

Falls at home: hospital admissions in a health region of Aotearoa New Zealand

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ABSTRACT

AIM: To report on the descriptive epidemiology and costs of trauma admissions to the Te Manawa Taki Trauma System (TMT) hospitals in Aotearoa New Zealand following falls at home.

METHODS: A retrospective, observational study was conducted using data from the TMT trauma registry to identify patients of all ages who presented following falls at home from 2012 to 2022. This study reports on incidence of Fall Related Injuries (FRIs) that occurred at home with regard to age, gender, ethnicity, Injury Severity Score (ISS), injury characteristics and direct cost to TMT facilities.

RESULTS: Searches identified 13,142 events to the TMT trauma system following falls at home. Most events were classified as non-major trauma. There were statistically significant relationships between gender, ethnicity and district, and ISS category. There were two distinctive age band incidence peaks: ≤ 9 years and 60+ years. Males were more likely to sustain major trauma. The most common cause was fall on the same level from slipping, tripping and stumbling. The average length of stay per event was 5.5 days. The average cost per event was NZ\$9,792.

CONCLUSIONS: The study has identified the demography, injury types, risk factors and outcomes for FRIs that occurred in the TMT region of Aotearoa New Zealand. The volumes and costs of injury represent a significant burden on the health system, individuals and communities. More detailed understanding of causative factors will allow targeting of prevention strategies to address high-risk activities and demographic groups.

Trauma is a significant public health concern, and is recognised as a major cause of death and disability across the globe^{1,2} and in Aotearoa New Zealand. Fall-related injuries (FRIs) are a significant source of this trauma burden in Aotearoa New Zealand and globally.³⁻⁶ Equitable use of resources for the prevention and treatment of fall injuries depends on the use of reliable and representative information on incidence rates and risks across ethnicities and demographic groups. FRIs are of a particular importance in the context of Aotearoa New Zealand. Annual reports from the New Zealand Trauma Registry indicate that in 2021/2022, falls were the most common cause of trauma presentation in patients with ISS >12 ; falls were responsible for 33% of major trauma presentations nationally.⁷ Furthermore, data from the Global Burden of Disease project suggests Aotearoa New Zealand has a relatively high burden of disease (as measured in disability adjusted life years) compared to an average of other high-income countries.⁸

The most common location for injury hospitalisations is home, which is second to roads as the location for injury mortality.⁹⁻¹³ An analysis of

people aged 25–64 years in a Scandinavian study found that 44% of unintentional home injury requiring medical treatment were due to falls.¹⁰ Falls are the leading cause of unintentional injury at home among children aged ≤ 4 years and adults aged 20–64 years in Aotearoa New Zealand.^{6,14,15} Additionally, nearly a third of self-reported injuries requiring medical attention occur at home in Aotearoa New Zealand.¹⁶

FRIs also have a significant economic impact on the Aotearoa New Zealand health system and beyond through the Accident Compensation Corporation (ACC).¹⁷ The ACC is a no-fault injury compensation scheme operating nationwide that covers the costs of medical treatment and rehabilitation.¹⁷ For the 2012/2013 to 2021/2022 financial years, there were 3,855,876 new claims lodged as a result of FRIs at home, which translated to active costs in excess of \$4 billion.¹⁸ In 2010, 18% of the total social and economic costs of all injuries in Aotearoa New Zealand were attributable to falls, highlighting the importance of prevention.¹⁹ The total economic and social cost per fall injury was estimated to be NZ\$1,735 (2008 prices).¹⁹ It is therefore important to characterise the pattern

of injury and determine what scope there is for preventative measures to reduce the burden of injury.

The Te Manawa Taki (TMT) Trauma Registry collects standardised data on trauma patients of all age groups and severities, providing a unique data source for studying the patterns of FRIs that result in hospitalisation. The TMT region covers a geographically large and diverse area and is demographically similar to Aotearoa New Zealand as a whole.^{20–22}

The volume of literature surrounding falls in the home environment is largely focussed on falls in the elderly. Evidence reporting on the descriptive epidemiology of patients admitted following injury from falls across all ages and all severities is limited. However, it is possible using the comprehensive data included in the Te Manawa Taki Trauma Registry (TMTTR) to define at-risk groups. To our knowledge, this is the first study examining the characteristics of patients of all age groups and severities that were admitted to Aotearoa New Zealand hospitals following falls at home over a prolonged period (11 years). This study will quantify the frequency of trauma presentations following FRIs by age, sex, ethnicity and district. Additionally, this study aims to assess associations between injury severity and cause of fall, alcohol use, time of fall, length of hospital stays and cost. By characterising the incidence and clinical characteristics of FRIs at home resulting in hospital inpatient treatment in the TMT region, this study aims to identify areas for targeted intervention and further research.

Methods

Study design

A retrospective analysis of trauma data from the TMTTR was performed to identify patients of all ages that were admitted to TMT hospitals following falls at home during the 11-year period from 1 January 2012 to 31 December 2022. The TMT region is formed by five health districts (Bay of Plenty, Lakes, Tairāwhiti, Taranaki and Waikato) with a combined population of approximately 1 million people. To qualify for inclusion in the trauma registry, patients must have been admitted to an inpatient TMT bed within 7 days of injury, or died in hospital after injury. The registry exclusion criteria was as follows: patients seen and discharged from the emergency department; injuries directly attributable to documented pathological processes (osteoporosis, metastatic

disease, etc.) or pre-existing medical conditions (Parkinson's, etc.); peri-prosthetic fractures; exertional injuries; hanging, drowning or foreign bodies without anatomical injury; poisoning. Cases of falls in which the patient died at the scene were not captured in this study. Data entry into the TMTTR occurs prospectively during each admission. Data-points are coded by Abbreviated Injury Scale (AIS) Scores and ICD-10-AM, and all data underwent extensive quality checking before entry into the TMTTR.^{23,24} Analysis for the study was done as part of a routine health audit; therefore, ethics approval was deemed unnecessary. This study was registered with Waikato Hospital Ethics: RD023047.

Data collection and analysis

The variables of interest were extracted from the TMTTR: age, sex, ethnicity (as listed under the patients National Health Index number), ICD place of injury code, ISS, inpatient costs. The ICD place of injury code "home" was used to identify falls that had occurred in a home environment ("home" includes driveway to home, garage, garden to home, yard to home and swimming pool in private house/garden). Duplicate entries (e.g., cross-hospital transfers of the same patient on the same admission) were identified and removed. Individual registry entries were audited in to confirm record accuracy. AIS scores are used by the registry to quantify injury patterns and severity by ranking injuries in each anatomical region from 1 (minor) and 6 (non-survivable).²⁵ The AIS is then used to assign each patient an Injury Severity Score (ISS), allowing cases to be stratified into major trauma (ISS >12) and non-major trauma (ISS <13). Population estimates were taken from the Statistics New Zealand demographic database.²⁶

Statistical analysis was conducted using RStudio Version 3.6.1.²⁷ Records with missing data were excluded from the analysis. Data are presented as count with percentage or mean with standard deviation (SD). Chi-squared tests were used to assess associations between injury severity and age, sex, ethnicity, district, height of fall and positive blood alcohol level (BAL). A p-value of <0.05 was considered significant.

Results

Searches identified 13,142 events related to falls at home. This includes both intentional and unintentional FRIs. This represented nearly 51.5% of the total falls-related trauma events recorded in

Table 1: Demographics of patients admitted to Te Manawa Taki hospitals following fall-related injuries that occurred at home between 2012 and 2022.

	Major n (%)	Non-major n (%)	Total n (%)	Statistical test (major vs non-major)
Total	704 (5.4)	12,437 (94.6)	13,142 (100)	
Gender				
Female	289 (3.9)	7,183 (96.1)	7,472 (100)	$\chi^2 = 75.11, p < 0.001$
Male	415 (7.3)	5,254 (92.7)	5,669 (100)	RR=0.53 (CI: 0.46–0.61)
Ethnicity				
Māori	110 (3.7)	2,829 (96.3)	2,939 (100)	$\chi^2 = 19.17, p < 0.001$
non-Māori	594 (5.8)	9,594 (94.2)	10,188 (100)	RR=0.64 (CI: 0.53–0.78)
Te Whatu Ora – Health New Zealand District				
Waikato	366 (6.7)	5,107 (93.3)	5,473 (100)	$\chi^2 = 26.83, p < 0.001$
Bay of Plenty	234 (5.8)	3,795 (94.2)	4,029 (100)	
Lakes	57 (3.6)	1,526 (96.4)	1,583 (100)	
Taranaki	82 (5.2)	1,497 (94.8)	1,579 (100)	
Tairāwhiti	34 (4.2)	772 (95.8)	806 (100)	

the registry during the study period. Of the 13,142 events, 12,437 (94.4%) events were classified as non-major trauma events.

Across all age bands, 56.9% (n=7,472) of falls involved females, and 43.1% involved males (Table 1). There were statistically significant relationships between gender, ethnicity and district, and having a major or non-major admitted trauma. Nearly 42% of all injuries occurred in the Waikato district and the majority of them fell while engaged in other activity. Among ≤ 9 years olds, 46.7% were female and 53.3% were male. However, from aged 40 years onward the proportion of falls at home among females increases and remains significantly higher (63.0%) than the proportion of males (37.0%) ($p < 0.001$). However, across all age bands, males accounted for 58.9% of all major trauma (ISS >12) due to falls at home. Overall, females were around half as likely to present as major trauma (Risk Ratio [RR] = 0.53, CI: 0.46–0.61) in comparison to males.

There are two distinct age peaks among trauma events due to falls at home: children aged ≤ 9 years,

and a wide peak among adults aged 60 years and over (Figure 1). Falls at home resulting in major trauma (ISS >12) are strongly skewed towards older age groups, with a peak in the aged over 60. Among children aged ≤ 9 years, 98.8% (2,479) of falls at home were non-major trauma (ISS <13) events (2012–2022).

Across all ages, Māori accounted for 22.3% (n=2,939) of trauma events due to falls at home; however, this was highly skewed towards the ≤ 9 years. In the ≤ 9 years, Māori represented 42.9% of falls at home trauma. Above the aged 60 years, non-Māori represented 91.5% of falls at home trauma.

During the study period, the annual incidence of falls at home increased steadily from a minimum of 902 events in 2012 to a maximum of 1,456 events in 2022. A breakdown of events over time is demonstrated in Table 2. A minority (n=704, 5.4%) of events due to falls at home have been major trauma (ISS >12), with 94.6% (n=12,437) of cases classed as non-major trauma (ISS <13).

As shown by the heat map in Figure 2, falls

at home were most common on weekends, particularly in the 15–64 age group. The older age groups (65+) had less variation by day of week than younger age groups. Falls at home were most common during the day (8 am–4 pm) and

least common in the early morning (midnight–4 am). In the ≤14 age group, admissions typically occurred between 4 pm to 8 pm. Within the 15–64 age group, the admissions were commonly on Saturday night between 7 pm to midnight.

Figure 1: Trauma events due to falls at home by age group, gender and severity (2012–2022, n=13,142).

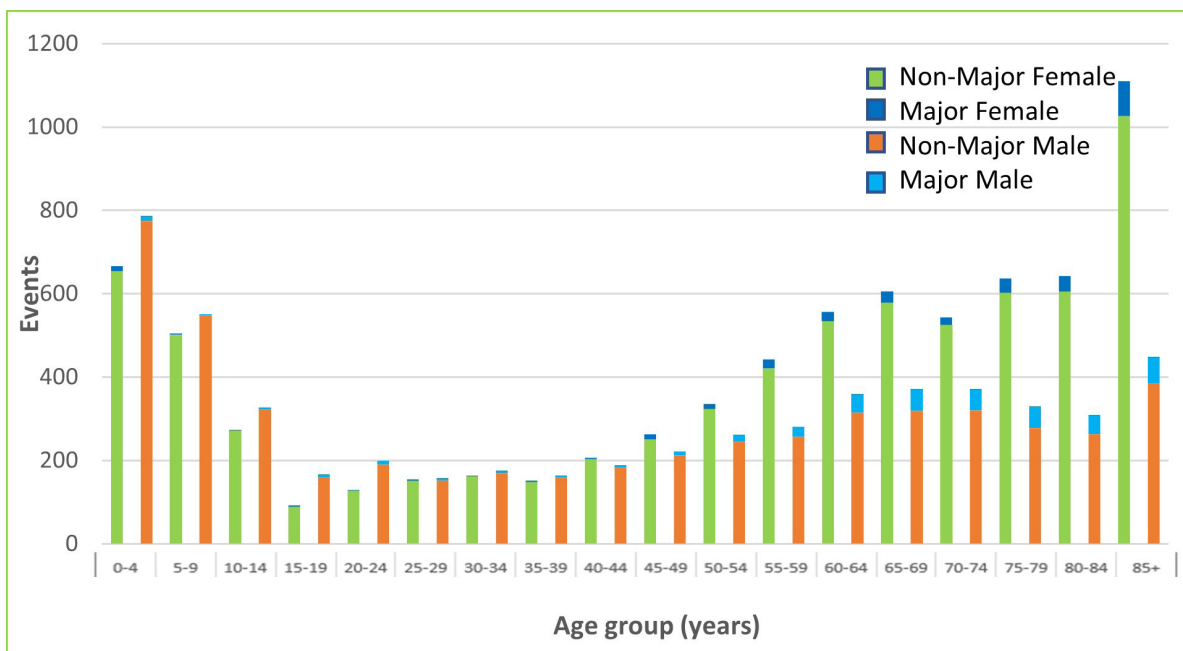


Table 2: Annual trauma events due to falls at home by severity (2012–2022, n=13,142).

Year	Number of events (n=13,142)		
	Major trauma	Non-major trauma	Total
2012	32	870	902
2013	38	963	1,001
2014	45	1,042	1,087
2015	40	1,094	1,134
2016	59	1,198	1,257
2017	47	1,068	1,115
2018	62	1,090	1,152
2019	61	1,161	1,222
2020	84	1,296	1,380
2021	101	1,334	1,435
2022	135	1,321	1,456

The three most common causes of falls at home were as follows: fall on same level from slipping, tripping, and stumbling (W01) (n=4,547, 34.6%); fall on and from stairs and steps (W10) (n=1,683, 12.8%); other fall on same level (W18) (n=1,383, 10.5%). A detailed breakdown of all fall causes is shown in Table 3.

There were 13,011 events where the height of fall was known. Falls from <1m were the most common, accounting for 9,621 (73.9%) events. Falls from 1–5m were present in 3,296 events (25.3%), and falls from >5m were the most uncommon (n=94, 0.7%). Across all age groups, falls from <1m remained the most common height of fall. The number of fall events for each height of fall split by age and subsequent injury severity is shown in Table 4. There was a significant association between height of fall and injury severity ($\chi^2=219.6$, $p<0.001$). The proportion of major trauma events compared to non-major trauma appeared to increase with height of fall.

There was a large variation in the incidence of injuries to the ISS coded body regions. In falls at home the most commonly injured region was the face (n=8,814). The number of events involving other body regions were as follows: external

(n=3,735); head and neck (n=2,157); abdominal and pelvic contents (n=1,026); extremities and pelvic girdle (n=509); chest (n=426).

There was a total of 152 deaths in hospital following fall at home events, including all “medical” deaths primarily due to medical causes rather than the injuries sustained. When medical deaths were excluded, this figure was reduced to 97 deaths. Of these, 58 deaths were due to central nervous system failure, 17 due to multi organ failure, 11 due to other, 7 due to hemorrhage and 4 were unknown. The global case fatality rate (CFR) for all FRI events was 0.74% (n=97 [died] vs n=13,045 [survived]). Older adults (65+ years) had the highest CFR of 1.57% (n=83 [died] vs 5,283 [survived]), with 15–64 year olds shown to have a CFR of 0.3% (n=14 [died] vs 4,654 [survived]); no children (<14 years) died following fall at home events. Major trauma events had a CFR of 9.93% (n=57 [died] vs n=574 [survived]) compared to a CFR of 0.32% (n=40 [died] vs n=12,471 [survived]) in non-major trauma.

The mean length of stay (LOS) per event was 5.5 (SD 6.9) days. Admissions were typically longer in major trauma events, with an average LOS of 8.7 (SD 8.7) days compared to 5.3 (SD 6.8)

Figure 2: A heat map demonstrating the number of events for each time across the week, split by age group.

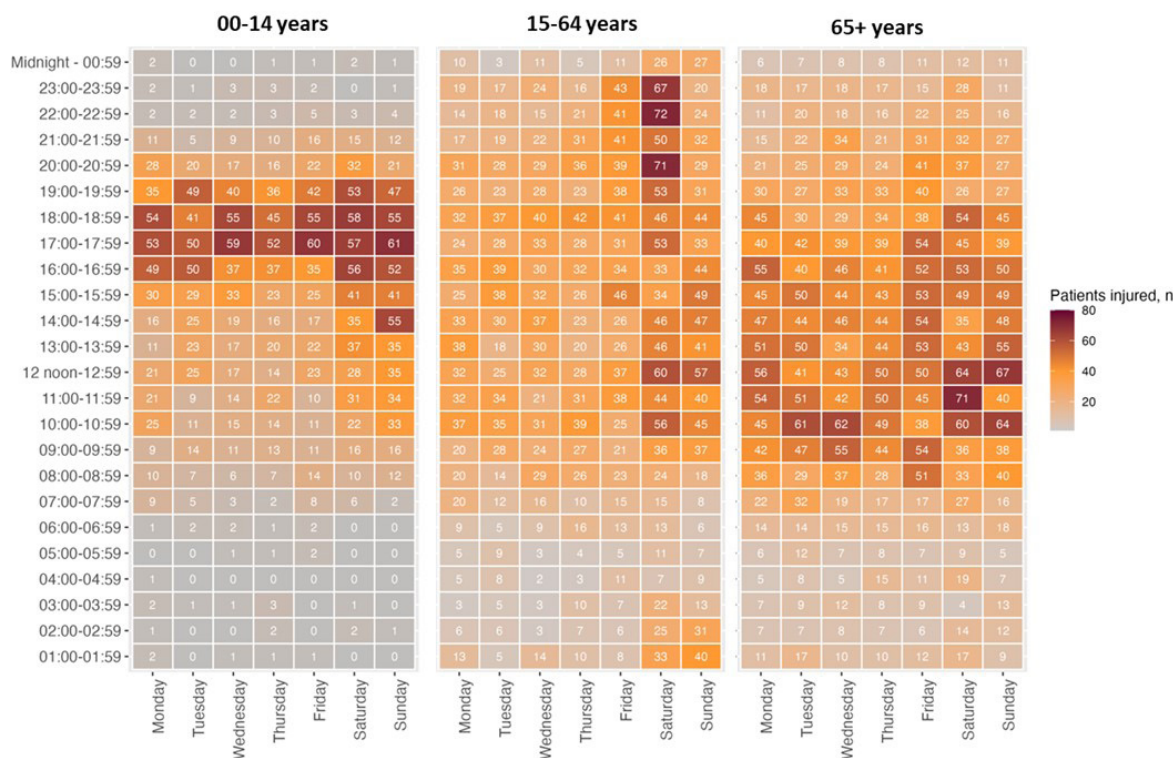


Table 3: The number of events by the Cause of Injury (total n=13,142).

Cause of Injury	n=13,142 n (%)
W01: Fall on same level from slipping, tripping and stumbling	4,547 (34.6)
W10: Fall on and from stairs and steps	1,683 (12.8)
W18: Other fall on same level	1,383 (10.5)
W13: Fall from, out of or through building or structure	930 (7.1)
W09: Fall involving playground equipment	821 (6.2)
W11: Fall on and from ladder	778 (5.9)
W06: Fall involving bed	451 (3.4)
W07: Fall involving chair	445 (3.4)
W19: Unspecified fall	439 (3.3)
W17: Other fall from one level to another	351 (2.7)
W02: Fall involving ice-skates, skis, roller-skates or skateboards	296 (2.3)
W14: Fall from tree	282 (2.1)
W08: Fall involving other furniture	281 (2.1)
W04: Fall while being carried or supported by other persons	147 (1.1)
W15: Fall from cliff	90 (0.7)
W03: Other fall on same level due to collision with, or pushing by, another person	72 (0.5)
W12: Fall on and from scaffolding	50 (0.4)
W05: Fall involving wheelchair	39 (0.3)
W16: Diving or jumping into water causing injury other than drowning or submersion	38 (0.3)
W00: Fall on same level involving ice and snow	19 (0.1)

days for non-major events. Average LOS appeared to increase with age categories from 1.8 (SD 1.9) days in the ≤14 year age group to 5.2 (SD 6.2) days for 14–64 year olds, and 7.8 (SD 8.3) days in the 65+ year age group.

During 2022, trauma events due to falls at home cost approximately NZ\$24.3 million directly to TMT facilities. Over the study period, the average cost across all events was NZ\$9,792 per event. Costs appeared to increase with both age and severity. Patients over 65 years incurred the greatest cost per event with an average of

NZ\$11,834, compared to NZ\$10,681 for the 15–64 year aged bracket and NZ\$4,930 for those up to age 14. The average cost for major trauma events (ISS >12) was NZ\$18,322, compared to an average of NZ\$9,362 for an event where the ISS was <13.

There were 260 patients whose BAL were recorded. BAL is only tested for in major trauma patients aged 16 and over that receive a trauma call on arrival (within 6 hours of first arrival). Of these 260 patients, 8.1% (n=21) had a positive BAL (EtOH/BAC 2mmol/L or more) on admission. A positive BAL was significantly ($\chi^2=8.40$, $p=0.0037$)

Table 4: The number of major and non-major events split by height of fall and age group.

Height of Fall	All age groups			≤14 age group			15–64 age group			65+ age group		
	Major	Non-major	Total	Major	Non-major	Total	Major	Non-major	Total	Major	Non-major	Total
Fall <1m	314	9,253	9,621	15	1,883	1,898	65	3,231	3,296	234	4,139	4,427
Fall 1–5m	289	3,007	3,296	19	1,120	1,139	128	1,141	1,269	142	746	888
Fall >5m	20	74	94	1	21	22	9	38	47	10	15	25
Total	623	12,334	13,011	35	3,024	3,059	202	4,410	4,612	386	4,900	5,340

more common in 15–64 year olds, with positive findings in 13.9% (n=15) of events compared to a rate of 3.9% (n=6) in the 65+ age group.

Discussion

This is the first study to report the descriptive epidemiology of patients admitted to hospital with a fall-related injury occurring at home, across all ages and all injury severities within a health region in Aotearoa New Zealand. Considering the significant biopsychosocial and economic impacts of FRIs, identifying at-risk populations and risk factors for at-home falls allows for better targeting of injury prevention strategies.

The study includes 13,142 events related to falls at home, with only 5.4% meeting severity criteria for major trauma (n=704) and 94.6% (n=12,437) classified as non-major trauma. There were statistically significant relationships between gender, ethnicity and district, and ISS. As expected, fall height was significantly associated with severity of injury (p<0.001), with falls from >5m proportionately more likely to present as major trauma.

The two most common causes of falls (slipping and tripping, and falls involving steps) accounted for 47.4% of all falls at home. This aligns with previous work suggesting structural hazards for falls are common in Aotearoa New Zealand homes.²⁸ Stairs without handrails were shown to be present in 54% of homes, which was identified as a specific risk factor for falls at home. Interventions specifically targeting structural hazards within the home may therefore have a marked impact on the volume of FRI events given the disproportionate ratio of events due to these causes.

The gender analysis shows that across all age

bands, 56.9% (7,472) of falls at home trauma events involved females and were around half as likely to present as major trauma (RR=0.53, CI: 0.46–0.61) in comparison to males. From aged 40 years onward, the proportion of falls at home among females increases and remains significantly higher (63.0%) than the proportion of males (37.0%) (p<0.001). However, across all age bands, males accounted for 58.9% of all major trauma (ISS >12). Either this may possibly reflect a greater proportion of females surviving into older age, or differences in time spent at home between genders, as well as other factors.

The age group analysis of the study shows two distinct age peaks among trauma events due to falls at home, children aged ≤9 years, and a wide peak among adults aged 60 years and over. Of these admissions, there was a peak of major trauma in 60+ year age group. As a result, older adults are more likely to have worse outcomes than in younger aged groups.^{29,30} Among children aged ≤9 years, 98.8% (2,479) of falls were non-major trauma (ISS <13) events.

Analysis of trauma events by ethnicity showed that though Māori accounted for 22.3% (n=2,939) of falls, this was highly skewed towards the ≤9 years (42.9%). This result is consistent with the literature, which identified the Māori population as being at greater risk of injuries at home, with disproportionate skew towards ≤9 years.³¹ Keall et al. specifically targeted this population in a randomised control trial, which evaluated the impact of low-cost home modifications, specifically designed to reduce the risk of falls in Māori households.^{32,33} They estimated an annual reduction in FRI events of 31% associated with the intervention. Although not specific to the age group we have identified here, the study demonstrates the potential

for successful targeted intervention to reduce the risk of FRIs in an at-risk population.

The results also show that falls at home were most common on weekends. This effect was most significant in the 15–64 age group, and may be attributed to working age adults spending greater periods of time at home during this time period. It may be beneficial to consider initiation of fall prevention initiatives at an earlier age than has generally been the case.

Interestingly, we identified a significant relationship ($p=0.0037$) between positive BAL and age group within the major trauma subgroup. Positive BAL in major trauma were shown to be significantly more common in those aged 15–64 years. This would be in keeping with previous evidence (originating from Aotearoa New Zealand and Australia) to suggest alcohol consumption increases both the likelihood and severity of injuries in the home setting, especially in younger, working age adults.^{15,34,35} Considering that alcohol-related presentations to the emergency department predominantly occur at weekends,³⁶ this appears to be consistent with the weekend admission relationship for working age adults. Consequently, alcohol specific interventions may be useful to reduce FRIs in the 15–64 age group. In contrast to the 15–64 years age group, there is no evidence to show an association between alcohol consumption and falls in the older age group (≥ 65 years). Given that BAL was only collected in major trauma events, our assessment of the relationship between alcohol consumption and FRIs is limited. However, future studies may provide in-depth analysis of the relationship between alcohol consumption and FRIs of all severities, and the

nature of the association between alcohol and falls in older age groups.

The study is unique in that it utilises a continuously collected dataset that represents hospitalised patients of all ages and injury severity within an Aotearoa New Zealand health region, including estimates of hospital cost. The TMT region is also representative of Aotearoa New Zealand as a whole in terms of demography.^{20–22} This study does not represent a population sample of all FRI that occurred at home because it does not include non-admitted persons, nor pre-hospital deaths from injuries. Notwithstanding these limitations, this study provides an up-to-date overview of patients admitted following FRI at home that can now be used for targeted interventions and health service planning.

Conclusion

Males and older age groups predominate in falls at home, resulting in significant cost and public health burden. Most events were classified as non-major (ISS <13) trauma. However, the significant relationships between gender, ethnicity and district and injury severity may suggest that some groups are more at risk of major trauma events. While the ≤ 9 years of Māori presenting with FRIs is much higher than the other age groups, additional research is required to better understand the causative reasons. Further work should also extend to in-depth analysis of the causation of FRIs occurring at home within the at-risk groups to help reduce this significant and potentially preventable burden on the health system, patients and the community.

COMPETING INTERESTS

The authors declare no competing interests.

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