LOW FALLS CAUSING MAJOR INJURY: A RETROSPECTIVE STUDY

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Abstract

Background

Falling from a height of under 2 meters (low fall) is the most common mechanism of injury causing major trauma in Ireland. This presentation encompasses a wide patient cohort, from paediatric sport injuries to elderly falls.

Aims

Our aim is to characterise major trauma resulting from a low fall, and its various sub-populations, to identify preventative strategies and care pathways to improve outcomes for patients.

Methods

The Trauma Audit and Research Network (TARN) which is used to provide Major Trauma Audit was used to retrospectively identify patients presenting to the Cork University Hospital Emergency Department with trauma resulting from a low fall from January 2015 to June 2018.

Results

The database returned 1066 qualifying cases (49.3% of cases in the time period), with a mean age of 67.3 years (SD=21) and a median age of 71.3 years (IQR=23); 44% were male. 'Mechanical falls' accounted for n= 513 (48%) of low fall injuries, followed by 'stationary falls' n= 265 (25%). Injuries occurred most often at home n = 515 (48%), followed by public places n= 208 (19.5%). The most severely injured body region was limbs n=526 (49.3%), followed by head n=253 (23.7%). The number of patients with Glasgow Outcome Scores of 4 (moderate disability) and 5 (good recovery) were n=488 (45.8%), and n =390 (36.6%).

Conclusions

Low falls occur in patients over 55 years of age; many do not return to independent living. Wait times to initial assessment, length of hospital stay, and mortality increase with age. Mechanical falls at home are the most common cause of low-fall major trauma.

Key words: Low fall, major trauma, mechanical fall, cohort

Introduction

Falling from a height of under 2 meters is the most common mechanism of life threatening or life changing injury in Ireland[1]. Research has shown that this presentation encompasses a wide age demographic, from paediatric sport injuries to elderly falls, includes all socioeconomic classes, and is not discriminatory for previous mental and physical health [2]–[6]. The World Health Organisation in 2018 identified the elderly as the most at-risk group for fatal falls, and stated that over 37 million non-fatal traumatic falls occur worldwide every year, resulting in over 17 million disability-adjusted life years (DALYs)[7]. The Major Trauma Audit 2017 national report described that 57% of major trauma patients in Ireland in 2017 had a low fall as their mechanism of injury[8]. This report, and many others recently published, highlight that increasing focus on low falls prevention will be of significant benefit.

Previous research into low falls has focused on specific sub-populations, commonly elderly falls[1], [9]–[13] or head injuries [11], [14]. These subsets are important, as they represent parts of the low falls population that should be targeted for early identification and have potential for different initial management. However, sub-population research is most effective when the full population has first been assessed. As society changes and evolves, definitions regarding age categorisation, capability, and comorbidity change to reflect longer life and evolving healthcare [15]. Because health status, especially for the aging population, is in flux, it is important not to rely solely on previous definitions (such as categorising all patients over 65 in an 'elderly' cohort) and instead take a comprehensive snapshot of the entire population, letting the data define at-risk populations.

The aim of this study is to characterise the low-fall patient population and the injuries they sustain to quantify the burden on local health services and to help identify preventative strategies. We will specifically sub-categorise paediatric (under 18), adult (18 to 64), and older adult (over 65) patients.

Methods

Data Collection

Data for this study came from the major trauma audit (MTA) at Cork University Hospital. The MTA describes the care and clinical outcomes of patients who experience major trauma in

Ireland [8]. The National Office of Clinical Audit has engaged the internationally recognised Trauma Audit and Research Network (TARN) to provide its methodological approach for MTA in Ireland [16], [17]. TARN has been in operation in the UK since the 1990s and has been at the forefront of quality and research initiatives in trauma care [17]. MTA commenced in Ireland in 2014; all 27 trauma receiving hospitals in Ireland are now contributing data with a national data coverage rate of 86% that has grown incrementally, and an excellent national data accreditation rate of 97% meaning the quality of the data collected is very high [17]. Operationally, data is gathered from the patient's hospital and ambulance records, radiology reports, hospital information systems etc and entered on the TARN portal by trained data collectors at the hospitals; injury severity coding is performed by trained coders on anonymised data at TARN Headquarters in Manchester.

As part of this research module the student is provided the MTA TARN training (0.5 day) and then, under the supervision of the local data co-ordinators, performs 40 hours of data acquisition and enters this onto the TARN portal. The student is then provided a trauma data set of patients who have attended CUH (i.e. not the national data set) for their trauma care.

TARN captures the care of traumatically injured patients whose lengths of stay are 72 hours or more, or who are admitted to a high dependency area, or who die after arrival to hospital, or who are transferred to another hospital for specialist care, and whose injuries meet specific criteria relating to bodily location [8]. Of note, TARN does not capture deaths that occur prehospital. Major trauma is defined as patients with an injury severity score (ISS) of 15 or greater and constitutes potentially life threatening injury; TARN also collects data on patients with lower ISS who meet TARN inclusion criteria for MTA and constitutes potentially life changing injury.

Patient Outcomes Measured

Patients' overall disability outcome is scored using the Glasgow Outcome Score (GOS). The GOS is a five-point scale for measuring neurological recovery six months after traumatic brain injury [18]. The five points on the scale (at six months post-injury) are: death, permanent vegetative state, severe disability (conscious but disabled and reliant on daily supports), moderate disability (disabled but independent and functional in a sheltered setting), and good recovery (return to pre-injury conditions) [19]. Beyond its initial role for assessing neurological recovery, the GOS can be used as a snapshot measure of patient disability status at discharge, which is how it is used in TARN.

The abbreviated injury score (AIS) and Injury Severity Score (ISS) are validated scoring systems used internationally to quantify the severity of injury. The AIS is a scale for measuring individual injuries, on a scale of 1 to 6 (Minor, Moderate, Serious, Severe, Critical, Maximal) [20]. There are nine body regions defined in the AIS: Head, Face, Neck, Thorax, Abdomen, Spine, Upper Extremity, Lower Extremity, External and other. The ISS uses the highest AIS value for each of six regions (Head/neck (including cervical spine), Face, Thorax (including thoracic spine), Abdomen (including lumbar spine), Extremities (including pelvic girdle), External) [21]. The three highest AIS scores are each squared, then added together ($A^2 + B^2 + C^2 = 75\ max$). If any of the three scores is a 6 (un-survivable), the ISS is automatically set at 75. These two scoring systems together are internationally recognised as the method of retrospective injury quantification, and as such are the best practice when comparing trauma-related patient data. Unfortunately, not all studies relating to traumatic low falls report AIS and ISS data, making compilation and meta-analysis impossible.

Paediatric patients are defined as being under 18 years of age. Adult patients are 18 to 64.9 years of age. Older adult patients are 65 and above. The incident description definitions are novel to this study. Here, a stationary fall is defined as a fall from standing, sitting, or from bed. A collapse is included in the category of a stationary fall because a collapse is a fall from standing, as such the physical mechanism is the same. A mechanical fall is defined as a fall whilst walking on flat ground. Fall descriptions such as “trip” and “slip” are categorised as mechanical falls. An athletic fall is a fall whilst moving faster than walking, e.g. fall due to sports injury [22]. Falls whilst ascending versus descending stairs are defined individually, due to the difference in physical mechanics and therefore potential injury patterns [23]. From a biomechanics perspective, a fall when ascending stairs involves a more controlled fall forward, with wrists taking a majority of the impact [24]. A fall whilst descending stairs has higher potential for head and back injury, as well as increased momentum towards the bottom of the staircase, leading to a higher potential for serious injury [24]. A fall due to external forces on the body (e.g. a fall from a horse, or fall due to impact inflicted by another person) involves an uncontrolled element of surprise and lack of bodily control, leading to higher risk of injury [25]. An impact fall is a fall from a height, where there is a change in elevation between initiation and completion of fall, other than a fall on stairs. Seizure-induced falls are separated from stationary and mechanical falls due to the lack of bodily control leading to higher risk of serious injury [25]. These categories are subject to paramedic report detail and handwriting legibility.

Data Analysis and Ethical Approval

Data analysis was completed using RStudio and the Tidyverse Datascience package**.** Tables 1, 2, and 3were created using the Create Table One function in Rstudio. Figures 1 and 2 were created using the Bar Chart function in Rstudio. Single factor ANOVA tests were run on Length of Stay and Wait time criteria, and a Z-test was used for mortality distribution data.

Ethical approval for this research was acquired from the Clinical Research Ethics Committee of the Cork Teaching Hospitals on 19 June 2018. No funding was sought for this project.

Results

Population Trends

1066 (49.3%) patients presented to the CUH Emergency Department subsequent to a low fall between 1 January 2015 and 30 June 2018, out of 2162 sustaining potentially life threatening of life changing trauma captured on the MTA. The data capture for CUH for the years included in this study are as follows: 2015 had an 80% case ascertainment percentage, with 556 cases approved and 97.3% accreditation; 2016 had an 83% case ascertainment percentage, with 607 cases approved and 97.8% accreditation; 2017 had a 93% case ascertainment percentage, with 647 cases approved and 99.7% accreditation. Case ascertainment was calculated using the Hospital In-Patient Enquiry (HiPE) system and a sequence inclusion code provided by TARN.

Table 1 outlines the demographics of our population, divided into the three age groups. Of note, 78.8% of the cohort arrived by ambulance, the median GCS on arrival for all three age groups was 15, the median ISS for all age groups was 9, and limbs were the most severely injured body region for 49.3% of the cohort. The single-factor ANOVA test for wait times showed a significant difference ($p=6.0x10^{-4}$) among the three age groups. Figure 1 extrapolates on the demographics in Table 1, showing a more precise age and sex distribution of the cohort, in 10-year age groups.

Patient Outcomes

Table 2 delineates the outcomes for the cohort in more detail. The single factor ANOVA test for length of stay showed a significant difference ($p=9.1x10^{-5}$) among the three age groups. Of note, 79 (7.4%) patients were dead at 30 days after admission, 190 (17.8%) patients were discharged to nursing homes, and 488 patients (45.8%) had a GOS of 4 (moderate disability) at discharge. 116 (61%) of the nursing home discharges were new admissions to nursing home, based on the difference between incident location and discharge location. Figure 2 shows the same 10-year age groups stratified by most severe injury, as reported by each patient's AIS. The TARN database records both individual AIS scores for body regions, and the over-all ISS for that patient. For patients with one injury that has a higher AIS score than any other, that was taken as the most severe injury. Where multiple injuries had the same highest score, these patients were categorised as "multiple". The majority of most severe injuries in all but one group is limbs. All six patients in the infant group had primary head injuries.

Incident Analysis

Table 3 shows the results of our novel incident analysis. There were 515 (48.3%) of the cohort who fell at home. Fall location was not specified in 299 (21.5%) cases. As nearly half the population fell at home, we further segmented the "home" category by room, where possible. The three commonly reported rooms were the bathroom, bedroom, and kitchen. Only 110 (10.3%) patient reports included details beyond a general "home" location. Incident reports for the impact surface were also analysed. There was a lack of detail for 602 (56.5%) reports that did not include these specifics, but where reported they are represented in Table 3. Notably, 105 (10%) patients had consumed alcohol prior to their fall.

Discussion

Our results highlight a number of important trends in this cohort. Firstly, there is a significant level of morbidity associated with this population, rather than a high risk of mortality. Wait times, length of stay, and risk of fall increase with age. Secondly, our enquiry into the details of the incident shows that mechanical falls and stationary falls most commonly lead to major trauma low falls. Falls at home are the most common location for a low-fall major trauma across adult and older adult cohorts.

Morbidity

Our population was 56% female, with the ratio of female-to-male cases increasing with age, as shown in Figure 1. The number of presentations in the adult population (18-64) was much less than that of the older adult population (65 and older), and the highest number of cases occurred in the 75-85 year old group. This suggests that the adult population (particularly 55-65 year olds) is at higher risk of traumatic low falls than previously reported.

The demographic analysis of this population suggests that low-fall patients are at a high risk of long-term morbidity rather than mortality. The median GCS on arrival for the entire population was 15, with no interquartile differences (Table 1). Of this population 90.6% had a mild GCS (13-15). Additionally, the median ISS was 9 (moderate severity) for all three age categories, with 50.3% of the entire population presenting with injuries significant enough to have an ISS between 9 and 15. When combined, these data describe a cohort of patients that have moderately severe injuries without a concurrent drop in level of consciousness.

It is important to note that there is no over-representation of ISS scores greater than 15, and only 79 patients (7.4%) were dead at 30 days after discharge. This is a surprisingly low mortality rate for a major trauma population. As expected, due to the body mechanics involved in falling from standing or low heights, the most common severely injured body regions were the limbs.

Analysis of the discharge locations showed that 61% of nursing home discharges were new admissions to nursing home (when compared to the incident location). The most common GOS at discharge for both the adult and older adult populations is 4 (moderate disability), which shows a potentially life-altering level of morbidity for the adult population.

Home is dangerous

Our novel analysis of the details surrounding the fall (description of fall mechanics, location of fall, and impact surface) have highlighted the danger of falling at home, the importance of specific places within the home, and the various surfaces that could cause the most problems. 48.3% of the population fell at home, with 54.1% of older adult patients falling at home. Further analysis showed that the bedroom, bathroom, and kitchen are the most likely locations for a fall. While this finding is not unexpected, it may serve to inform future public health measures to protect this population. Concrete and tile were the most common impact surfaces; ubiquitous materials used in home flooring particularly in the aforementioned rooms. More detailed incident reports are required to make further inferences with regards to the locations within the home and the impact surfaces.

Our results highlight the importance of a comprehensive and detailed population analysis, as we are able to identify age group specific morbidity. This study has gone into more detail on the incident mechanism and location than previously published. The most at-risk population is the over-55 population, and our preliminary data suggests that particular attention should be paid to slipping and falling on tiled surfaces in the home and when getting in or out of bed.

Given this information, possible initial public health consideration could work towards increased access to panic buttons (and possibly decreased age for eligibility of panic buttons), home safety with regards to phone locations and railing placement, and evaluating the grip on shoes marketed to older adults.

The strengths of this study include the numbers of patients in the study (1066 patients over 3.5 years), and the reliability of the data. The data capture for CUH for the years included in this study meet and exceed the yearly goals set by the National Office of Clinical Audit. Some limitations to be considered include how specifically defined this population is, as only cases that met the TARN inclusion criteria could be accepted in the study. Therefore, this study is analysing a biased and skewed ‘major trauma snapshot’ of the even larger overall low-falls population. Specifically, the TARN inclusion criteria exclude single-limb injuries. With a larger dataset, we hope to be able to differentiate between an older adult cohort (55-75) and an elderly cohort (>76). With the current dataset there are not enough patients to yield significant differences. The GOS is measured at discharge for this cohort, where we would get a more accurate image of patient recovery with a GOS taken 3 months after discharge. The detailed incident analysis was limited to what specific information relating to the fall event was present in free-text paramedic reports, as transcribed to the database, so there are missing data regarding the location of the fall, location within the home, and the surface upon which the patient fell. While this is not data we expect to collect robustly on every patient, we need a larger cohort of patients to gain any statistical significance in relation to these data points.

Our results demonstrate in detail the demographics and circumstances of the traumatic low fall population in one hospital. It re-emphasises the high proportion of older adult and elderly patients presenting with low falls [10], [12], [13]. In agreement with previous studies, high ISS and low GCS have been shown to correlate with mortality [10], [12], [26]. However, in contrast to previous studies which reported head and spine injuries as most common, we found limb injuries to be most prevalent [1], [11], [13], [14].

Conclusion

The population presented in this study is primarily middle-aged to elderly (55-85) and female, suffering significant morbidity as a result of their traumatic low-fall injuries. Wait times, length of stay, and mortality increase with age. Research into the details of the incident shows that mechanical falls at home are the most common cause of low-fall major trauma. These results confirm the current understanding of trends in low falls and provides the first complete report of this population in Ireland.

REFERENCES

[1] H. Lee, K. J. Bein, R. Ivers, and M. M. Dinh, ‘Changing patterns of injury associated with low-energy falls in the elderly: a 10-year analysis at an Australian Major Trauma Centre: Low-energy falls in the elderly’, *ANZ Journal of Surgery*, vol. 85, no. 4, pp. 230–234, Apr. 2015, doi: 10.1111/ans.12676.

[2] G. Weingart, L. Glueckert, G. Cachaper, K. Zimbro, R. Maduro, and F. Counselman, ‘Injuries Associated with Hoverboard Use: A Case Series of Emergency Department Patients’, *Western Journal of Emergency Medicine*, vol. 18, no. 6, pp. 993–999, Oct. 2017, doi: 10.5811/westjem.2017.6.34264.

[3] H. Wang *et al.*, ‘Traumatic fractures as a result of falls in children and adolescents: A retrospective observational study’, *Medicine*, vol. 96, no. 37, p. e7879, Sep. 2017, doi: 10.1097/MD.0000000000007879.

[4] K. N. Shankar, N. J. Treadway, A. A. Taylor, A. H. Breaud, E. W. Peterson, and J. Howland, ‘Older adult falls prevention behaviors 60 days post-discharge from an urban emergency department after treatment for a fall’, *Injury Epidemiology*, vol. 4, no. 1, Dec. 2017, doi: 10.1186/s40621-017-0114-y.

[5] D. Denver, A. Shetty, and D. Unwin, ‘Falls and Implementation of NEXUS in the Elderly (The FINE Study)’, *The Journal of Emergency Medicine*, vol. 49, no. 3, pp. 294–300, Sep. 2015, doi: 10.1016/j.jemermed.2015.03.005.

[6] B. Beck, W. Teague, P. Cameron, and B. J. Gabbe, ‘Causes and characteristics of injury in paediatric major trauma and trends over time’, *Archives of Disease in Childhood*, vol. 104, no. 3, pp. 256–261, Mar. 2019, doi: 10.1136/archdischild-2018-315565.

[7] ‘WHO | Falls’, *WHO*. [Online]. Available: http://www.who.int/mediacentre/factsheets/fs344/en/. [Accessed: 26-Mar-2018].

[8] National Office of Clinical Audit, ‘Major Trauma Audit National Report 2017’. National Office of Clinical Audit, 06-Feb-2019.

[9] D. Evans, J. Pester, L. Vera, D. Jeanmonod, and R. Jeanmonod, ‘Elderly fall patients triaged to the trauma bay: age, injury patterns, and mortality risk’, *The American Journal of Emergency Medicine*, vol. 33, no. 11, pp. 1635–1638, Nov. 2015, doi: 10.1016/j.ajem.2015.07.044.

[10] J. Miu, K. Curtis, and Z. J. Balogh, ‘Profile of fall injury in the New South Wales older adult population’, *Australasian Emergency Nursing Journal*, vol. 19, no. 4, pp. 179–185, Nov. 2016, doi: 10.1016/j.aenj.2016.07.001.

[11] L. J. Scheetz, ‘Injury patterns, severity and outcomes among older adults who sustained brain injury following a same level fall: A retrospective analysis’, *International Emergency Nursing*, vol. 23, no. 2, pp. 162–167, Apr. 2015, doi: 10.1016/j.ienj.2014.09.003.

[12] S. C. H. Kuo, P.-J. Kuo, C.-S. Rau, S.-C. Wu, S.-Y. Hsu, and C.-H. Hsieh, ‘Hyponatremia Is Associated with Worse Outcomes from Fall Injuries in the Elderly’, *Int J Environ Res Public Health*, vol. 14, no. 5, May 2017, doi: 10.3390/ijerph14050460.

[13] C.-S. Rau *et al.*, ‘Geriatric hospitalizations in fall-related injuries’, *Scand J Trauma Resusc Emerg Med*, vol. 22, Nov. 2014, doi: 10.1186/s13049-014-0063-1.

[14] M. Majdan, A. Brazinova, I. Wilbacher, M. Rusnak, and W. Mauritz, ‘The impact of body mass index on severity, patterns and outcomes after traumatic brain injuries caused by low level falls’, *Eur J Trauma Emerg Surg*, vol. 41, no. 6, pp. 651–656, Dec. 2015, doi: 10.1007/s00068-014-0490-8.

[15] W. Sanderson and S. Scherbov, ‘Rethinking Age and Aging’, vol. 63, no. 4, p. 20, 2008.

[16] National Office of Clinical Audit, ‘The National Office of Clinical Audit (NOCA)’.

[17] National Office of Clinical Audit, ‘The Trauma Audit Research Network (TARN)’.

[18] B. Jennett and M. Bond, ‘ASSESSMENT OF OUTCOME AFTER SEVERE BRAIN DAMAGE: A Practical Scale’, *The Lancet*, vol. 305, no. 7905, pp. 480–484, Mar. 1975, doi: 10.1016/S0140-6736(75)92830-5.

[19] B. Jennett, J. Snoek, M. R. Bond, and N. Brooks, ‘Disability after severe head injury: observations on the use of the Glasgow Outcome Scale.’, *J Neurol Neurosurg Psychiatry*, vol. 44, no. 4, pp. 285–293, Apr. 1981.

[20] L. Greenspan, B. A. McLellan, and H. Greig, ‘Abbreviated Injury Scale and Injury Severity Score: a scoring chart’, *J Trauma*, vol. 25, no. 1, pp. 60–64, Jan. 1985.

[21] S. P. Baker, B. O’Neill, W. Haddon, and W. B. Long, ‘The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care’, *J Trauma*, vol. 14, no. 3, pp. 187–196, Mar. 1974.

[22] W.-R. Chang, S. Leclercq, T. E. Lockhart, and R. Haslam, 'State of science: occupational slips, trips and falls on the same level', *Ergonomics*, vol. 59, no. 7, pp. 861–883, Jul. 2016, doi: 10.1080/00140139.2016.1157214.
[23] K. Wang *et al*., 'Differences Between Gait on Stairs and Flat Surfaces in Relation to Fall Risk and Future Falls', *IEEE Journal of Biomedical and Health Informatics*, vol. 21, no. 6, pp. 1479–1486, Nov. 2017, doi: 10.1109/JBHI.2017.2677901.
[24] H. H. Cohen, J. Templer, and J. Archea, 'An analysis of occupational stair accident patterns', *Journal of Safety Research*, vol. 16, no. 4, pp. 171–181, Dec. 1985, doi: 10.1016/0022-4375(85)90004-0.
[25] F. L. Lew and X. Qu, 'Effects of mental fatigue on biomechanics of slips', *Ergonomics*, vol. 57, no. 12, pp. 1927–1932, Dec. 2014, doi: 10.1080/00140139.2014.937771.
[26] B. L. Strong, J. M. Torain, C. R. Greene, and G. S. Smith, 'Outcomes of trauma admission for falls: influence of race and age on inhospital and post-discharge mortality', *The American Journal of Surgery*, vol. 212, no. 4, pp. 638–644, Oct. 2016, doi: 10.1016/j.amjsurg.2016.06.002.