, compared with the domestic falls group.

To our knowledge, this is the first study of its kind to describe the differences in outcomes between domestic falls and border-fence falls in the Rio Grande Valley area. It has been well established in the literature that immigrants crossing the USA-Mexico border illegally often sustain musculoskeletal injuries related to falls from the fence and subsequent apprehension.<sup>1–6</sup> While these immigrants sustain a wide variety of injuries, falls from the border fence remain the most common.<sup>6</sup> In comparison, domestic falls have a wider range of underlying mechanisms with varying outcomes.<sup>7–13</sup> However, there have been no previous publications to examining specific height fallen while comparing patient characteristics and outcomes between border and domestic falls.

Significantly, we were able to observe differences in injury patterns that may improve predictions and treatment protocols for falls from height. In domestic falls, our data showed more severe injuries to the head and chest. However, in border falls, there was a much higher predominance for extremity injuries. A theory for this difference in injury pattern could be related to the

fact that border falls are intentional and more prepared, whereas domestic falls are typically accidental and therefore less braced. Therefore, border falls suffer from an axial load mechanism of injury from bracing their falls. Vertical deceleration forces are well described as predominantly affecting the musculoskeletal system: particularly extremity bones such as the calcaneus, tibia, and lumbar and sacral spine.<sup>11</sup>

Interestingly, we observed a significantly lower ISS on admission in patients sustaining injuries after border-fence falls compared with domestic falls. This may be explained by the younger age and lower prevalence of comorbidities observed in border falls. Other studies have observed a significant correlation between fall height and number and extent of injuries.<sup>11–13</sup> Richter *et al* similarly examined patients who fell from 24 ft between patients who fell accidentally, and those who committed suicide, yet conversely from our study, found no differences between accidental versus intentional injuries.<sup>11</sup> In addition to this unique injury pattern, border-fence falls had a high proportion of cases that required at least one surgical intervention, a finding very similar to Burk *et al*.<sup>3</sup>

Furthermore, we found significantly less border falls were admitted to the ICU and less were put on mechanical ventilation. Because domestic patients presented with a higher average ISS, more ICU admissions and thus more patients on the ventilator is not unusual. Despite the higher overall severity of injury in domestic patients, mortality rates were not statistically different between groups. The three patients who died were much older than average, at 56 (46–50) years, all had an ISS of at least 33, and an admission GCS between 3 and 8. Other studies on falls from height typically had worse morbidity and mortality than this population, due to a higher age range of intentional falls.<sup>10–13</sup>

The primary limitations of this study are the small sample size and the locality of the results. While these results can have an application on a local level, it may be difficult to generalize to other states. Patients that sustained fatal falls would never reach the trauma center which in turn leaves several fall patients unaccounted for in this study. Additionally, the type of ground surface that a fall is sustained on and whether a fall is interrupted before hitting the ground is unknown in this patient population. It is worth noting that comorbid conditions were self-reported by patients which can underestimate the prevalence of undiagnosed comorbidities in patients that cannot afford medical care which is the trend in the immigrant population.<sup>1</sup> Our data are limited to the hospital course at the time of presentation to the trauma center. Further research into long-term outcomes including the need for rehabilitation is required.

## CONCLUSION

Differences in intentional versus unintentional falls from heights demonstrate unique differences in injury patterns, as well as injury severity. Patients sustaining injuries from border falls compared with domestic falls fell from a greater height, yet had a lower ISS, fewer comorbidities, more extremity injuries, and were less likely to be admitted to the ICU. There was no difference in mortality between both groups. Because border and domestic falls have different characteristics and outcomes, there is a need for increased awareness of the risks of falls from height to decrease preventable injuries and improve treatment.

**Contributors** MD conceived of the study, conducted literature searches, data collection, data analyses, and data interpretation, drafted the manuscript, provided critical manuscript revisions, and approved the final manuscript. CM conducted literature searches, data collection, data analyses, and data interpretation, assisted

with drafting of the manuscript, provided critical manuscript revisions, and approved the final manuscript. CWF, CC, and DB-O participated in data interpretation, provided critical manuscript revisions, and approved the final manuscript. CHP supervised the study, participated in data interpretation, provided critical manuscript revisions, and approved the final manuscript.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not applicable.

**Ethics approval** Approval to conduct this retrospective study was obtained from the Institutional Review Board at the participating center: Western Institutional Review Board (South Texas Health System, 20216226). The research involves no more than minimal risk to the subjects. The waiver or alteration will not adversely affect the rights and welfare of the subjects. The research could not practicably be carried out without the waiver or alteration; whenever appropriate, the subjects will be provided with additional pertinent information after participation.

**Provenance and peer review** Not commissioned; internally peer reviewed.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

## ORCID iDs

Muhammad Darwish <http://orcid.org/0000-0001-7517-4337>

Christopher W Foote <http://orcid.org/0000-0001-5299-0139>

David Bar-Or <http://orcid.org/0000-0002-3685-314X>

## REFERENCES

- 1 Ramey WL, Walter CM, Zeller J, Dumont TM, Lemole GM, Hurlbert RJ. Neurotrauma from border wall jumping: 6 years at the Mexican-American border wall. *Neurosurgery* 2019;85:E502–8.
- 2 Palacio CH, Cruz B, Vanier C, Cano J, Scott BG. The mechanism and pattern of injuries of undocumented immigrants crossing the texas-mexico border along the rio grande valley. *Inj Epidemiol* 2021;8:58.
- 3 Burk DR, Pah AR, Ruth JT. Analysis of musculoskeletal injuries sustained in falls from the United states-mexico border fence. *Orthopedics* 2017;40:e432–5.
- 4 McLean SF, Tyroch AH. Injuries sustained after falls from bridges across the united states-mexico border at el paso. *Rev Panam Salud Publica* 2012;31:427–34.
- 5 Kelada A, Hill LL, Lindsay S, Slymen D, Fortlage D, Coimbra R. The U.S.-mexico border: a time-trend analysis of border-crossing injuries. *Am J Prev Med* 2010;38:548–50.
- 6 Koleski J, Aldulaimi S, Moran E. From dehydration to fractures: medical issues faced by people crossing the United States: Mexico border. *J Immigr Minor Health* 2019;21:1181–4.
- 7 Alizo G, Sciarretta JD, Gibson S, Muertos K, Romano A, Davis J, Pepe A. Fall from heights: does height really matter? *Eur J Trauma Emerg Surg* 2018;44:411–6.
- 8 Obeid NR, Bryk DJ, Lee T, Hemmert KC, Frangos SG, Simon RJ, Pachter HL, Cohen SM. Fatal falls in New York City: an autopsy analysis of injury patterns. *Am J Forensic Med Pathol* 2016;37:80–5.
- 9 Nau C, Leiblein M, Verboket RD, Hörauf JA, Sturm R, Marzi I, Störmann P. Falls from great heights: risk to sustain severe thoracic and pelvic injuries increases with height of the fall. *J Clin Med* 2021;10:2307.
- 10 Turgut K, Sarihan ME, Colak C, Güven T, Gür A, Gürbüz S. Falls from height: a retrospective analysis. *World J Emerg Med* 2018;9:46–50.
- 11 Richter D, Hahn MP, Ostermann PA, Ekkernkamp A, Muhr G. Vertical deceleration injuries: a comparative study of the injury patterns of 101 patients after accidental and intentional high falls. *Injury* 1996;27:655–9.
- 12 Rey-Merchán MDC, Gómez-de-Gabriel JM, López-Arquillos A, Choi SD. Analysis of falls from height variables in occupational accidents. *Int J Environ Res Public Health* 2021;18:13417.
- 13 Kusior ME, Pejka K, Knapik M, Sajuk N, Kłaptocz S, Konopka T. Analysis of the nature of injuries in victims of fall from height. *Arch Med Sadowej Kryminol* 2016;66:106–24.