Archives of Gerontology and Geriatrics 83 (2019) 155–160

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Injury-related hospitalisation in community-dwelling older people across the cognitive spectrum: A population based study

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ARTICLE INFO

Keywords:
Injury
Mild cognitive impairment
Dementia
Falls
Aged

ABSTRACT

Objectives: To describe the injury profile, hospitalisation rates and health outcomes for older people with cognitive impairment and to determine whether these differ from those with normal cognition.
Methods: Participants were 867 community-dwelling 70–90 year olds enrolled in the population-based longitudinal Sydney Memory and Ageing Study (MAS). Participant's cognitive status was classified as normal, mild cognitive impairment (MCI) and dementia at baseline, then 2, 4 and 6 years' follow-up. MAS records were linked to hospital and death records to identify injury-related hospitalisations for the 2-year period following each assessment.
Results: There were 335 injury-related hospitalisations for participants; 222 (25.6%) participants had at least one injury-related hospitalisation. The injury-related hospitalisation rate for participants with MCI (63.0 [95%CI 51.6–74.4] per 1000 person-years) was higher than for people with normal cognition (39.3 [95%CI 32.4–46.1] per 1000 person-years) but lower than people with dementia (137.1 [95%CI 87.2–186.9] per 1000 person-years).

Upper limb fractures (22.1%) were the most common injuries for participants with normal cognition, and non-fracture head injuries for participants with MCI and dementia (25.9% and 23.3% respectively). Participants with dementia had a higher proportion of hip fractures (20.0%, p = 0.0483) than participants with normal cognition. There was no difference in 30-day mortality between participants with normal cognition, MCI and dementia (3.9%, 1.7%, 3.3% respectively).
Conclusion: Older people with objectively defined MCI are at higher risk of injury-related hospitalisation than their cognitively intact peers, but lower risk than people with dementia. Falls-risk screening and fall prevention initiatives may be indicated for older people with MCI.

1. Introduction

Cognitive impairment is common in old age and is associated with increased health care utilisation, loss of independence, dementia and death (Australian Institute of Health and Welfare, 2012). Mild cognitive impairment (MCI) is conceptualised as an intermediate state between normal cognitive ageing and dementia, where an individual's cognitive performance is below expectation for age and education level, but does not interfere with activities of daily life (Feldman and Jacova, 2005; Petersen et al., 2014). This is distinct from dementia, where cognitive deficits impact directly on function. The number of people living with MCI exceeds the number of people with dementia, with global prevalence estimates suggesting between 5.9%–12.0% of adults over 60 years have MCI (Sachdev et al., 2015) and between 4.6%–8.7% have

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https://doi.org/10.1016/j.archger.2019.03.028
Received 14 August 2018; Received in revised form 27 March 2019; Accepted 31 March 2019
Available online 01 April 2019
0167-4943/

dementia (Prince et al., 2015). People with MCI are at higher risk of developing dementia than the general population, with annual conversion rate to dementia of around 10% of those presenting for clinical assessment, and 2.4% in one population based sample (Brodaty et al., 2013; Mitchell and Shiri-Feshki, 2009).

Dementia is a known independent risk factor for falls (Allan et al., 2009; Muir et al., 2012; Tinetti et al., 1988; Tinetti et al., 1995), and injury-related hospitalisations including hip fractures (Baker et al., 2011; Harvey et al., 2016a), head and traumatic brain injuries (Harvey et al., 2015), burns (Harvey et al., 2016b) and poisoning (Mitchell et al., 2015). In Australia, injury is the most common reason for admission to hospital for people with dementia (Australian Institute of Health and Welfare, 2012), with hospitalisation rates 1.8 times higher for people with dementia than their cognitively intact counterparts (Harvey et al., 2015). Outcomes after injury are also worse for people with dementia, with longer hospital length of stays (LOS), higher admission rates to residential aged care following hospitalisation and higher 30-day mortality (Harvey et al., 2015).

There is a growing body of research that suggests people with MCI may also be at increased risk of falls (Delbaere et al., 2012; Liu-Ambrose et al., 2008; Tyrovolas et al., 2016), and injurious falls (Delbaere et al., 2012). While it is unclear why people with MCI should fall more, it has been suggested that the increased risk is related to impaired executive functioning (Delbaere et al., 2012; Muir et al., 2012). A diminished ability to identify high risk situations combined with a reduced capacity to respond to danger in a timely and appropriate manner may lead to higher risk of all injuries, not solely those resulting from falls. No research to date has explored whether people with MCI are at an increased risk of serious injury requiring hospitalisation, nor whether the causes, characteristics and outcomes of these hospitalisations differ from people with normal cognition and dementia. The aim of this study was to describe the injury profile, hospitalisation rate, health outcomes and hospital costs across the cognitive spectrum in a representative sample of community-dwelling older people in Australia.

2. Methods

2.1. Participants

Participants were drawn from the Sydney Memory and Ageing Study (MAS), a population-based longitudinal cohort study of 1037 community-dwelling older adults without dementia aged between 70–90 years, which has been described in detail previously (Sachdev et al., 2010). Participants of the MAS underwent extensive physical and psychological assessments over four waves of the study; at baseline commencing in 2005, and at two, four and six years later. Assessment included a detailed medical and lifestyle history, physical examination and a comprehensive battery of neuropsychological tests administered by experienced research psychologists.

The inclusion criteria for this study were i) undergoing comprehensive neuropsychological assessment at baseline, ii) having an English-speaking background (due to the potential for misclassification of MCI in non-English speakers), and iii) having provided written consent for linkage of health records. A total of 867 (83.6%) participants met these criteria and were included in the analysis.

2.2. Data linkage

Participant MAS records were linked to hospital and death records from 2001 to 2014 to identify all injury-related hospitalisations and outcomes for a two year period following each wave. Hospitalisation data for all public and private hospitals in New South Wales (NSW) were obtained from the Admitted Patient Data Collection (APDC) which contains information on patient demographics, diagnosis, external causes and procedures coded to the International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) (National Centre for Classification in Health, 2010). Mortality data were obtained from the NSW Register of Births, Deaths and Marriages (RBDM), which includes records of all deaths of NSW residents and provides date of death. Probabilistic linkage of records was undertaken by the Centre for Health Record Linkage (CHeReL). The false positive and false negative rates for APDC and RBDM linkage are 0.3% and 0.5% respectively (Centre for Healh Record Linkage, 2012). Ethics approval was obtained from the NSW Population and Health Service Research Ethics Committee (HREC/15/CIPHS/11).

2.3. Creation of study variables

2.3.1. Classification of cognitive status

Participants were categorised as having normal cognition, MCI, or dementia at each wave, recognising that there is considerable scope for change in cognitive status over time (Aerts et al., 2017). Using international criteria (American Psychiatric Association, 2000; Winblad et al., 2004) participants were classified as having MCI if all of the following criteria were met; i) participant or informant reported cognitive complaint (memory or non-memory) regarding current cognitive function compared to 5 years ago, ii) they did not have dementia, iii) they had normal function or minimal impairment in instrumental activities of daily living (Bayer-ADL scale), (Hindmarch et al., 1998) and iv) evidence of cognitive impairment on objective testing. Cognitive impairment was defined as a test performance of 1.5 SD or more below published normative values adjusted for age, sex and education. Dementia was classified according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Revision criteria (American Psychiatric Association, 2000). Where participants were unavailable for re-assessment or had missing test results, a category of 'unclassified' was allocated for that wave, unless a previous diagnosis of dementia had been assigned.

2.3.2. Hospitalisation characteristics

Injury-related hospitalisations were identified using a principal diagnosis code in the ICD-10-AM range 'S00-T75' or 'T79'. Causes of injury were categorised using the external cause code (ICD-10-AM Chapter 20) adjacent to the injury diagnosis. Comorbidities contributing to the Charlson Comorbidity Index (CCI) were identified from the 55 additional diagnosis fields using the Quan coding algorithm (Quan et al., 2005) and a 12 month lookback period. Length of stay (LOS) was defined as the difference in days between the final discharge date and the date of admission for the index episode-of-care. Hospitalisations consisting of several contiguous episodes-of-care for the same injury were counted as one hospital stay. LOS was truncated to 3 standard deviations above the mean to exclude extreme outliers (Australian Health Performance Authority, 2013). Thirty-day mortality was defined as death from any cause within 30 days, and 28-day readmission was defined as an unplanned admission within 28 days of hospital discharge, excluding participants who had died within 28 days. Hospital costs were by calculated by multiplying the LOS for each episode-of-care by the average Australian Refined-Diagnosis Related Group (AR-DRG) cost per day from the National Hospital Costs Data Collection (Independent Hospital Pricing Authority, 2012) and summed for an individual's hospital stay. Costs are expressed as 2012 AUD.

2.4. Statistical analysis

All analyses were conducted using SAS Enterprise Guide v6.2. (SAS Institute Inc, Cary NC). Descriptive analysis was conducted to characterise the MAS cohort by cognitive status, and differences tested by chi-square or Fisher's exact test for categorical variables as appropriate and students t-tests for continuous variables.

To determine the incidence of injury-related hospitalisations for each cognitive status, the 'person-years at risk' approach was used whereby the total number of injury-related hospitalisations that

Table 1
Cohort characteristics at baseline assessment.

	Total (n = 867)	Normal (n = 539)	MCI (n = 328)	P value
Female, n (%)	494 (57.0)	321 (59.6)	173 (52.4)	0.0495
Age, mean years (SD)	78.7 (4.8)	78.5 (4.8)	78.9 (4.7)	0.2193
Education, mean years (SD)	11.6 (3.5)	11.6 (3.4)	11.5 (3.6)	0.7318
Excellent/very good/good general health[1], n (%)	736 (85.1)	459 (85.5)	277 (84.5)	0.6818
Self-reported multimorbidity [2], n (%)	156 (18.0)	97 (18.0)	59 (18.0)	0.9975
Self-reported history of osteoporosis[3], n (%)	185 (22.2)	124 (23.9)	61 (19.3)	0.1181
No limitations in activities of daily living[3], n (%)	752 (89.7)	464 (90.8)	288 (88.1)	0.2041
Impaired instrumental activities of daily living[4], n (%)	40 (4.8)	19 (3.7)	21 (6.4)	0.0733
Planned physical exercise[5], hours/week, (SD)	1.7 (3.1)	1.8 (2.9)	1.6 (3.3)	0.5752

Notes:
[1] Self-reported general health, categorised as excellent/very good/ good vs fair/poor.
[2] Three or more self-reported comorbidities included in the Charlson Comorbidity Index, excluding dementia.
[3] ADLs measured using Lawton and Brody Physical Self-Maintenance Scale (score range 0–6, with 6 denoting no limitations in ADLs), n = 834, excludes 33 'Don't know' or 'Missing' responses at baseline.
[4] IADLs measured using Bayer-Activities of Daily Living scale (impairment defined as score > 3.0).
[5] Incidental and Planned Exercise Questionnaire- average weekly exercise over the past 3 months.

occurred whilst a person was in a cognitive state (normal, MCI, dementia or unclassified) was divided by the person-years at risk for that cognitive status category. Person-years were calculated as the time in days between assessments for each individual and summed for each cognitive state.

Multimorbidity and osteoporosis were assessed at baseline and at each subsequent wave of the study. Generalised linear mixed models using repeated measures with exposure time as the offset were conducted. The models controlled for the influence of individual characteristics (age and sex) and factors associated with falls and injury risk and outcomes (osteoporosis and multimorbidity) at each wave.

3. Results

The mean age of the participants at baseline assessment was 78.7 (SD = 4.8) years, and 494 (57.0%) were female. Over a third of participants (328, 37.8%) had a baseline classification of MCI. Characteristics of the sample at baseline by cognitive status are shown in Table 1. A higher proportion of participants with MCI were male. There was no difference in mean age, years of education, general health, number of self-reported CCI comorbidities, history of osteoporosis, limitations to activities of daily living (ADLs) and Instrumental Activities of Daily Living (IADLs) or hours of planned physical exercise undertaken each week between participants with MCI and normal cognition.

There was considerable variation in participant's cognitive trajectories over the four study waves as shown in the lasagna plot (Jones et al., 2014) in Fig. 1. By wave four, just under a half (48.8%) of participants classified as having normal cognition at baseline remained classified as normal, 17.8% had progressed to MCI, 4.6% to dementia, 14.5% were unclassified and 14.3% had died. For participants classified as having MCI at baseline; 34.1% remained classified as MCI, 16.5% had reverted to normal cognition, 12.5% had progressed to dementia, 18.6% were unclassified and 18.3% had died. Rapid cognitive decline was not common, with 19 (2.2%) of participants progressing from normal cognition to dementia between consecutive waves.

There were 335 injury-related hospitalisations for participants during the study period; 222 (25.6%) participants had at least one injury-related hospitalisation. Of these, the majority (70.7%) had only one injury hospitalisation. Hospitalisation characteristics by cognitive status are summarised in Table 2. Of the 116 hospitalisations for participants with MCI, the majority (79.3%) were as a result of falls and 6.9% resulted from transport incidents. There were no differences in mechanism of injury between participants with normal cognition, MCI or dementia. For participants with MCI, non-fracture injuries of the head (30, 25.9%), and upper limb and trunk fractures (16, 13.8%) were the most common types of injury. Compared to participants with normal cognition, people with MCI had a higher proportion of head and neck injuries and lower proportion of upper limb fractures. The most common injuries for participants with dementia were non-fracture injuries of the head (7, 23.3%) and hip fracture (6, 20.0%). The average length of stay overall was 14.8 days, with participants with dementia staying on average 2 days longer than either participants with normal cognition or MCI. Thirty-day mortality was low for this cohort, with no difference between participants with normal cognition, MCI and dementia (3.9%, 1.7% and 3.3% respectively), however participants with dementia had higher rate of 28-day unplanned re-admissions (3.9%, 6.2% and 16.7%). The total estimated cost for injury related hospitalisations over the study period was AUD$6.2 million, with median cost of participants with MCI and dementia double that of those with normal cognition.

The injury-related hospitalisation rate for participants with MCI (63.0 per 1000 person-years [95%CI 51.6–74.4]) was significantly higher than for participants with normal cognition (39.3 per 1000 person-years [95%CI 32.4–46.1]) but significantly lower than participants with dementia (137.1 [95%CI 87.2–186.9] per 1000 person-years).

In the age, sex, multimorbidity and osteoporosis adjusted model, participants with MCI had 1.7 (95%CI 1.3–2.4) times higher odds of having an injury-related hospitalisation than participants with normal cognition, whilst participants with dementia had 2.3 (95%CI 1. 3–4.0) times higher odds. There was no difference in odds between participants with MCI and dementia.

4. Discussion

To our knowledge this is the first study to examine injury-related hospitalisation in community-dwelling people with objectively defined MCI. It highlights that people with MCI have a higher rate of injury-related hospitalisations than their cognitively intact peers, but a lower rate than people with dementia. The majority of the hospitalisations for people with MCI were as a result of falls, which supports previous studies suggesting that MCI is associated with an increased risk of falls (Muir et al., 2012) and fall-related injury (Delbaere et al., 2012). Whilst previous studies have relied on self-reported injury data or participant recall of falls in the previous twelve months, the strength of the current study is the linkage to hospitalisation records eliminating the potential for recall bias. Impaired executive functioning and decision-making have been implicated in the increased falls risk, however there was no evidence from our well-functioning community-dwelling sample that

Unclassified		16.0	20.3	16.0
Normal	62.2	48.7	45.7	36.6
MCI	37.8	29.0	20.3	24.0
Dementia		1.9	4.8	7.6
Dead		4.5	8.9	15.8

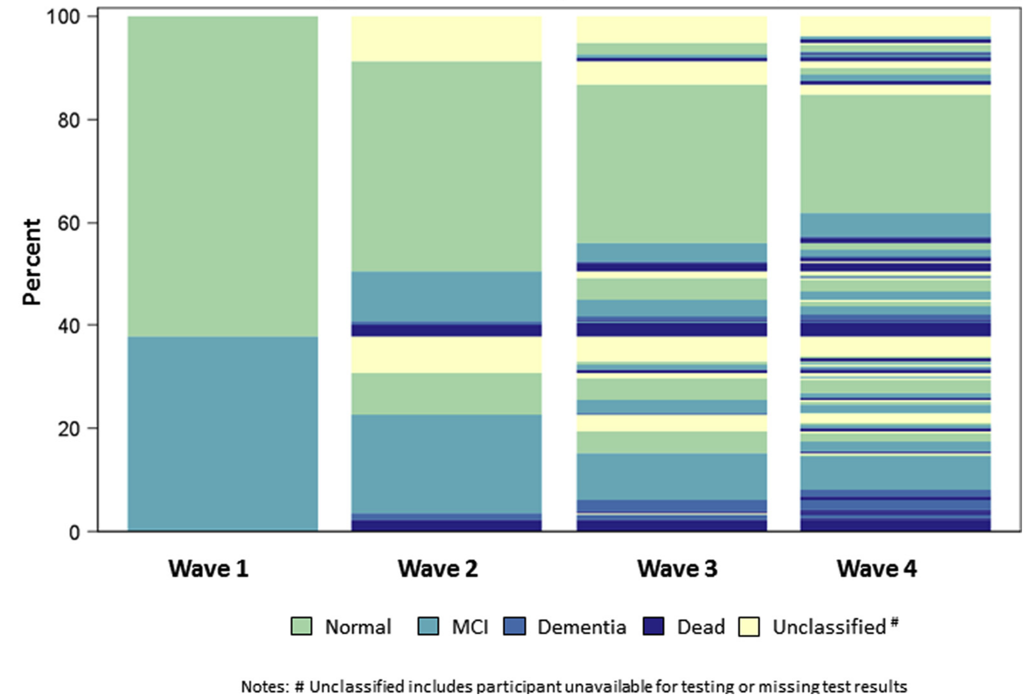

Fig. 1. Plot and marginal distribution table of cognitive status over survey waves.1–4.

participants with MCI were also at increased risk of injuries resulting from transport incidents or other mechanisms compared to participants with normal cognition.

The pattern of injury differed between participants with normal cognition, MCI and dementia. Almost a third of the injuries for participants with normal cognition were to the upper limb with a relatively low proportion of injuries to the head, likely reflecting preserved neuroprotective reflexes and the ability to use one's hands to break the impact of a fall. In contrast, the highest proportion of injuries for people with MCI were to the head with a lower proportion of upper limb fractures, suggesting diminished reflexes. Studies have shown that older adults with MCI have a higher prevalence of gait disturbances, a predictor of future falls, than cognitively normal older adults (Verghese et al., 2008). In our study non-fracture injuries to the head and hip fractures were the most common injuries for people with dementia. It is likely that these participants had mild dementia as all participants were dementia free on recruitment. People with dementia generally have slower gait speeds than those without dementia (van Iersel et al., 2004), resulting in a fall to the side and onto the hip region rather than being propelled forward (Greenspan et al., 1998). This pattern of hip fractures outnumbering upper limb fractures has been reported previously in clinical audits of fractures in people with dementia and residential aged care clients (Jensen et al., 2002; van Dijk et al., 1993).

Early clinical diagnosis of MCI in people with reported cognitive decline may be an important first step for both reducing the risk of serious injury and potentially slowing progression of cognitive decline. Undertaking a falls risk screen and enrolment in falls prevention initiatives may be beneficial for those newly diagnosed with MCI. There is emerging evidence that falls can be prevented among those with dementia (Wesson et al., 2013), however identifying those at risk earlier in the process may provide a valuable window of opportunity for intervention. Although cognitive impairment, assessed using the Mini-Mental State Examination (MMSE), is a common exclusion criterion in falls prevention trials and interventions, it is likely that many people with MCI will not have been identified and therefore included in these interventions. If fall prevention strategies incorporating strength and balance exercise programs (Montero-Odasso et al., 2018) or pharmacological approaches (Montero-Odasso et al., 2009) prove effective among people with MCI, it would have enormous clinical importance. Physical activity is currently considered a key factor in the prevention of MCI, specifically resistance training exercise may attenuate cognitive impairment (Fiatarone Singh et al., 2014).

It is well documented that people with dementia have longer hospitals stays, more unplanned readmissions and higher mortality rates than people without (Harvey et al., 2015). In this study, hospital stays for people with dementia were on average 2 days longer than those with MCI or normal cognition and the rate of unplanned readmission within 28 days was three times higher. There were no differences in 30-day mortality, which was low in our cohort. Hospital costs for the 867 participants over the study period amounted to over AUD$6.2 M for injury-related hospitalisations alone, highlighting the economic imperative for preventing injuries in the older active community-dwelling population, whose numbers will increase over the coming decades.

The strengths of this study include the population-based sample, long study period, linkage to hospital and mortality records and rigorous classification of cognitive status. The study however has several limitations. First, the classification of cognitive status for each injury hospitalisation within a study wave was determined by assessment at the beginning of that wave. There is potential for misclassification where a participant's cognitive status changed during the two year period between assessments as the precise time of transition was unknown. However, to test the impact of this, a sensitivity analysis was

Table 2
Hospitalisation characteristics, outcomes and costs, by cognitive status.

	Normal (n = 127)	MCI (n = 116)	Dementia (n = 30)	Unclassified (n = 62)
Mechanism				
Falls	105 (82.7)	92 (79.3)	28 (93.3)	56 (90.3)
Transport accidents	12 (9.5)	8 (6.9)	0	3 (4.8)
Exposure to inanimate mechanical forces	5 (3.9)	3 (2.6)	0	2 (3.2)
Other	5 (3.9)	13 (11.2)	2 (6.7)	1 (1.6)
Injury type				
Fracture	***67 (52.8)***	***53 (45.7)***	***13 (43.3)***	***33 (53.2)***
Head and neck	6 (4.7)	5 (4.3)	0	3 (4.8)
Upper limb	28 (22.1)	16 (13.8)[a]	3 (10.0)	11 (17.7)
Trunk	15 (11.8)	16 (13.8)	4 (13.3)	12 (19.3)
Hip	10 (7.9)	10 (8.6)	6 (20.0)[a]	4 (6.5)
Lower limb (excludes hip)	8 (6.3)	6 (5.2)	0	3 (4.8)
Non fracture	***60 (47.2)***	***63 (54.3)***	***16 (53.3)***	***29 (46.8)***
TBI	8 (6.3)	2 (1.7)	1 (3.8)	2 (3.2)
Head and neck	10 (7.9)	30 (25.9)[a]	7 (23.3)[a]	15 (24.1)
Upper limb	11 (8.7)	4 (3.5)[a]	1 (3.3)	3 (4.8)
Trunk	8 (6.3)	5 (4.3)	5 (16.7)[b]	6 (9.7)
Lower limb	16 (12.6)	12 (10.3)	2 (6.7)	2 (3.2)
Other	7 (5.6)	10 (8.7)	1 (3.3)	1 (1.6)
Outcome				
Total LOS in days, mean (SD)	12.6 (19.5)	12.6 (16.3)	15.1 (19.2)	13.0 (16.4)
Acute care LOS, mean (SD)	6.7 (10.4)	6.7 (8.9)	8.6 (13.5)	6.8 (7.9)
Rehabilitation LOS, mean (SD)	25.2 (12.4)	21.8 (10.8)	28.0 (14.8)	22.4 (11.8)
30-day mortality	5 (3.9)	2 (1.7)	1 (3.3)	1 (1.6)
28-day unplanned readmission	5 (4.0)	7 (6.2)	5 (16.7)[a]	7 (11.7)
Cost[c]				
Median cost per hospitalisation, $ (IQR)	4712 (2,935-21,783)	8082 (1,368-27,776)	8634 (1,368-34,272)	9593 (2,333-19,123)
Total cost, $M	2.3	2.4	0.6	0.9

Notes: [a] Significantly different to normal ($p < 0.05$), [b] Significantly different to MCI ($p < 0.05$), [c] all costs in AUD.

conducted whereby cognitive status was applied to hospitalisations that occurred within a one-year period before and after the assessment date for each wave. The rate of injury hospitalisations for participants with MCI remained higher than those with normal cognition and lower than those with dementia (data not shown). Second, identification of injury hospitalisations is reliant on the accuracy of hospitalisation coding. In Australia diagnosis codes are used in the calculation of hospital funding and quality-care indicators against which hospitals are benchmarked, hence training of coders has concentrated on ensuring their accuracy. Further, clinical audit has shown there is a high level of concordance between coders in identifying fall-related injuries (McKenzie et al., 2009). Third, the relatively small number of injury hospitalisations for individuals with MCI meant the study was not powered to explore differences in injury patterns by subgroups of MCI. Finally, we would expect that individuals who experience a rapid decrease in cognitive performance would be at increased risk of injury compared with individuals who did not decline, or declined more slowly over time, however due to the small number of individuals who declined rapidly and sustained an injury in our cohort (n = 4) we unable to explore this relationship.

5. Conclusion

Older people with objectively defined MCI are at higher risk of injury, predominantly as a result of falls, than their cognitively intact peers, highlighting a potentially vulnerable population with the ability to gain from strategies for injury risk minimization and specifically falls prevention initiatives.

Declaration of interests

None.

Acknowledgements

The authors thank the participants and research team of the Sydney Memory and Ageing study, the NSW Ministry of Health and the NSW Registry of Birth, Deaths and Marriages for the provision of the hospitalisation and death data extracts, and the Centre for Health Record Linkage (CHeReL) for the provision of the unique patient identifiers used to link the datasets. The MAS study was supported by an Australian National Health and Medical Research Council Program Grant (350833) and Capacity Building Grant (358940). Lara Harvey was supported by an Australian National Health and Medical Research Foundation Early Career Fellowship. Rebecca Mitchell was supported by the NSW Ministry of Health under the NSW Health Early-Mid Career Fellowship Scheme.

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