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Who crashes their car following wrist fracture?

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Background: Wrist fractures are common injuries associated with high disability in the early recovery period. The impact of wrist fractures on safe return to drive is not understood.
Purpose: (1) To compare the proportion of adults who were drivers in car crashes before and after wrist fracture; (2) To examine potential factors (demographic and/or clinical) associated with increased odds of being a driver in a car crash following wrist fracture.
Study Design: Retrospective cohort study.
Methods: Three state-wide government datasets (MainRoads Western Australia [WA], Hospital Morbidity Data Collection and the Emergency Department Data Collection) were used to obtain and link demographic, clinical and car crash information relating to adults with a wrist fracture sustained between 2008 and 2017. McNemar's tests were used to compare the proportion of drivers in a car crash within the 2 years prior to and following the fracture date. Multivariable logistic regressions were used to identify if any variables were associated with increased odds of crashing in the post-fracture period.
Results: Data relating to 37,107 adults revealed a 3.3% (95% CI 3.0%–3.6%, $p < 0.05$) decrease in the proportion of drivers in a car crash following wrist fracture, persisting for the entire 2 years post-fracture, when compared to the proportion who crashed before their fracture. Those with more severe wrist fracture injury patterns had 79%(95% CI 1.07–3.0, $p = 0.03$) higher odds of having a crash in the first 3 months following their injury, compared to those with isolated wrist fracture injuries.
Conclusions: These results inform and update return to drive recommendations. The reduced proportion of drivers involved in crashes following wrist fracture persisted for 2 years; longer than the expected physical recovery timeframe. It is important that hand therapists actively educate the sub-group of adults with more severe wrist fracture injury patterns of the increased likelihood of car crash for the 3 months following their fracture.

Introduction

Driving is a complex task that requires co-ordination of physical, behavioral and cognitive processes and is important for independence in social and work-related activities.[1] Individuals commonly ask "when is it safe to return to drive?" following upper limb fracture. There are associated safety and medicolegal risks if individuals with restricted driving capacity are given inaccurate advice, especially if they are involved in a subsequent car crash. Conversely, delaying return to drive has financial and social consequences, results in reduced independence and increased work absences.[1] The ultimate medical fitness to drive is often given by the treating doctor.[2,3] However, the skill set of hand therapists entailing assessments and understanding of functional capacity of patients is uniquely placed within the multidisciplinary team to inform this complex decision.[2]

Wrist fractures account for approximately 20% of all adult fractures and are among the most common fractures across all ages, affecting both young and older drivers.[4] The mechanism of injury is often low impact trauma in post-menopausal women, while wrist fractures in young adults are often sustained during high impact trauma for example, car crash or sporting injuries.[5] Wrist fractures

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are associated with disabling functional limitations, especially in the first six weeks of recovery.[6] Most improvement in physical and functional status occurs in the first three months of recovery, with subsequent smaller, consistent improvements for at least 1 year post-fracture.[6]

Given the overall difficulty in performing activities of daily living following wrist fracture,[6] fitness to drive may also be affected. Previous literature investigating return to drive following any upper limb trauma is exceedingly scarce.[2,7,8] However, there is a small body of evidence to suggest that driving performance is impaired in uninjured participants when using an immobilization cast.[7] In addition, results from clinical studies that assessed driving performance among those recovering from wrist fracture showed that steering wheel control is reduced when compared to uninjured controls.[8] Additionally, 30% (7/23) of participants failed a driving test when assessed within 18 days of distal radius fracture surgery.[9] Despite these reports of reduced driving capacity following wrist fracture, it is not known if this increases the likelihood of car crash.

Internationally, there are no practice guidelines or objective evidence to assist clinicians in deciding on the timepoint that individuals are able to return to drive following wrist fracture.[3,10] It is plausible that this has resulted in inconsistencies in return to drive recommendations; advice from health professionals varies from no requirement to abstain from driving, to restrictions for 12 weeks post-fracture.[7] In addition, patient behavior does not always follow recommendations from health professionals. One study reported that many patients admit to returning to drive while still on narcotic pain medications, despite contrary recommendations from their doctor, family or friends, and/or feeling unsafe when driving following their injury. Another study reported the average timeframe taken to return to drive following distal radius fractures was 16 days post fracture fixation surgery.[11] Both medical recommendations and self-reported patient behavior correspond with most individuals returning to drive well within three months following wrist fracture.[9,11] However, the overall safely of this behavior is not well understood as the crash risk encountered when returning to drive following wrist fracture has not yet been investigated.

Given that upper limb disability and persistent impairments are highest during the first 3 months post-fracture, car crash occurrence during this period should be of particular interest. Previous research suggests the majority of individuals return to drive early in their recovery while impairments and functional restrictions are ongoing. However, studying the frequency of car crashes over a longer 1-to-2-year period may provide a better understanding of change in crash frequency over time, especially as a proportion of individuals may take longer to return to drive and impairments can extend beyond 3 months.

Purpose of study

To our knowledge, the occurrence and risk factors relating to car crashes following wrist fracture have not previously been reported. A better understanding in this area will assist patients, hand therapists and other health practitioners to make informed recommendations or decisions on returning to drive following wrist fracture. We hypothesize that car crashes are most likely to occur in the first three months following wrist fracture when the physical impairments are the greatest. Therefore, our primary aims were to:

1) Compare the proportion of individuals who have a car crash within 2 years following wrist fracture with the proportion of individuals who crashed during the 2 years prior to the fracture.
2) Determine if any factors (demographic, clinical/injury-related) are associated with increased odds of being a driver in a car crash following wrist fracture.

Methods

This paper is written in accordance with the RECORD reporting checklist for studies reporting on routinely collected health data, including those from administrative data sets. Ethics was granted from the Department of Health WA Human Research Ethics Committee.

Procedures in brief

Three state-wide datasets were used to obtain car crash information relating to a cohort of adults with a wrist fracture managed at a hospital in Western Australia (WA) over a 10-year period: The Emergency Department Data Collection (EDDC), the Hospital Morbidity Data Collection (HMDC) and the MainRoads WA. Western Australia covers approximately a third of Australia's total landmass (2.5 million square kilometers) and is populated by 2.6 million people.[12]

The WA Data Linkage Branch was employed to extract and assimilate the data from the above data collections to ensure quality matching and confidentiality, using person-level linkage, before transfer for analysis to the authors via a secure online transfer. The linkage procedures and quality checking are reported in detail by this group.[13]

Two government health-based data collections EDDC and HMDC identified the retrospective population-based cohort. These datasets contain health-related information representative of public and private hospitals in city and rural locations across WA. The third government data collection, Main Roads WA, was used to obtain car crash data relating to the cohort. Car crash data were obtained for the 2-year period prior to and the 2 years following each individual's fracture date. The MainRoads WA dataset contains information relating to reported car crashes in WA including crash dates, demographics of individuals in each crash and the seating position of involved individuals.

Inclusion criteria comprised all adults (> 18 years old) with a hospital presentation date between 01/01/2008-31/12/2017 and a diagnosis of wrist/forearm fracture, as defined by International Classification of Diseases, Tenth Revision, Australian Modification (ICD-10AM) diagnostic codes. Types of wrist fracture included the distal radius and/or ulna (S52.50-S52.59, S52.6), carpal bones (S62.0-S62.19) and/or midshaft radius and/or ulna (S52.20, S52.30, S52.4) The car crash information was sourced for the corresponding 2-year period before and after the fracture date within the 01/01/2006-31/12/2019 time period.

Design

We conducted a retrospective, cohort study using linked data from administrative government datasets. Each individual served as their own control for the comparison of a car crash incident before and after their wrist fracture. This methodology is often used in car crash studies,[14] as it reduces confounding due to individual personalities and risk-taking behavior, demographics and other comorbidities which potentially influence car crash risk.

The following data were extracted:

Demographics

Sex, age, employment status.

Wrist fracture date

To account for those with a history of more than one wrist fracture (and potential multiple admissions relating to the wrist fracture), a new wrist fracture was recorded if any fracture related hospital/ED admission occurred more than 18 months following any previous wrist/forearm fracture related admission.

Acute fracture management

Conservative (immobilization +/− closed reduction) or surgical management (open or closed reduction with internal or external fixation). Acute fracture fixation procedures were grouped according to the Australian Classification of Health Interventions, 8th Edition (ACHI) codes in Supplementary Table 1. It was assumed that those with no recorded acute surgical procedure codes were managed conservatively.

Concurrent injury(ies)

Diagnosed at the same hospital presentation as the wrist fracture. These include concurrent injury to the wrist/forearm (including injury or laceration to the skin, muscle, tendon, nerve[s] or vessel[s]), concurrent injury elsewhere in the body (other fracture, organ injury, or injury or laceration to the skin, muscle, tendon, nerve[s] or vessel[s] elsewhere to the wrist/forearm). Diagnostic codes for concurrent injury are described in Supplementary Table 2.

Complications

Were defined according to predefined ICD-10AM codes (Supplementary Table 3). Early complications were those requiring hospital/ED (re)admission within 30 days post-fracture. Requirement for secondary wrist/forearm surgery was recorded (detailed in Supplementary Table 4), occurring > 30 days but within 2 years of the fracture.

Comorbidities

The Elixhauser Index (EI) was calculated by using diagnostic codes relating to hospital/ED admissions in the 2 years before and after the fracture date (with resultant health data from 01/01/2006-31/12/2019). The EI uses 30 co-morbidities with a final score of −7 to +12. Lower scores reflect better health.

Car crash recording

The Main Road WA database includes the seating position data of the involved person(s). Only car crashes where the individual was listed as the driver were included. If the seating position data was missing, these were excluded from analyses. The car crash timing was defined as either 'before fracture or 'after fracture. Those with the date of the car crash falling on the same date (or up to and including 3 days before) as the wrist fracture were in the pre-injury group to ensure any delays in presentation to hospital and/or delays in fracture diagnoses were accounted for.

Analysis

Data cleaning and analyses were performed using Stata (16.1, StataCorp LLC, College Station, TX). A significance level a of 0.05 was used for statistical tests, including the final logistic regression models.

Descriptive statistics, mean (standard deviation) of demographic, clinical and fracture related variables were reported for those who were a driver in a car crash following the wrist fracture date and those with no reported crashes. Where necessary in reporting, small cell counts ($n < 5$) were suppressed.

McNemar's tests were used to determine if the proportion of individuals who were drivers in a car crash was higher among those recovering from wrist fractures compared to the proportion of those who had a crash history in the pre-injury timeframes. The McNemar's tests were completed for 3-month, 6-month, 1- and 2-year time points separately.

To determine if any variables were associated with the odds of car crash, logistic regression was first performed for association with car crash during the first 3 months and then the regression was repeated for the remaining time up until 2 years (3–24 months) following the wrist fracture. The variables of interest included age, sex, health status, wrist/forearm fracture type, acute surgical management, compensable funding status, reported complications and/or concurrent multi-trauma sustained at the time of the fracture. The relationship between continuous variables and car crashes were checked for linearity and transformed if non-linear.

Starting with a full model, backwards elimination methods were used. Prior to elimination of a candidate variable the change in the remaining coefficients were checked to ensure no more than 15% change with each step. A likelihood ratio was calculated and the Akaike information criterion was checked to ensure goodness of fit was not reduced with the elimination steps. Finally, the model was checked for multicollinearity. The logistic regression results are presented as odds ratios (OR) and 95% CI.

Results

Data were derived from 37,107 individuals who had a wrist fracture. Among these, 3071 (8.3% of 37,107) individuals were drivers in (at least) one car crash during the 2 years before and/or the 2 years after their fracture date. Of interest, there were 796 individuals with the crash and fracture date occurring on the same day (i.e., the mechanism of injury for the wrist fracture was a car crash). These individuals are included in the "pre-injury" crash group.

The demographics of the individuals who were a driver in a car crash differ from those with no crash following their wrist fracture. Those who had at least one crash following their wrist fracture were, on average, younger, a greater proportion were male, currently employed and/or had compensable funding and fewer had acute surgical management of their wrist fracture (Table 1).

At all intervals within the 2-year pre- and post- time period, we found that the proportion of drivers involved in at least one car crash after wrist fracture was less than those involved in at least one car crash before wrist fracture (Table 2). This equated to 1006 drivers (2.7% of 37107) who crashed at least once during the 2 years following the fracture date, compared to 2234 drivers (6.0% of 37,107) who were in at least one car crash during the 2 years prior to the fracture date. This corresponds to a 3.3% (95% CI = 3.0%–3.6%, $p < 0.05$) reduction in the proportion of drivers in a car crash in the 2 years. The frequency and proportion of drivers in a car crash in the 3-, 6- and 12- month periods before and after the wrist crashes are detailed in Table 2.

Considering all months during the 2 years prior to the wrist fracture, there was a mean of 200 (SD 13.5) crashes per quarter. In the 2 years following the wrist fracture, the mean number of crashes was 135 (SD 10.5) per quarter (detailed in Supplementary Table 5*)*. When crashes occur in the first 3 months following fracture there was a bimodal distribution with a small peak at 20 days and a larger peak at 10 weeks following fracture (shown in Supplementary Fig. 1*)*.

For the post fracture period, the final multivariable logistic regression showed that a number of variables were associated with odds of car crash. After accounting for associations between age and sex on likelihood of car crash, those with concurrent injury(ies) to wrist (in addition to the wrist fracture) had 79% higher odds (OR 1.79, $p = 0.03$, 95% CI 1.1–3.0) of being a driver in a car crash in the first 3 months following their fracture than those with isolated wrist fracture injury patterns (Table 3 and Fig. 1). Those who were currently employed had higher odds of crash (OR 1.59, $p = 0.01$, 0. 95% CI 1.1–2.3) than those unemployed.

In the time period later than 3 months following the fracture date, the only variables associated with increased likelihood of crash

Table 1
Demographics and clinical profile of those with no reported car crash(es) compared to those with reported crash in the 3 months after the wrist fracture date

	No crash n = 36,969	At least one crash n = 138
Age in years		
mean (SD)	48.6 (21.1)	31.9 (14.3)
Female		
n (% of group)	21,054 (56.9%)	41 (29.7%)
Type of wrist fracture n (% of group)		
Midshaft	8437 (22.8%)	43 (31.2%)
Distal radius	21,282 (57.6%)	54 (39.1%)
Carpal	6761 (18.3%)	39 (28.3%)
Multiple	489 (1.3%)	2 (1.4%)
Acute surgical fracture management		
n (% of group)	4377 (11.4%)	7 (5.1%)
Concurrent injury n (% of group):		
Wrist/forearm	2336 (6.3%)	17 (12.3%)
Elsewhere in body	4625 (12.5%)	24 (17.4%)
Any of the above	5809 (15.7%)	32 (23.2%)_
Early complication n (% of group)	1328 (3.6%)	9 (6.5%)
Secondary surgical procedure n (% of group)	3629 (9.8%)	15 (10.9%)
Employed		
n (% of group)	21,033 (56.9%)	89 (64.5%)
Health status: Elixhauser index		
mean (SD)	0.52 (1.2)	0.34 (0.8)

Table 2
Frequency (%) of drivers with (at least one) car crash in the 3 months, 6 months, 1 year and 2 years before and after wrist fracture*

Timepoint	Crash after?	Crash before?		Total
		Yes	No	
3 months*				
	Yes	12 (< 0.1%)	126 (0.3%)	138 (0.4%)
	No	984 (2.7%)	35,985 (97.0%)	36,969 (99.6%)
	Total	996 (2.7%)†	36,111 (97.3%)	37,107
6 months*				
	Yes	26 (0.01%)	235 (0.6%)	261 (0.7%)
	No	1139 (3.1%)	35,707 (96.3%)	36,846 (99.3%)
	Total	1165 (3.1%)†	35,942 (96.9%)	37,107
1 y*				
	Yes	60 (0.2%)	475 (1.3%)	535 (1.4%)
	No	1473 (4.0%)	35,099 (94.6%)	36,572 (98.6%)
	Total	1533 (4.2%)†	35,574 (95.9%)	37,107
2 y*				
	Yes	169 (0.5%)	837 (2.3%)	1006 (2.7%)
	No	2065 (5.6%)	34,036 (91.7%)	36,101 (97.3)
	Total	2234 (6.0%)†	34,873 (94.0%)	37,107

* McNemars p-value $<$ 0.001 for all time comparisons.
† Includes 796 individuals (1.9% of 37107) with the car crash and wrist fracture occurring on the same day.

Table 3
Final logistic regression model of variables associated with increased likelihood of car crash in the first 3 months following wrist fracture

	Odds ratio	p-value	95% CI	
			(Lower)	(Upper)
Age (years)	0.96	< 0.001	0.9	0.97
Males	1.52	0.03	1.0	2.2
Workers	1.59	0.01	1.1	2.3
Concurrent wrist injury	1.79	0.03	1.1	3.0

were younger age, male sex and being employed. We did not find association between car crash occurrence and general health status, compensable funding status, acute fracture management pathway, concurrent multi-trauma injuries or the presence of complications at any time period. There were no significant interactions between predictors.

Secondary analysis of car crashes distribution among those with isolated wrist fracture, compared to those with concurrent injury to the wrist or elsewhere in the body (i.e., multi-trauma injury patterns) is described in Supplementary Table 6.

Discussion

This paper identified several novel findings regarding car crashes following wrist fracture. Firstly, we identified a 3.3% reduction in the proportion of individuals who were in a car crash in the 2 years following their wrist fracture, compared to the proportion of individuals in a car crash in the 2 years before their wrist fracture. Further to this finding, factors associated with likelihood of car crash were identified. As well as known relationships between younger males and with increased likelihood of car crash, those with more severe wrist injury patterns were 79% more likely to be in a car crash in the first 3 months following fracture, compared to those with isolated wrist fractures. In addition, workers were more likely to be in a crash compared to those who were not employed.

The reduced occurrence of car crashes persisted across the entire 2-year study period following wrist fracture. This was surprising and contrary to our hypothesis that an increased number of crashes would be apparent within the first 3 months post fracture when impairments are most pronounced. One possibility is that the rate of car crashes (i.e., the crash rate per person per exposure time) is under-represented due to reduced exposure to driving. Reduced driving exposure is expected up to 3 months post-fracture, when those with fractures drive less than usual, but it is also expected that driving exposure reaches normal levels after that timeframe.[9] Without driving exposure data, we cannot establish whether this is the case, which merits further investigation. A further explanation is that this finding reflects more cautious driving over an extended period. Evidence suggests some drivers may be more cautious after wrist fracture for example, less likely to speed or overtake at speed.[8,15] Given that the mechanism of injury for the wrist fracture was a car crash for a large portion of the cohort (25.9%, 796/3071 individuals), it would be expected that many drivers would exhibit cautious driving practices upon returning to drive. Additionally, there was an increased likelihood of car crash among workers when compared to those who were not employed (including retirees). This relationship was observed for the whole 2-year period and perhaps suggest that those who work may have a higher crash risk because of their driving exposure rather than factors relating to their wrist fracture. There were no significant interactions between workers and age and/or sex.

Despite the overall reduced number of car crashes following wrist fracture, it is important to recognize the relationship between car crash occurrence and those with more severe wrist fracture injury patterns. After accounting for the known influence of age and sex on car crash risk, the likelihood of being in a car crash within 3 months following wrist fracture was significantly higher with more severe wrist injury (e.g., those with concurrent additional injury to the wrist) and among those who were currently employed. There was no association found between wrist fracture severity and car crash occurrence after 3 months post-fracture, which is understandable as most functional impairments resolve during this timeframe. In our cohort, almost 10% of individuals had a concurrent wrist injury, therefore approximately one in 10 individuals (those with more severe injury patterns) should be actively educated on their increased likelihood of car crash in the first 3 months following their fracture. It is recommended that this patient sub-group is cautioned about returning to drive within this time period.

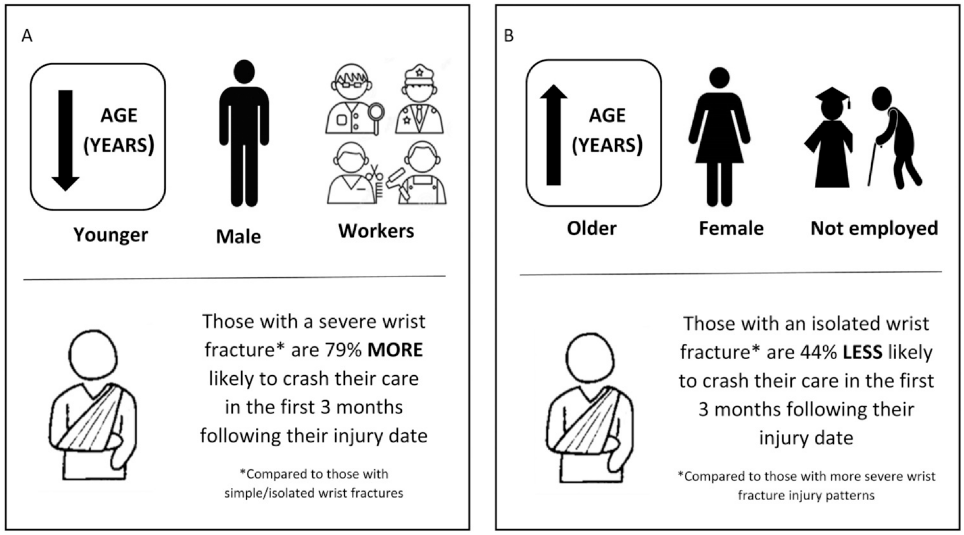

Fig. 1. Infographic showing patient profiles associated with (**A**) higher odds of being in a car crash within 3 months of wrist fracture (**B**) lower odds of being in a car crash within three months of wrist fracture.

When crashes do occur in the first 3 months following fracture, they most often take place around week 3 and week 10 after fracture. It is possible that these peaks correlate with the times when many individuals return to drive following their wrist fracture. It is expected that some individuals return to drive early in their recovery once acute pain settles, while other drivers wait until the plaster cast or orthoses is removed and they are able to use their injured limb more fully. Other research indicates that individuals return to drive on average 15.8 days post-fracture,[11] with 77% of adults driving by week 3 and all by 3 months.[9] Given that scores on the self-reported "Disability of the arm, shoulder and hand" questionnaire at 3 weeks following a distal radius fracture are approximately 50 out of a 100[6] (best score of 0% reflecting no upper limb functional concern), it is possible that this crash distribution reflects increased risk of car crashes when returning to drive with marked physical impairments and functional limitations.

Research regarding driving capacity following upper limb trauma is scarce,[2,7] however, some preliminary evidence is worth noting. One study indicated that 29% (7/23) of those recovering from wrist fracture did not pass a driving examination performed in the first month following wrist fracture surgery.[9] The assessment was undertaken on-road, on a closed course with evaluation of many aspects of driving, but not testing scenarios requiring reaction to potential hazards. Similarly, pilot data demonstrates measurable differences in driving performance in those recovering from wrist fracture when assessed using a driving simulator at five weeks following injury, but not in the follow-up assessment 2 weeks later. These two studies form early evidence to suggest that some individuals demonstrate impaired driving capacity up to 2 months following wrist fracture. Combined with our finding that those with concurrent wrist injuries are more likely to be involved in a subsequent car crash, the emerging evidence suggests that a sub-group of individuals with wrist fracture have a greater risk of car-crash; likely those with more complex injury profiles, higher levels of physical impairments and resultant reduced driving capacity. Additional research is justified to explore links between more detailed clinical profiles (e.g., physical impairments, functional limitations, pain) and return to drive timeframes, driving capacity and risk of car crash.

Limitations of this paper not previously mentioned include possible omission of data from police reports or under reporting of car crashes, and no record of minor/non-reported crashes such as those occurring in car parks or low speed crashes involving no injuries or only minor property damage. However, arguably the most important car crashes are those resulting in injuries that require hospital treatment and/or large property damage, which were included through the mandatory reporting of car crashes in WA.

There are limitations relating to the use of administrative data that was not created to answer the specific research questions. Resultingly, we were limited in the pre-recorded variables and as there are no clinical assessment measures within the datasets, variables such as pain and other clinical variables could not be included in the regression. Although the Data Linkage Service of WA reports quality checking protocols to ensure linkages are of a high quality, it is possible that there was missing data or missing linkage not known to the authors. Finally, this study is only relevant to wrist and forearm fractures; the relationship between other upper limb injuries and car crash rates in other jurisdictions warrants investigation.

Conclusion

There was a 3.3% reduction in the proportion of drivers involved in a car crash in the 2 years following wrist fracture, when compared to the same time period prior to the injury. After wrist fracture those with concurrent injury to the wrist or forearm had 79% higher odds of having a car crash within the first 3 months after injury, compared to those with an isolated wrist fracture. In addition, those employed are at higher risk of crash than those who are not employed. It is important that hand therapists actively educate patients of these risks and caution those with more severe injury patterns of their increased likelihood of car crashes for the three months following the fracture date.

CRediT statement of author contributions

Susan Stinton: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualisation, Writing (original draft, review and edition). Evangelos Pappas: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Validation, Visualisation, Formal analysis, Writing (review and edition), Supervision. Alberto Nettel-Aguirre: Methodology, Validation, Visualization, Writing (review and editing). Niamh Moloney: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Validation, Visualisation, Writing (review and edition), Supervision. Kathryn Refshauge: Interpretation of data, Supervision, Writing (review and editing). Dale Edgar: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Validation, Visualisation, Writing (review and edition), Supervision.

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Data availability statement

We are unable to provide the full data set. As the data contains confidential health information, as a requirement to gain access, we signed a data transfer agreement confirming we will not disclose the data to any third party. However, individuals are able data is available via request to the data custodians within the WA Department of Health.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Susan Stinton reports financial support was provided by Physiotherapy Research Foundation.

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Statement of informed consent

As this was secondary analysis of de-identified data, we were granted a waiver of consent from the Department of Health WA Human Research Ethics Committee: according to the National Statement on Ethical Conduct in Human Research 2.3.10 this study met the required criteria.

Supporting material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jht.2023.09.002.

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