

## Original research

# Epidemiology of work-related fall injuries resulting in hospitalisation: individual and work risk factors and severity

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► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/oemed-2023-109079>).

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Received 2 July 2023

Accepted 1 November 2023

## ABSTRACT

**Objectives** Injuries at work are common and costly for individuals and employers. A common mechanism of workplace injury is through falls, but there have been few epidemiological studies of risk factors. This study aimed to identify patient, work and injury factors associated with injuries causing hospitalisation after falling at work in Victoria, Australia.

**Methods** Data came from work-related hospitalised injury admissions, identified by International Classification of Diseases and Related Health Problems, Tenth Revision Australian Modification codes and compensation status, from Victorian Admitted Episodes Dataset between 1 July 2017 and 30 June 2022. Multivariate logistic regression analyses were conducted to identify factors associated with same-level falls and falls from height.

**Results** This study included 42 176 work-related injury admissions: 8669 (20.6%) fall injuries and 33 507 (79.4%) other injuries. Rates of high falls were more common in males than females (0.44 (95% CI: 0.43, 0.46) vs 0.08 (0.08, 0.09) admissions per 1000 employed), while same-level falls were more common in females than males (0.21 (0.20, 0.22) vs 0.18 (0.17, 0.18)). Patients with same-level fall injuries, relative to all other work injuries, were more likely to be older women, and have at least one chronic condition; falls from height were associated with male sex and construction work and more likely to result in intracranial, internal organ injuries and fractures and longer hospital stay than non-fall injuries.

**Conclusion** Work-related falls were common and relatively severe. Same-level falls are relatively likely to occur in older women, the fastest-growing workplace demographic, and therefore the incidence is expected to increase. Comorbidities are an important fall risk factor. Employers could consider industry-relevant high and same-level fall prevention strategies for reducing the workplace injury burden.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Approximately 20% of workplace injuries occur as a result of falling, yet there have been little or no studies on the risk factors for workplace falls using hospitalisation data.

## WHAT THIS STUDY ADDS

⇒ This study of hospital admission records in Victoria, Australia shows that male workers have the highest rates of injuries caused by falls from height, whereas female workers, in particular older women, have the highest rates of injuries caused by same-level falls. Comparing fall injuries with other workplace injuries, older women and those with comorbidities, such as neurological conditions, are at increased risk of same-level falls; males and those working in construction are at increased risk of falls from height. Injuries caused by falls from height are associated with serious injury and longer stay in hospital than workplace injuries caused by other mechanisms.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Workplace injuries caused by falling, in particular, same-level falls, are likely to become more frequent as more older women work until retirement. Prevention strategies should be tailored to the prevention of falls from height versus same-level falls; the latter may need to involve identifying workers with comorbidities. Employers may need to place more emphasis on preventing workplace falls to reduce workplace injuries.



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**To cite:** Wah W, Berecki-Gisolf J, Walker-Bone K. *Occup Environ Med* Epub ahead of print: [please include Day Month Year]. doi:10.1136/oemed-2023-109079

## INTRODUCTION

Injuries that occur in the workplace are common and preventable. An estimated 1.53 million deaths and 76.1 million disability-adjusted life years were lost due to occupational factors in 2016 globally.<sup>1</sup> Of those, approximately 22% of deaths and 28% of DALYs were related to workplace injury.<sup>1</sup> In Australia in 2021/2022, there were an estimated 497 300 work-related injuries or illnesses affecting 3.5% of all people who worked at some time during

the 12 months.<sup>2</sup> In total, 106 000 work-related injuries were caused by falls, amounting to one in five of all work-related injuries.<sup>2</sup> While injuries arising from manual handling have received considerable attention in workplace health and safety research, policy and practice, similar rigour in workplace fall prevention is currently lacking.

Fall injuries are more common among older people (≥65 years), with an estimated 27% probability of falling in any given year.<sup>3</sup> Similarly, work-related fall injuries have been shown to increase steeply with age, particularly among women.<sup>4</sup> In women, fall injury rates in the 55–64 age group were reported to be three times higher than in the

15–24 age group.<sup>4</sup> Older women are, therefore, particularly at risk of falls, while this demographic is the fastest-growing in the Australian workforce.<sup>5,6</sup>

According to studies of hospital-treated fall injuries, comorbidities were common.<sup>7,8</sup> The Australian workforce is ageing such that workers aged 50–64 years accounted for 11% of employed persons in the mid-90s, increasing to 21% in 2023.<sup>6</sup> Ageing is associated with a higher prevalence of comorbidities together with an increase in the prevalence of risk factors for chronic disease, for example, obesity. It is expected there will be more comorbidities among workers which may increase the likelihood of workplace falls.

Given this, more research into falls in the workplace and risk factors for falls is needed to inform workplace fall prevention. Most quantitative studies of workplace injury analysed workers' compensation claims data, which are recognised to result in underestimated rates as not all workers report work-related injuries.<sup>9</sup> Therefore, a secondary analysis of administrative hospital admission records in Victoria, Australia was undertaken, with the following aims: (1) present rates and patient profile of work-related injuries resulting in hospital admission; (2) compare the characteristics of people with fall versus non-fall injuries in terms of the patient profile, comorbidities and injury severity.

## METHODS

### Data

Hospital admission records were extracted from the Victorian Admitted Episodes Dataset (VAED), sourced from the Victorian Department of Health. The VAED captures hospital-admitted episodes from all public and private hospitals in Victoria, including rehabilitation, extended care and day procedure centres.<sup>10</sup> Labour force data for calculating population-based rates per employed people in Victoria were sourced from the Australian Bureau of Statistics.<sup>6</sup>

Hospital admission records with an admission date between 1 July 2017 and 30 June 2022 were extracted. Transfers and statistical admissions, which are admission records resulting from the commencement of a new episode of care within one hospital stay, were excluded to prevent overcounting. Work-related admissions were selected if the International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) codes U73.00–U73.09 (activity while working for income) or Y96 (work-related condition) occurred anywhere in the 40 diagnosis data fields.<sup>10</sup> Admissions with workers' compensation recorded in the separation account data field were also selected as work-related admissions. The sample included admissions of patients aged ≥15 years and injury admissions only. These injuries were selected as admissions with a principal diagnosis in the range of S00–T14 (excluding foreign body, burns, frostbite, poisoning, unspecified injury, sequelae and complications of care).

This study included the following variables: fall versus non-fall cause of injury, 'falls from height' and 'same-level falls' (subsets of falls), age, sex, chronic conditions, time and place of injury occurrence, types of work, injury types, body locations, severity (International Injury Classification of Disease Injury Severity Score (ICISS))<sup>11</sup> and hospital stay. Fall types, place of injury occurrence and types of work were classified using ICD-10-AM codes. Chronic conditions were identified primarily using ICD-10-AM supplementary codes besides diagnosis codes. Details of definitions and classifications of these variables are presented in online supplemental appendices 1 and 2.

## Statistical modelling

Statistical analyses were carried out using SAS V9.4. Work-related injury rates were calculated as the number of admissions per 1000 employed persons (part-time and full-time) in Victoria over the study period (1 July 2017–30 June 2022). Descriptive statistics of work-related injury admissions due to falls, falls from height, same-level falls and all-cause are presented in [tables 1 and 2](#); differences between each of the fall types on other workplace injuries were tested using  $\chi^2$  tests. The association between various factors and fall-from-height injury admissions (vs all other work-related injury admissions) was modelled in four consecutive logistic regression models. The same analysis was repeated for same-level fall injury admissions versus all other work-related injury admissions. In each of these analyses, the first three models provide results on the patient profile and situational factors associated with specific fall injury admissions. The fourth model shows the severity of specific fall injury admissions.

1. Sociodemographics model: age group and sex (composite variable), chronic disease.
2. Time and place: weekday/weekend, season, place of occurrence.
3. Work-related factors: type of work, workers' compensation status of admissions.
4. Injury profile and severity: injury type, bodily location, severity, length of stay (LOS).

All models were adjusted for age and sex (composite variable).

## RESULTS

There were 45 539 hospital admissions for work-related injuries in Victoria in the 5-year period (2017/2018–2021/2022). After excluding 3363 (7.3%), which were statistical separations and transfers, the remaining 42 176 incident admissions were analysed. Of these, 24 569 (58.3%) were recorded as workers' compensation accounts, and 34 946 (82.9%) had ICD-10-AM activity codes indicating *working for income* at the time of injury. There was substantial overlap with 17 339 cases (41%) flagged as workers' compensations and *working for income* codes. The average annual rate of work-related injury admissions was 2.54 per 1000 employed persons: 3.91 for males and 0.98 for females.

There were 8669 (20.6%) fall-related injuries among the 42 176 work-related injury admissions. The most common type of falls was 'same-level'/low falls (36.2%), with most of the remaining fall types classified as non-same-level/high falls: the latter consisted ladder/scaffolds (21.2%), stairs/steps (8.6%), building/structure (8.5%) and different level-other (13.4%). Other specified and unspecified falls represented 1.6% and 10.5%, respectively.

The average annual rate of work-related fall injury admissions was 0.52 (95% CI=0.51 to 0.53) per 1000 employed persons: 0.68 (0.66 to 0.70) for males and 0.34 (0.33 to 0.36) for females. Fall rates by age and sex are shown in [figure 1A](#); from ages 35–39 to 65+ years, fall rates increased with increasing age in both sexes. Fall rates were higher in males among all age groups, but in the oldest age groups, a diminishing male/female rate difference was observed. Rates of high falls and rates of same-level falls are shown in [figure 1B,C](#), respectively. While high fall rates were higher in males than females (0.44 (95% CI=0.43 to 0.46) vs 0.08 (0.08 to 0.09) per 1000 workers, respectively), same-level falls were higher in females than males (0.21 (0.20 to 0.22) vs 0.18 (0.17 to 0.18)). Same-level fall rates were relatively low in the youngest age groups and showed a steep increase with age, with the highest rates observed in the oldest female age groups.

**Table 1** Sociodemographic characteristics, comorbidities and injury occurrence settings of work-related fall injuries compared to other work-related injuries

|                                              | Fall injuries                | High falls                   | Same-level falls            | Other injuries | Total          |
|----------------------------------------------|------------------------------|------------------------------|-----------------------------|----------------|----------------|
|                                              | 8669 (20.6%)                 | 4544 (10.8%)                 | 3179 (7.5%)                 | 33 507 (79.4%) | 42 176 (100%)  |
| Sociodemographic and chronic disease profile |                              |                              |                             |                |                |
| Age and sex                                  |                              |                              |                             |                |                |
| Male, 15–24 years                            | 797 (9.2%)‡                  | 588 (12.9%)‡                 | 159 (5.0%)‡                 | 5726 (17.1%)   | 6523 (15.5%)   |
| Male, 25–44 years                            | 2198 (25.4%)                 | 1533 (33.7%)                 | 496 (15.6%)                 | 13 205 (39.4%) | 15 403 (36.5%) |
| Male, 45–64 years                            | 2423 (28.0%)                 | 1503 (33.1%)                 | 682 (21.5%)                 | 8517 (25.4%)   | 10 940 (25.9%) |
| Male, 65+ yrs                                | 578 (6.7%)                   | 278 (6.1%)                   | 221 (7.0%)                  | 1094 (3.3%)    | 1672 (4.0%)    |
| Female, 15–24 years                          | 193 (2.2%)                   | 60 (1.3%)                    | 102 (3.2%)                  | 1020 (3.0%)    | 1213 (2.9%)    |
| Female, 25–44 years                          | 623 (7.2%)                   | 206 (4.5%)                   | 333 (10.5%)                 | 2135 (6.4%)    | 2758 (6.5%)    |
| Female, 45–64 years                          | 1509 (17.4%)                 | 317 (7.0%)                   | 948 (29.8%)                 | 1650 (4.9%)    | 3159 (7.5%)    |
| Female, 65+ yrs                              | 348 (4.0%)                   | 59 (1.3%)                    | 238 (7.5%)                  | 160 (0.4%)     | 508 (1.2%)     |
| Chronic conditions                           |                              |                              |                             |                |                |
| 0                                            | 6043 (69.7%)‡                | 3395 (74.7%)‡                | 2012 (63.3%)‡               | 27 264 (81.4%) | 33 307 (79.0%) |
| 1                                            | 1867 (21.5%)                 | 880 (19.4%)                  | 790 (24.9%)                 | 4997 (14.9%)   | 6864 (16.3%)   |
| 2                                            | 594 (6.9%)                   | 220 (4.8%)                   | 296 (9.3%)                  | 1023 (3.1%)    | 1617 (3.8%)    |
| 3+                                           | 165 (1.9%)                   | 49 (1.1%)                    | 81 (2.6%)                   | 223 (0.7%)     | 388 (0.9%)     |
| Conditions groupings                         |                              |                              |                             |                |                |
| Endocrine                                    | 346 (4.0%)‡                  | 148 (3.3%)†                  | 149 (4.7%)‡                 | 830 (2.5%)     | 1176 (2.8%)    |
| Mental behavioural                           | 579 (3.7%)‡                  | 279 (6.1%)‡                  | 237 (7.5%)‡                 | 1250 (6.7%)    | 1829 (4.3%)    |
| Neurological                                 | 120 (1.4%)‡                  | 44 (1.0%) <sup>n.s.</sup>    | 48 (1.5%)‡                  | 207 (0.6%)     | 327 (0.8%)     |
| Circulatory                                  | 1373 (15.8%)‡                | 587 (12.9%)‡                 | 621 (19.5%)‡                | 2674 (8.0%)    | 4110 (9.7%)    |
| Respiratory                                  | 541 (6.2%)†                  | 212 (4.7%)‡                  | 257 (8.1%)‡                 | 1874 (5.6%)    | 2413 (5.7%)    |
| Musculoskeletal                              | 548 (1.6%)‡                  | 130 (2.9%)‡                  | 233 (7.3%)‡                 | 420 (4.8%)     | 968 (2.3%)     |
| Time, place and setting                      |                              |                              |                             |                |                |
| Day of the week                              |                              |                              |                             |                |                |
| Weekday                                      | 7340 (84.7%) <sup>n.s.</sup> | 3904 (85.9%)‡                | 2623 (82.5%)‡               | 28 270 (84.4%) | 35 610 (84.4%) |
| Weekend                                      | 1329 (15.3%)                 | 640 (14.1%)                  | 556 (17.5%)                 | 5237 (15.6%)   | 6566 (15.6%)   |
| Season                                       |                              |                              |                             |                |                |
| Summer                                       | 2047 (23.6%) <sup>n.s.</sup> | 1061 (23.4%) <sup>n.s.</sup> | 747 (23.5%) <sup>n.s.</sup> | 7936 (23.7%)   | 9983 (23.7%)   |
| Autumn                                       | 2215 (25.6%)                 | 1147 (25.2%)                 | 829 (26.1%)                 | 8766 (26.2%)   | 10 981 (26.0%) |
| Winter                                       | 2237 (25.8%)                 | 1186 (26.1%)                 | 813 (25.6%)                 | 8290 (24.7%)   | 10 527 (25.0%) |
| Spring                                       | 2170 (25.0%)                 | 1150 (25.3%)                 | 790 (24.9%)                 | 8515 (25.4%)   | 10 685 (25.3%) |
| Place of occurrence                          |                              |                              |                             |                |                |
| Home                                         | 429 (5.0%)‡                  | 266 (5.9%)‡                  | 128 (4.0%)‡                 | 592 (1.8%)     | 1021 (2.4%)    |
| Residential institution                      | 99 (1.1%)                    | 9 (0.2%)                     | 81 (2.6%)                   | 194 (0.6%)     | 293 (0.7%)     |
| School, other*                               | 611 (7.1%)                   | 138 (3.0%)                   | 396 (12.5%)                 | 733 (2.2%)     | 1344 (3.2%)    |
| Sports and athletic area                     | 82 (1.0%)                    | 23 (0.5%)                    | 46 (1.5%)                   | 420 (1.3%)     | 502 (1.2%)     |
| Road, street and highway                     | 189 (2.2%)                   | 51 (1.1%)                    | 119 (3.7%)                  | 1995 (6.0%)    | 2184 (5.2%)    |
| Trade and service area                       | 985 (11.4%)                  | 393 (8.7%)                   | 507 (16.0%)                 | 3904 (11.7%)   | 4889 (11.6%)   |
| Industrial and construction area             | 1205 (13.9%)                 | 844 (18.6%)                  | 316 (9.9%)                  | 4557 (13.6%)   | 5762 (13.7%)   |
| Farm                                         | 190 (2.2%)                   | 95 (2.1%)                    | 87 (2.7%)                   | 1263 (3.8%)    | 1453 (3.5%)    |
| Other specified places of occurrence         | 439 (5.1%)                   | 192 (4.2%)                   | 201 (6.3%)                  | 1188 (3.6%)    | 1627 (3.9%)    |
| Unspecified place of occurrence              | 4440 (51.2%)                 | 2533 (55.7%)                 | 1298 (40.8%)                | 18 661 (55.7%) | 23 101 (54.8%) |
| Workers' compensation                        | 4661 (53.8%)‡                | 2340 (51.5%)‡                | 1766 (55.6%)‡               | 19 908 (59.4%) | 24 569 (58.3%) |

\*School, other institution and public administrative areas.

†chi-square test for (each) falls, high falls and same level falls, vs other work injury; results at  $p < 0.05$ .

‡chi-square test for (each) falls, high falls and same level falls, vs other work injury; results at  $p < 0.01$ .

n.s., not significant.

An overview of patient demographics, injury setting, injury types and severity of falls versus other injuries is provided in [tables 1 and 2](#). Most work-related falls occurred in the age range 25–64 years, and males accounted for 69% of falls. Women aged  $\geq 45$  years, however, accounted for 21% of falls (5.4% of non-fall injuries). There were demographic differences in the fall types, with males accounting for the majority of high falls and females, particularly older women, over-represented same-level

falls. In this study, 21% had at least one comorbidity recorded during their hospital stay (30% in fall-related injuries and 19% in other work-related injuries). All six major comorbidities were more common among same-level falls, particularly circulatory, respiratory and musculoskeletal.

There was no clear association between day, season or place of occurrence and fall, noting that place of occurrence was coded as unspecified in over half of the study sample admissions. Fall

**Table 2** Work types, injury characteristics and length-of-stay of work-related fall injuries compared to other work-related injuries

|                                                        | Fall injuries | High falls    | Same-level falls | Other injuries | Total          |
|--------------------------------------------------------|---------------|---------------|------------------|----------------|----------------|
| Type of work                                           |               |               |                  |                |                |
| Agriculture, forestry and fishing                      | 240 (2.8%)‡   | 131 (2.9%)‡   | 96 (3.0%)‡       | 1637 (4.9%)    | 1877 (4.5%)    |
| Mining                                                 | *             | *             | *                | *              | 53 (0.1%)      |
| Manufacturing                                          | 83 (1.0%)     | 31 (0.7%)     | 47 (1.5%)        | 925 (2.8%)     | 1008 (2.4%)    |
| Construction                                           | 1338 (15.4%)  | 1100 (24.2%)  | 196 (6.2%)       | 4289 (12.8%)   | 5627 (13.3%)   |
| Wholesale and retail trade                             | 156 (1.8%)    | 46 (1.0%)     | 99 (3.1%)        | 528 (1.6%)     | 684 (1.6%)     |
| Transport and storage                                  | 276 (3.2%)    | 184 (4.1%)    | 77 (2.4%)        | 1001 (3.0%)    | 1277 (3.0%)    |
| Government administration and defence                  | *             | *             | *                | *              | 140 (0.3%)     |
| Health services                                        | 349 (4.0%)    | 55 (1.2%)     | 261 (8.2%)       | 690 (2.1%)     | 1039 (2.5%)    |
| Other specified work for income                        | 1657 (19.1%)  | 785 (17.3%)   | 731 (23.0%)      | 5193 (15.5%)   | 6850 (16.2%)   |
| While working for income, unspecified                  | 3403 (39.3%)  | 1687 (37.1%)  | 1254 (39.5%)     | 12 988 (38.8%) | 16 391 (38.9%) |
| Missing                                                | 1127 (13.0%)  | 514 (11.3%)   | 391 (12.3%)      | 6103 (18.2%)   | 7230 (17.1%)   |
| Injury profile                                         |               |               |                  |                |                |
| Injury type                                            |               |               |                  |                |                |
| Superficial injury                                     | 403 (4.7%)‡   | 237 (5.2%)‡   | 136 (4.3%)‡      | 1191 (3.6%)    | 1594 (3.8%)    |
| Open wound                                             | 691 (8.0%)    | 378 (8.3%)    | 264 (8.3%)       | 9986 (29.8%)   | 10 677 (25.3%) |
| Fracture                                               | 4562 (52.6%)  | 2417 (53.2%)  | 1627 (51.2%)     | 7500 (22.4%)   | 12 062 (28.6%) |
| Dislocation, sprain and strain of joints and ligaments | 651 (7.5%)    | 283 (6.2%)    | 264 (8.3%)       | 2343 (7.0%)    | 2994 (7.1%)    |
| Injuries of nerves & spinal cord                       | 66 (0.8%)     | 38 (0.8%)     | 26 (0.8%)        | 1040 (3.1%)    | 1106 (2.6%)    |
| Injuries of blood vessels                              | 40 (0.5%)     | 29 (0.6%)     | 9 (0.3%)         | 1025 (3.1%)    | 1065 (2.5%)    |
| Injuries of muscle and tendon                          | 389 (4.5%)    | 169 (3.7%)    | 145 (4.6%)       | 4579 (13.7%)   | 4968 (11.8%)   |
| Crushing injury/traumatic amputation/eye injury        | 23 (0.2%)     | 10 (0.2%)     | 13 (0.4%)        | 2224 (6.7%)    | 2250 (5.3%)    |
| Intracranial injury                                    | 517 (6.0%)    | 294 (6.5%)    | 177 (5.6%)       | 777 (2.3%)     | 1294 (3.1%)    |
| Injury to internal organs                              | 95 (1.1%)     | 80 (1.8%)     | 13 (0.4%)        | 150 (0.5%)     | 245 (0.6%)     |
| Other and unspecified injury                           | 1229 (14.2%)  | 609 (13.4%)   | 505 (15.9%)      | 2692 (8.0%)    | 3921 (9.3%)    |
| Bodily location                                        |               |               |                  |                |                |
| Injuries to the head/neck                              | 1563 (18.0%)‡ | 801 (17.6%)‡  | 609 (19.2%)‡     | 4090 (12.2%)   | 5653 (13.4%)   |
| Injuries to the trunk                                  | *             | *             | *                | *              | 4178 (9.9%)    |
| Injuries to the upper extremities                      | 2787 (32.2%)  | 1276 (28.1%)  | 1075 (33.8%)     | 21 550 (64.3%) | 24 337 (57.7%) |
| Injuries to the lower extremities                      | 2686 (30.1%)  | 1355 (29.8%)  | 1070 (33.7%)     | 5270 (15.7%)   | 7956 (18.9%)   |
| Unspecified/multiple body regions                      | *             | *             | *                | *              | 52 (0.1%)      |
| Serious injury (ICISS<0.941)                           | 298 (3.4%)‡   | 204 (4.5%)‡   | 72 (2.3%)‡       | 267 (0.8%)     | 565 (1.3%)     |
| Length of stay                                         |               |               |                  |                |                |
| Same day                                               | 3220 (37.1%)‡ | 1507 (33.2%)‡ | 1351 (42.5%)‡    | 17 662 (52.7%) | 20 882 (49.5%) |
| Overnight                                              | 2624 (30.3%)  | 1390 (30.6%)  | 914 (28.8%)      | 9997 (29.8%)   | 12 621 (29.9%) |
| Two days                                               | 1013 (11.7%)  | 590 (13.0%)   | 325 (10.2%)      | 2892 (8.6%)    | 3905 (9.3%)    |
| Three days or longer                                   | 1812 (20.9%)  | 1057 (23.3%)  | 589 (18.5%)      | 2956 (8.8%)    | 4768 (11.3%)   |

\*Frequency of 5 or less has been suppressed with an "\*\*\*\*\*". Other cells in the same row and/or column may be suppressed in order to maintain confidentiality.

‡chi-square test for (each) falls, high falls and same level falls, vs other work injury; results at  $p<0.05$ .

‡chi-square test for (each) falls, high falls and same level falls, vs other work injury; results at  $p<0.01$ .

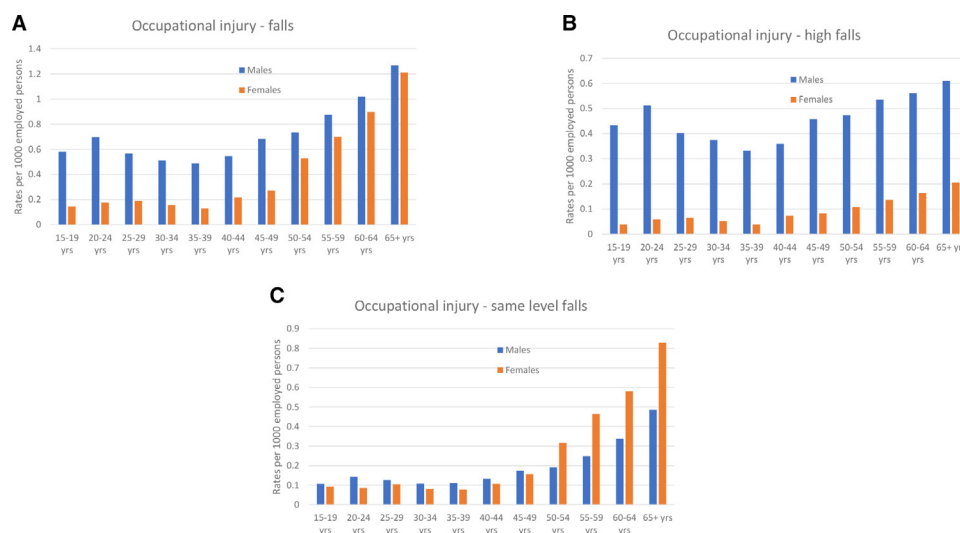
n.s., not significant.

injuries, especially falls from height, were more common among those working in *construction*, whereas other work-related injuries were more common among *agriculture, forestry, fishing and manufacturing*. However, 16% of the admissions overall had 'other specified' type of work, and 39% were unspecified. Fall injuries were less likely to have workers' compensation compared with other injuries. Regarding injury type, falls were predominantly fractures (53%), while other work-related injuries were more often open wounds (30%). Upper extremity injuries were more common in non-fall than fall injuries (64% vs 32%), whereas lower extremity injuries were more common in falls than non-fall injuries (30% vs 16%).

Fall injuries were more likely to be serious, according to the ICISS, compared with other work-related injuries; this was even more pronounced in high falls. Correspondingly, prolonged LOS was also more common in falls than other work-related injuries.

When selecting all work-related injuries ( $n=45\,539$ , including statistical separations and transfers), there were 31 272 hospital days due to falls and 69 795 hospital days due to other work-related injuries. In this tally, same-day admissions and overnight stays each count as 1 day. Work-related falls, therefore, accounted for 30.9% of work-related injury hospital days, whereas they accounted for 20.6% of work-related injury admissions.

Results of factors associated with high falls versus other work-related injuries are presented in online supplemental appendix 3. Model 1 (patient factors) shows that high falls were associated with males, particularly men  $\geq 45$  years. There was no pronounced relation between multiple comorbidities and high falls, but there was an increased risk associated with mental/behavioural conditions. Model 2 (time and place), adjusted for age and sex, shows high falls were associated with place of occurrence coded as home and trade and service area. Weekday versus



**Figure 1** Population-based rates of workplace injury in Victoria, 2017/2018–2021/2022 by age group and sex: (A) fall injury; (B) fall from height injury; (C) same-level fall injury. Results are shown as annual rates per 1000 employed persons averaged across the 5-year time period.

weekend and season were not notably associated with high falls. Model 3 (work-related factors) demonstrates a very strong association between high falls and working in construction and also associations between high falls and working in transport and storage, government administration and other specified/unspecified working for income. Workers' compensation was negatively associated with high falls. Model 4 (injury severity) is focused on injury type and severity. Compared with musculoskeletal injuries, fractures, superficial injuries, injury to internal organs and intracranial injuries were positively associated with high falls. Trunk injuries were positively, and upper extremity injuries, were negatively associated with high falls. Model 4 also shows high falls were more likely to be classified as *severe*, according to ICISS. LOS of fall admissions was likely to be longer. Online supplemental appendix 4 presents the results of same-level falls compared with all other work-related injuries. In model 1, older women had much higher odds of same-level falls (vs all other work injuries) than men aged 25–44 years. Chronic conditions were associated with same-level falls, in particular neurological conditions. Model 2 showed associations between places of occurrence recorded as residential institutions and also school/other (vs industrial and construction areas), and same-level falls. Model 3 did not show an increase in same-level falls in those working in construction (which was associated with *high falls*; (online supplemental appendix 3). Working in government administration and defence and working in wholesale and retail trade were associated with same-level falls. Model 4 demonstrated an association between fracture and intracranial injury and same-level falls. Low falls (vs other work-related injuries) did not appear to be associated with relatively severe injury, as determined from the ICISS and LOS.

## DISCUSSION

This analysis of admissions to hospitals necessitated by work-related injuries has shown that 21% of work-related injuries occur after a fall; 52% of these were high falls, while 37% were same-level falls. The remainder were other and unspecified fall types. While males had higher falls rates than females overall, these were more likely to be high falls, whereas females had higher rates of same-level falls. When comparing fall injuries relative to all work-related injuries, workers with high falls were more likely to be males and work in construction, whereas workers

with same-level falls were more likely to be older women and have at least one comorbidity. Falls from height (compared with other work injuries) were likely to result in severe injuries with longer LOS; this was not observed in same-level falls. Over 30% of hospital days due to work-related injuries in this study were due to falls overall.

Previous studies of work-related falls used compensation<sup>4 12 13</sup> and survey<sup>14</sup> data. Consequently, they provided limited evidence about individual risk factors for occupational injuries and falls. There has been a shortage of high-quality studies and inconsistent evidence of association.<sup>4 14–16</sup> However, risk factors previously identified include older age, female gender, hearing and vision impairment, neurotic illness, use of sedative medications, substance abuse, impaired functional strength, standing balance and visuospatial ability, and long-term health conditions such as epilepsy, diabetes, musculoskeletal disorders, obesity, urogenital problem, chronic bronchitis or emphysema.<sup>4 14–16</sup> Besides these risk factors, previous studies on falls in general (not limited to the workplace) reported additional risk factors, history of falls, depression, cognitive impairment, low education, poor sleep, hyperuricaemia and metabolic syndrome.<sup>3 17–23</sup> Thus, our findings add to a growing body of evidence suggesting that older working-aged women are at increased risk of same-level falls and fall-related injuries, particularly in the presence of comorbidity (whereas we observed a different risk profile for high falls, which were associated with males and which did not have a pronounced association with the number of comorbidities). Moreover, it appears that the types of comorbidities that increase the risk of work-related same-level falls are similar to those in community-dwelling older adults, particularly neurological conditions.<sup>7 17</sup> Given the severity of the injuries that have occurred after falling in this sample (ie, hospital-admitted injuries), our findings point to the importance of prevention where possible. However, identifying risks and opportunities for prevention can sometimes be missed since some workers might be reluctant to share their diagnosis with work when they develop new comorbidity.<sup>24</sup> For employers of middle-aged female workers, employers either need to consider a generalised approach to fall reduction among their entire workforce (measures including slip-resistant flooring, footwear, appropriately dimensioned stairs, handrails, etc) or perhaps a targeted 'screening' approach in which workers are offered opportunities to share health information relevant to

fall risk (including history of falls) with an occupational health and safety representative who can put in place fall prevention measures relevant to that worker without disclosing their health information.

In the current analyses, all fall-related injuries were severe enough to necessitate hospital admission, and over half were fractures. There is an important relationship between bone health and fracture risk, which is influenced by hormonal factors. Women undergo an accelerated phase of bone loss in the immediate postmenopause<sup>25</sup> which, given that they attain a lower peak bone mass than men, means that their bone becomes more vulnerable to fracture at earlier ages (while still working). There are available screening techniques to identify people at increased risk of fracture that combine assessment of bone mineral density with clinical risk factors (comorbidity, glucocorticoid treatment, fracture history).<sup>26</sup> Thus, raising awareness of determinants of bone health (diet, exercise) and possibly offering optional assessment of bone health using fracture assessment tools<sup>26</sup> might be applicable.

Although our analyses were confined to those most serious work-related injuries which resulted in hospital admissions, most previous studies used workers' compensation databases, which tend to underestimate rates by around 35–57% in Australia.<sup>10 27</sup> Additionally, under-reporting is more common among low-wage earners, migrants, ethnic minority workers and workers in a (perceived) poor psychosocial work environment.<sup>9 28</sup> This suggests that rates are not only underestimated but also somewhat biased as they disproportionately affect workers more vulnerable to workplace injuries and diseases.

In the current study, over half of the identified injuries resulting in hospital admission from falls were associated with a workers' compensation claim. Other studies of hospitalised work-related injuries identified a lower proportion of claims,<sup>27 29</sup> with estimates of 1.5–22.6% of admitted injuries resulting in claims. Not every worker is eligible to make a workers' compensation claim, particularly those who are self-employed (15–20% of the working population in Australia) and those with minor injuries resulting in limited sickness absence. Moreover, data from New South Wales showed that only 53% of workers eligible to claim in the preceding 12 months had done so.<sup>30</sup> Certainly, falls accounted for the highest proportion of workers' compensation costs for disabling injuries, specifically same-level falls, with a 42% growth in direct costs of disabling workplace injuries.<sup>31</sup> It is clear that fall-related work injuries are expensive to individuals, healthcare providers, insurers and societies.

Compared with those working in the manufacturing sector, this study identified an association between construction work and high falls, whereas government administration, defence and health services work was associated with same-level falls. Like our study, other studies on Australian compensation data reported the greatest proportion of occupational falls in construction work and manufacturing<sup>12</sup> and more injuries unrelated to falls in agriculture, forestry and fishing.<sup>32</sup> One hypothesis is that there are a higher proportion of young, healthy workers in the agriculture sector who are more at risk of other injuries (eg, through exposure to machinery and livestock) rather than falls or that the other workplace hazards in this sector present a greater risk of injuries than those caused by falling. Interestingly, our study showed no significant association with the time and season of occurrence of work-related falls, whereas others have reported a steady reduction in worker compensation injury claims from Monday to Friday<sup>33 34</sup> and an increase in the risk of workplace falls causing fractures before and after shift changes<sup>35</sup> likely due to adjustments to the work environment following the

weekends and work-shift migration. An increased risk has also been reported between occupational injuries and shift duration >12 hours,<sup>36</sup> and falls on slippery surfaces due to icy or wet conditions in colder months.<sup>13 37</sup>

Perhaps surprisingly, work-related falls from height were associated with the home, and same-level falls were associated with occurrence in schools and other public administrative areas. Because of the COVID-19 pandemic, the Victoria government mandated six lockdowns, including working from home when feasible, starting March 2020 until 2021–2022, which did increase the number of people working from home during this analysis. Post-pandemic, home working is still more common than ever among the workforce. Employers may need to consider fall prevention measures encompassing structural or design features of home.<sup>38</sup> Similar to compensation data,<sup>12</sup> men had higher rates of high falls, whereas women, particularly older women (≥50 years), had higher rates of same-level falls. It is possible that this higher rate of high falls among men is explained by the greater rates of men, particularly young men, relative to women, working in sectors in which working at height is relatively common, for example, construction, telecommunications and mechanical engineering.

Considering the results of other studies, our findings indicate that prevention strategies that specifically target workplace fall and injury prevention would usefully consider a range of factors, including organisational factors, physical and social environments, equipment and individuals. Most importantly, fall injury prevention measures in the workplace need to be tailored specifically to the prevention of high falls versus same-level falls, which have different risk profiles regarding worker demographics and workplace settings. In the past decades, overall work-related injuries have decreased in Australia,<sup>2</sup> as in other high-income countries,<sup>37</sup> due to improved workplace mechanisation, workplace safety policy and health insurance. However, there has been a recent increase in work-related severe injuries<sup>39</sup> and fall hospitalisation.<sup>40</sup> Given that occupational injuries make up the greatest burden of occupation-attributable disability and should be largely preventable,<sup>1</sup> it thus justifies the need for ongoing prevention and control initiatives, particularly in the context of an ageing workforce and increasing chronic disease burden.

The strength of this study was the use of a population-based sample that is representative of all hospital admission data with work-related injuries obtained at the individual level. Our study used ICD-10-AM codes and workers' compensation status in hospital admissions data to identify work-related hospitalised injuries, which likely captured most hospitalised work-related injuries. Additionally, this study used ICD-10-AM, both actual and supplementary codes, to define chronic conditions, which can benefit evidence on targeted chronic disease management of the workforce for work-related fall prevention in future studies.

The main limitation of this study was the use of VAED data, which were collected for administrative and case-mix funding purposes rather than clinical outcome monitoring and were not specifically designed to research work-related injuries. Particularly, the coding of place of occurrence is relatively poor with a high proportion of 'unspecified' entries, limiting the utility of this information in the VAED. Linkage of the VAED with other sources, such as workers' compensation claims data, could clarify this information further. Since data in this study were not linked, the outcomes after patient transfers within or between hospitals were not captured. Although this study did not rely solely on activity variables or compensation status to identify work relatedness, there

might be some underestimation of work-related hospitalised injuries due to the substantial proportion of unspecified or unknown activity in the ICD-10-AM activity codes. The significant mismatching between work-relatedness codes and workers' compensation payer status also suggests imperfect case identification of work-related injuries. These limitations are likely to have resulted in underestimates of the presented rates; however, this is unlikely to have impacted the presented patterns and relationships, that is, internal validity of this study. Finally, due to the nature of the databases, data specific to the job or task the worker was doing during their injury were unavailable.

## CONCLUSION

Work-related high falls (relative to all workplace injuries) were more common among males and those working in construction, whereas work-related same-level falls were more common among older women and workers with at least one comorbidity. Compared with work-related injuries from other causes, high falls resulted in more severe injuries and longer LOS. Fall injuries, particularly same-level falls, are likely to increase in workplaces with current demographic changes, and employers, regulators and policymakers could usefully consider raising the profile of workplace falls and developing effective prevention strategies.

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**Contributors** JB-G—conceptualisation, data curation and analysis. JB-G and WW—interpretation and writing (original draft). JB-G, KW-B and WW—writing (review and editing). JB-G, KW-B and WW—responsible for the overall content as the guarantors.

**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 required.

**Ethics approval** This study involves human participants. Ethics approval for the Victorian Injury Surveillance Unit's use of the Victorian Admitted Episodes Dataset (VAED) was obtained from Monash University Ethics Committee (21427). This study analysed hospital admission records extracted from the VAED. VAED data were initially collected for administrative or statutory functions by the Department of Health. This particular dataset is used for research purposes. The dataset is fully de-identified before it is sent to the researchers. The dataset includes data from all work-related injuries in Victoria presented to the hospital. Obtaining consent from such a large number of persons is impracticable. Consequently, we requested a waiver of consent for this project under the NHMRC (National Health and Medical Research Council) guidelines section 2.3.9. The NHMRC guidelines section 2.3.9 states: There is no known or likely reason for thinking that participants would not have consented if they had been asked: (1) there is sufficient protection for their privacy, (2) there is an adequate plan to protect the confidentiality of data, (3) the possibility of commercial exploitation of derivatives of the data or tissue will not deprive the participants of any financial benefits to which they would be entitled.

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

**Data availability statement** Data may be obtained from a third party and are not publicly available.

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## REFERENCES

- Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet* 2017;390:1211–59.
- Australian Bureau of Statistics. Work-related injuries 2023. Available: <https://www.abs.gov.au/statistics/labour/earnings-and-working-conditions/work-related-injuries/latest-release#data-downloads> [Accessed 22 Sep 2023].
- Ganz DA, Bao Y, Shekelle PG, et al. Will my patient fall? *JAMA* 2007;297:77–86.
- Fan J, McLeod CB, Koehoorn M, et al. Descriptive epidemiology of serious work-related injuries in British Columbia, Canada. *PLoS ONE* 2012;7:e38750.
- Australian Bureau of Statistics. Historical charts from August 1966 to February 2023. 2023. Available: <https://www.abs.gov.au/articles/historical-charts-august-1966-february-2023> [Accessed 22 Sep 2023].
- Australian Bureau of Statistics. Labour force, Australia, detailed. 2023. Available: <https://www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia-detailed/latest-release> [Accessed 22 Sep 2023].
- Vu T, Finch CF, Day L. Patterns of Comorbidity in community-dwelling older people hospitalised for fall-related injury: a cluster analysis. *BMC Geriatr* 2011;11:45.
- Sattin RW, Lambert Huber DA, DeVito CA, et al. The incidence of fall injury events among the elderly in a defined population. *Am J Epidemiol* 1990;131:1028–37.
- Kyung M, Lee SJ, Dancu C, et al. Underreporting of workers' injuries or illnesses and contributing factors: a systematic review. *BMC Public Health* 2023;23:558.
- Mitchell R, Williamson A. Examining the burden of work-related hospitalized injuries: definitional issues. *Inj Prev* 2008;14:101–5.
- Berecki-Gisolf J, Tharanga Fernando D, D'Elia A. International classification of disease based injury severity score (ICISS): a data linkage study of hospital and death data in Victoria, Australia. *Injury* 2022;53:904–11.
- Mangharam J, Moorin R, Straker L. A comparison of the burden and resultant risk associated with occupational falls from a height and on the same level in Australia. *Ergonomics* 2016;59:1646–60.
- Drebit S, Shajari S, Alamgir H, et al. Occupational and environmental risk factors for falls among workers in the healthcare sector. *Ergonomics* 2010;53:525–36.
- Osuka Y, Okubo Y, Nofuji Y, et al. Modifiable intrinsic factors related to occupational falls in older workers. *Geriatr Gerontol Int* 2022;22:338–43.
- Palmer KT, Harris EC, Coggon D. Chronic health problems and risk of accidental injury in the workplace: a systematic literature review. *Occup Environ Med* 2008;65:757–64.
- Peng L, Yu RW, Chan AH, et al. Chronic health problems of older workers and their occupational safety: a meta-analysis. human aspects of IT for the aged population healthy and active aging. 6th International Conference, ITAP 2020, Held as Part of the 22nd HCI International Conference, HCII 2020; Copenhagen, Denmark: Springer, 2022.
- Li Y, Hou L, Zhao H, et al. Risk factors for falls among community-dwelling older adults: a systematic review and meta-analysis. *Front Med (Lausanne)* 2022;9:1019094.
- Jehu DA, Davis JC, Falck RS, et al. Risk factors for recurrent falls in older adults: a systematic review with meta-analysis. *Maturitas* 2021;144:23–8.
- Deandrea S, Lucenteforte E, Bravi F, et al. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology* 2010;21:658–68.
- Cheng MH, Chang SF. Frailty as a risk factor for falls among community dwelling people: evidence from a meta-analysis. *J Nurs Scholarsh* 2017;49:529–36.
- Stubbs B, Binnekade T, Eggermont L, et al. Pain and the risk for falls in community-dwelling older adults: systematic review and meta-analysis. *Arch Phys Med Rehabil* 2014;95:175–87.
- Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age Ageing* 2012;41:299–308.
- Stolt LROG, Kolish DV, Cardoso MRA, et al. Accidental falls in middle-aged women. *Rev Saude Publica* 2020;54:141.
- Hakkarainen P, Moilanen L, Hänninen V, et al. Disclosure of type 1 diabetes at work among Finnish workers. *Diabet Med* 2017;34:115–9.
- Compston JE, Bhamhani M, Laskey MA, et al. Body composition and bone mass in post-menopausal women. *Clin Endocrinol (Oxf)* 1992;37:426–31.
- Adami G, Biffi A, Porcu G, et al. A systematic review on the performance of fracture risk assessment tools: FRAX, Defra, FRA-HS. *J Endocrinol Invest* 2023;46:2287–97.
- Muscattello D, Mitchell R. Identifying work-related injury and disease in routinely collected NSW Hospitalisation data. *N S W Public Health Bull* 2001;12:195–8.
- Moyce SC, Schenker M. Migrant workers and their occupational health and safety. *Annu Rev Public Health* 2018;39:351–65.
- Boufous S, Williamson A. Work-related injury in NSW Hospitalisation and workers' compensation datasets: a comparative analysis. *Aust N Z J Public Health* 2003;27:352–7.
- Australian Bureau of Statistics. *Work-related injuries and illnesses*. Canberra: NSW, 1993.

- 31 Work Safe BC. Serving British Columbians statistics 2019. 2019. Available: <https://www.worksafebc.com/resources/about-us/annual-report-statistics/2019-stats?lang=en&direct> [Accessed 22 Sep 2023].
- 32 Safe Work Australia. Work-related injury fatalities ; key WHS Statistics Australia. 2021. Available: <https://www.safeworkaustralia.gov.au/sites/default/files/2021-10/Key%20work%20health%20and%20safety%20statistics%20Australia%202021.pdf> [Accessed 22 Sep 2023].
- 33 Wigglesworth E. Occupational injuries by hour of day and day of week: a 20-year study. *Aust N Z J Public Health* 2006;30:505–8.
- 34 Frattaroli S, Warner M, Baker S. *Temporal factors in injuries to automotive workers*. Baltimore (MD): Johns Hopkins School of Hygiene and Public Health, 1996.
- 35 Hayashi C, Ogata S, Toyoda H, *et al*. Risk factors for fracture by same-level falls among workers across sectors: a cross-sectional study of national open database of the occupational injuries in Japan. *Public Health* 2023;217:196–204.
- 36 Anderson C, Grunstein RR, Rajaratnam SMW. Hours of work and rest in the rail industry. *Intern Med J* 2013;43:717–21.
- 37 Lundstrom EW, Hendricks SA, Marsh SM, *et al*. Temporal trends in occupational injuries treated in US emergency departments, 2012–2019. *Inj Epidemiol* 2023;10:13.
- 38 Gunatilaka A, Clapperton A, Cassell E. Preventing home fall injuries: structural and design issues and solutions. *Hazards* 2005;59:1–17.
- 39 Safe Work Australia. Analysis of ABS work-related injuries survey data. 2021. Available: [https://www.safeworkaustralia.gov.au/sites/default/files/2023-04/safe\\_work\\_australia\\_analysis\\_of\\_abs\\_work-related\\_injuries\\_data\\_0.pdf](https://www.safeworkaustralia.gov.au/sites/default/files/2023-04/safe_work_australia_analysis_of_abs_work-related_injuries_data_0.pdf) [Accessed 22 Sep 2023].
- 40 Australian Institute Of Health and Welfare. Injury in Australia: falls 2022. Available: <https://www.aihw.gov.au/reports/injury/falls> [Accessed 22 Sep 2023].