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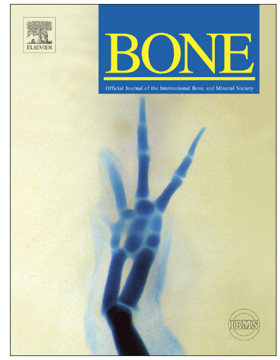

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The epidemiology of hip fractures across Western Victoria, Australia

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Abstract

Background

Hip fractures are associated with considerable morbidity and mortality. Hip fracture incidence varies across different levels of accessibility/remoteness and socioeconomic status (SES). As part of the Ageing, Chronic Disease and Injury Study, we aimed to map the pattern of hip fractures across the western region of the Australian state of Victoria, which contains a range of remoteness levels and SES.

Methods

Data on hip fractures resulting in hospital admission were extracted from the Victorian Admitted Episodes Dataset (VAED) for men and women aged 40+ years during 2010-2013 inclusive. An age-adjusted incidence rate (per 10,000 population/year) was calculated for the entire region. Crude incidence rates and length of acute care hospital stay (excluding rehabilitation) were calculated for each Local Government Area (LGA). The impact of aggregated age, accessibility/remoteness index of Australia (ARIA) and SES on hip fracture rates aggregated across LGAs was determined using Poisson regression.

Results

For men, the age-standardised rate of hospitalisations for hip fracture across the whole region was 19.2 per 10,000 population/year (95%CI 18.0-20.4) and for women, 40.0 (95%CI 38.3-41.7). The highest incidence rates for both sexes occurred in the less accessible LGAs of Yarriambiack and Hindmarsh, as well as the LGA with the lowest SES, Central Goldfields. In both sexes, approximately two thirds of individuals were discharged from acute hospital care within 14 days. Increasing age, higher remoteness and lower SES were all associated with higher hip fracture rates.

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Conclusion

Crude incidence rates varied by location. Given that a high proportion of patients had acute hospital care of ≤14 days, and accessibility and SES were associated with hip fracture rates, these results can inform policy and provide a model for other groups to conduct similar research in their local environment.

Keywords: hip fracture; women; men; Australia; incidence; accessibility/remoteness; socioeconomic status

Highlights:

Hip fractures rates varied across different geographical areas.

Increasing remoteness was associated with an increase in hip fracture rates.

Increasing socioeconomic status was associated with a decrease in hip fracture rates.

Most patients had an acute hospital care length of stay ≤14 days.

Men appeared to have longer lengths of stay for acute hospital care than women.

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Introduction

Hip fractures are associated with considerable morbidity and can lead to decreased quality of life, chronic pain, disability, increased demand on health infrastructure and institutionalisation, as well as an increase in mortality [1-4]. Hip fractures are a significant public health issue for both sexes; one in three hip fractures occur in men and mortality is 2-3 times higher than in women [5]. Hip fractures are also associated with extended hospital stays and significant hospitalisation costs. In Australia, between 2008 and 2009, older men and women who sustained hip fractures had a mean length of stay (including readmissions) of 30.8 days, and mean hospitalisation cost between AUD$23,243 and AUD$33,576 per admission [6, 7]. The incidence of hip fractures seems to have stabilised or even declined in developed countries [3, 5, 8, 9], however, the absolute numbers of hip fractures and additional comorbidities are increasing due to an ageing population [3, 10].

Risk factors for hip fractures include advanced age, female sex, greater height, low bone mineral density (BMD), low body mass index (BMI), comorbidities, smoking, drinking (alcohol), reduced cognitive function, impaired vision, medication use, impaired balance, physical inactivity and falls [10-12]. Place of residence is also an important risk factor for hip fractures and length of stay post-fracture [13]. Geographical variations in hip fracture rates between countries, and in different regions in the same country, have been reported [2, 14]. For example, hip fracture rates are nearly seven times higher in northern, compared to southern, European countries [2, 14]. A similar pattern exists across North America, where the more northern states of America have a higher hip fracture rate than southern states [2].

Residents of urban areas have been reported to have a ~30% higher risk of hip fracture than residents of rural areas and data suggest that this is not entirely due to the preferential placement of aged-care institutions in urban areas [15, 16]. Previous studies have also

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reported that individuals living in urban areas have lower BMD, which may contribute to higher hip fracture rates [1, 12, 17, 18]. A higher incidence of fractures at all skeletal sites in urban areas has also been reported in the USA [19] and in Australia [16]. However, this pattern is not supported in all studies. In Australia, health is generally poorer in rural residents due to lesser accessibility to health services and migration of older individuals away from urban areas following retirement [20]. Individuals living in rural areas are three times less likely to undergo BMD testing, are less likely to use vitamin D supplements, calcium supplements or bisphosphonates and thus are less likely to be aware that they have osteoporosis, or receive treatment to manage osteoporosis, than individuals who live in an urban area [20]. Socioeconomic status (SES), measured at the area-level (rather than an individual level), is another factor that affects hip fracture incidence. A higher incidence of hip fractures has been reported in areas with lower SES, which may be mediated by a lower BMD in lower SES areas [12, 18, 21]. Our data on the impact of SES on major osteoporotic fractures (including hip fracture) also indicated that individuals with lower SES had higher rates of these type of fractures [22]. However, a few studies have reported a lower hip fracture incidence in lower SES areas [3, 23] and one reports no association between SES and hip fracture rates [24].

This study forms part of the larger Ageing, Chronic Disease and Injury (ACDI) study [25], which aims to map the pattern of chronic diseases and injury across the western region of the Australian state of Victoria. The ACDI study region includes urban, rural and agricultural areas, with a range of SES. The ability to identify gaps in healthcare service delivery, as well as implement intervention and prevention strategies is dependent upon obtaining contemporary data. The ACDI study will provide this type of data, allowing targeted resource allocation to effectively manage the burden of chronic disease and injury, as well as demonstrating a profiling model which can be used in other geographical regions, particularly

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in non-metropolitan settings. Studies from this region will also allow assessments of internal (in region) changes in health practices and how these impact healthcare, as well as comparison to other regions. This may allow broader validation of not only hip fractures, but also a range of other drivers of fractures and healthcare outcomes. This study aimed to investigate the incidence of hip fractures in men and women aged 40+ years as part of the larger ACDI study.

Methods

Study Region

Australia comprises eight states and territories; the state of Victoria is the second most populous (Figure 1). In Victoria, there are 79 clearly-defined geographical regions known as Local Government Areas (LGAs). The study region includes 21 of these 79 LGAs, making up nearly one-third of the state by area. In 2011, the estimated residential population for the study region was 617,794, representing ~11% of the population in Victoria. The study region encompasses a large number of individuals aged 40 years or older; they constitute ~51% (~316,000) of the total population [26]. The study region covers large agricultural areas that generate 60% of the state's total dairy production and major cropping areas in its north-west sector. Overall, there is a trend for an increasing proportion of the population to be aged 40+ years in the more western (rural) areas of the study region (Figure 1). This is a sentinel area from which the evidence may inform other regions and locations.

The study region contains LGAs with different levels of accessibility and remoteness. We used the Australian Bureau of Statistic's (ABS) Accessibility/Remoteness Index of Australia (ARIA) classification score to estimate urban or rural status. ARIA takes into account

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distance from localities, access to goods and services and opportunities for social interaction [27]. These scores are divided into five categories ranging from highly accessible (≤1.84), accessible (1.84-3.51), moderately accessible (3.51-5.80), remote (5.80-9.08) and very remote (≥9.08). In this study region, the LGAs of Hindmarsh, West Wimmera and Yarriambiack have the highest ARIA scores (4.4, 4.1 and 3.9 respectively), which are in the 'moderately accessible' category. These areas are mostly agricultural based LGAs producing grain and sheep [28]. The other LGAs in the study region are in the 'highly accessible' or 'accessible' categories, with no LGAs in the 'remote' or 'very remote' categories. It is also important to note that within Victoria the highest possible ARIA is 4.4, that belongs to the LGA of Hindmarsh in the study region. Three of the LGAs in the region (Hindmarsh, West Wimmera and Yarriambiack) rank within the top five LGAs with the highest ARIA scores in Victoria; Hindmarsh ranks as first (4.4), West Wimmera second (4.1), East Gippsland third (3.9), Yarriambiack fourth (3.9) and Mildura, fifth (3.8).

The study region also has a wide range of SES, as measured by the Index for Relative Socioeconomic Advantage and Disadvantage (IRSAD) scores (2011 Census data). IRSAD scores are divided into deciles using cut-points for the state of Victoria, with decile 1 being the most disadvantaged (IRSAD < 931) and decile 10 being the most advantaged (IRSAD >1059) [29]. The study region contains LGAs across all deciles of IRSAD scores, except for the sixth decile.

<u>Data Source</u>

The data source for this study was the Victorian Admitted Episodes Dataset (VAED), which provides a complete dataset of all public and private hospital admissions in the state of Victoria, Australia. In Victoria, all residents have access to hospital-based health care (either

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publicly or privately funded, depending on health insurance status). The VAED currently uses the International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modifications (ICD-10-AM) [30], which has eight codes for "fracture of femur," however only three of them are related to hip fractures (S57.0, S57.1 and S57.2). We obtained aggregate data from the VAED for all hospital admissions occurring in the region during the years 2010 to 2013 inclusive, with a diagnosis of hip fracture. This study, is part of the larger ACDI study [25] which aims to determine the burden of chronic conditions across the region of western Victoria, among individuals aged 40 years and over. Therefore, for this analysis, we excluded data for individuals aged <40 years as hip fracture rates are low in younger ages and are more likely to be due to higher energy trauma. We also obtained data from the VAED regarding the length of acute care stay in hospital (excluding rehabilitation), stratified by weeks. The Barwon Health Human Research Ethics Committee approved this study (HREC 15/11).

Statistical analyses

Analyses were performed using aggregated data from 2010-2013 (inclusive). This is unlikely to have caused problems with the statistical analysis because hip fracture incidence did not change significantly over this time period. For the four years investigated, 2010, 2011, 2012 and 2013, the hip fracture incidence rates (per 10,000 population/year) for men and women aged 40+ over the whole study region were 35.2 (95%CI 33.1-37.4), 33.4 (95%CI 31.4-35.5), 34.2 (95%CI 32.2-36.3) and 34.1 (95%CI 32.1-36.2), respectively (all $p>0.05$).

The analyses were divided into two parts: (i) the whole study region and (ii) by LGA. For the whole study region, an overall age-adjusted incidence rate was calculated as well as the incidence rates by age decade. Direct age standardisation to the 2011 Australian population

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was completed using data from the ABS 2011 Census Community Profile Series [31]. Hip fracture incidence rates were expressed as fractures per 10,000 population per year, however, to improve clarity, Figure 2 has been presented on a logarithmic scale with rates reported as 100,000 population/year. Population data from the ABS National Regional Profiles by LGA were used to estimate hip fracture rates and calculate 95%CIs [32].

For LGA level, the calculation of age-adjusted incidence rate was not possible for each LGA separately, as VAED does not release data fields that have <5 cases due to privacy/ethics issues and some LGAs had small numbers of hip fractures in some age decades. Only the total numbers of fractures aggregated by age groups were available for each LGA, therefore standardisation was not possible. Instead, we used the percentage of residents aged over 70 years in each LGA as an aggregated age factor. Crude incidence rates were calculated for each LGA. We calculated incidence rates with data for men and women separately, as the pattern of hip fractures is different between the sexes.

For length of acute care hospital stay, a distribution stratified by weeks was calculated for the whole study region. For separate LGAs, the proportions of long hospital stays were calculated, which involved determining the proportion of hip fracture admission cases that had an acute care hospital stay longer than 14 days.

An additional analysis was conducted to investigate associations between age (i.e. percentage of individuals aged 70+ years in each LGA), ARIA and IRSAD (converted to quintiles) across the LGAs and corresponding hip fracture rates. This was performed using Poisson regression for aggregated data and incidence rate ratios (IRR) were calculated. Since we did not have age-stratified data for each LGA, this analysis adjusts for age using the proportion of total residents in each LGA who were aged 70 years or over, as this is the age with the highest number of hip fractures, and therefore are at the highest risk [33]. Stata (version 13,

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StataCorp, 2013) and Minitab (version 16, Minitab, State College, PA, USA) were used for all analyses.

Results

<u>Incidence rates</u>

Whole study region

During the study period, there were 1,305 fractures sustained by men and 2,903 by women. The incidence rate of hip fractures across the entire region increased with age for both men and women (Figure 2a). For men, the rate ranged from 2.8 per 10,000 population/year (95%CI 2.0-3.7) in the 40-49 year age-group to 37.3 (95%CI 33.2-41.7) in the 70-79 year age-group and 159.4 (95%CI 148.1-171.3) in the oldest age-group (80+ years). For women, the rate ranged from 0.4 per 10,000 population/year (95%CI 0.2-0.9) in the 40-49 year age-group to 70.9 (95%CI 65.5-76.6) in the 70-79 year age-group and 276.8 (95%CI 265.0-288.9) in the oldest age-group (80+ years).

Hip fracture incidence rates for the whole region were different between men and women. For men, the unadjusted incidence rate was 21.2 (95%CI 20.0-22.3) and the age-adjusted rate was 19.2 (95%CI 18.0-20.4). For women, the unadjusted rate was 45.4 per 10,000 population/year (95%CI 43.7-47.0) and the age-adjusted rate was 40.0 (95%CI 38.3-41.7).

The absolute number of hip fractures is presented in Figure 2b. The pattern is similar to that observed in Figure 2a for incidence rates. The oldest group (80+ years) has the highest

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number of hip fractures (725 in men and 2013 in women) and the lowest number was observed in the 40-49 years age-group (45 in men and 7 in women).

Local Government Areas

Figures 3a and b show maps of crude hip fracture incidence in men and women, aged 40+ years for all LGAs across the study region. In men, the highest incidence rates of hip fractures occurred in Hindmarsh (46.0 per 10,000 population/year 95%CI 31.3-65.3) and Yarriambiack (35.9 95%CI 24.4-50.9), which represent sparsely populated areas of western rural Victoria used for cropping and grazing, as well as Central Goldfields (39.0 95%CI 29.6-50.3), which is primarily a cropping and sheep farming area, as well as meat and meat product manufacturing, other food manufacturing and printing, and has the lowest IRSAD in the entire state. These LGAs also had the highest rates of hip fractures in women, with incidence rates of 64.1 (46.8-85.7), 93.1 (95%CI 74.1-115.4) and 77.9 (95%CI 64.6-93.0), respectively. Both the Northern and Southern Grampians, which represent western rural areas, also had high rates of hip fractures in women; 61.6 (95%CI 49.3-76.0) and 63.6 (95%CI 52.7-76.1), respectively.

Length of acute care hospital stay

Entire western Victoria region

Figure 4 shows the distribution of length of acute care hospital stay across the entire western Victoria region for men and women. For both men and women, the length of acute hospital stay was usually less than 14 days. For men, 42% were discharged after 1-7 days, a further 25% after 8-14 days, and 33% were discharged after more than 14 days. The pattern in

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women was similar; 40% were discharged after 1-7 days, 28% after 8-14 days and the remaining 33% after more than 14 days.

Local Government Areas

Figures 5a and b and Table 2 show the percentage of long acute care hospital stays (length of stay 15+ days) by LGA for men and women, respectively. In men, the highest percentages of individuals with a long acute care hospital stay occurred in residents of Queenscliffe (67%), which comprises a large number of retired older adults, followed by two rural LGAs; Pyrenees (43%) and Hepburn (43%). The lowest percentage for men occurred in residents of Horsham (18%) and Hindmarsh (19%), which are both rural LGAs in the western area of the study region. In women, the highest percentage of long acute care hospital stays occurred in residents of Queenscliffe (42%). The lowest percentages for women occurred in residents of Ararat (14%), Corangamite (21%) and Moyne (24%). Overall, women appeared to have shorter length of acute care hospital stay than men across many LGAs in the study region.

Age, Accessibility/Remoteness and Socioeconomic status

The LGA of Golden Plains, which has a high proportion of individuals working in the manufacturing industry, had the lowest proportion of residents aged 70+ years; 12.8% for men and 13.3% for women. The proportion was highest in Queenscliffe, where a large proportion of retirees reside, with 31.5% of men and 38.2% of women, aged 70+ years.

Analyses showed that hip fracture rates increased with an increasing proportion of individuals in the population aged 70+ years (Table 3). For men, the IRR was 1.079, meaning that for

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every 1% increase in the population aged 70 years or over in the LGA, the hip fracture rate increased by 7.9%. Age was more important in women than men, with an IRR of 1.097.

Increasing ARIA score (indicative of increasing remoteness) was also associated with an increase in hip fracture rate in this analysis. For men, the IRR was 1.664, indicating that for every one point increase in ARIA score, the hip fracture rate increased by 66.4%. In women, the effect was greater, with an IRR of 2.095, indicating an increase of more than twofold for every one point increase in ARIA.

IRSAD was inversely associated with an increase in hip fracture rates (all $p<0.001$). For men, the lowest quintile had an incidence rate of 32.2 (95%CI 28.0-36.8) and the highest quintile, 15.4 (95%CI 11.3-20.4). Hip fracture data for women also followed this pattern; 64.9 (95%CI 59.0-71.4) and 36.4 (95%CI 30.1-43.7) for the lowest and highest quintiles of IRSAD, respectively.

Bubble plots for the association between age (LGAs population are visualised by bubble size), ARIA and IRSAD are shown in Figure 6. There were some exceptions to the associations for age; for example, hip fracture incidence rate was lower than expected in Queenscliffe, for both men and women (Figure 6a and d), and in the rural LGA of Pyrenees for men (Figure 6a). West Wimmera also had lower rates than expected based on ARIA in both men and women (Figure 6b and e). Further, there were also a group of rural LGAs with higher rates than expected based on IRSAD: Hindmarsh, Central Goldfields, Yarriambiack, Northern Grampians and Ararat (Figure 6c and f).

Discussion

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This study examined age-adjusted fracture incidence rates for hospital admission due to hip fracture across the western Victorian region of Australia. Incidence rates and acute length of stay differed across LGAs according to ARIA and IRSAD scores. Incidence rates were highest in the western rural LGAs of Hindmarsh and Yarriambiack, as well as the central rural LGA of Central Goldfields, which has the lowest IRSAD score in the state of Victoria. Length of acute care hospital stay also varied between LGAs, and was greater in men. Increasing age and ARIA were associated with higher hip fracture rates while increasing IRSAD was associated with lower hip fracture rates in both men and women.

Area-level SES has been associated with hip fracture rates. Reyes et al [3] investigated the association between hip fractures (during 2009-2012) and SES quintiles in Spanish men and women, measured using the MEDEA score, and reported that hip fracture rates were lower in the lowest SES quintile compared to the highest quintile. That study reported hip fracture incidence rates (per 10,000 person-years) of 34.3 (95%CI 32.9-35.8) and 38.5 (95%CI 37.1-40.0) in the lowest and highest SES quintiles, respectively. In this study, rates for men and women combined were 48.6 (95%CI 44.9-52.5) and 26.1 (95%CI 22.3-30.4) in the lowest and highest quintiles of IRSAD, respectively. The reasons for the differences between our study and the Spanish study could include differences in age/sex composition, definition of SES (MEDEA score versus IRSAD score) and that the Spanish study only examined individuals living in urban areas, whereas we investigated individuals living in both urban and rural areas.

Guilley et al [18] have reported, using income as a measure of SES, that Swiss men and women with a medium income have a lower hip fracture incidence than those with lower income, independent of urban/rural status. Another study by Bacon et al [34] also used area-level income as a proxy measure for SES and reported that after adjustment for age and sex, areas with the highest income had a lower hip fracture rate (31 per 10,000 persons/year)

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compared to the lowest income areas (51 fractures per 10,000). Another study in Swedish residents [23] used several different measures of SES and reported that hip fracture rates were higher in those who were not living with a partner (ORs 2.91, 95%CI 2.72–3.13 for women and 2.21, 95%CI 2.02–2.41 for men), lower in those not born in Sweden (0.40, 95%CI 0.35–0.45 for women and 0.42, 95%CI 0.34–0.52 for men) and lower in those areas with social status (defined as a combination of population density, car ownership, and proportion of people in rented accommodation) of a medium (0.73, 95%CI 0.68–0.78 for women and 0.77, 95%CI 0.69–0.85 for men) and low (0.67, 95%CI 0.59–0.77 for women and 0.61, 95%CI 0.48–0.76 for men) level. A similar result was found in Oslo, Norway; hip fracture rates were higher in areas that were considered to have lower SES (RRs ranged from 1.23, 95%CI 1.03–1.48 for women and 1.67, 95%CI 1.14 –2.24 for men) [35]. Our results are similar; we also report an increased hip fracture incidence in LGAs with greater socioeconomic disadvantage.

Not all studies report a higher hip fracture rate in areas with lower SES. A study by West et al [23] used Townsend scores as a measure of SES across residents of the UK to determine any relationship with hip fracture rate, reported no association. Additionally a study by Icks et al [36] reported that although they found a higher risk of hip fractures in areas with a higher proportion of individuals receiving welfare (RR 1.07), single parent families (RR 1.02) and a higher population density (RR 1.01), they also reported that a higher unemployment rate as well as a higher number of foreign-born individuals was associated with a lower hip fracture risk (RRs 0.91 and 0.96, respectively).

Some studies have identified an interaction of SES with age. One such study by Jones et al [37] examined the effect of area-level SES on hip fracture rates in Wales, and found that lower SES was associated with higher hip fracture rates in younger age groups (<85yr; 1.64, 95% CI 1.57-1.72), but there was no association for older age groups (85+yr; RR 0.94, 95% CI 0.87-1.01). Another study in Portugal [38] also reported a similar result; compared to

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deprived areas, more affluent areas had a lower hip fracture rate in younger age-groups (50+54yr; RRs 0.83, 95%CI 0.65-1.00 for women and 0.90, 95%CI 0.66-1.34 for men), but a higher rate in older age groups (85+yr; 1.09, 95%CI 1.01-1.18 for women and 1.16, 95%CI 1.03-1.30 for men). Benetou et al [39] also report that living alone was associated with a higher hip fracture risk in those aged 60-69yr (HR 1.12, 95 %CI 1.02–1.22), but the effect was less pronounced in other age-groups (1.07, 95 %CI 1.01–1.14).

In regards to urban/rural status, several studies have reported lower hip fracture rates in rural areas compared to urban areas [18, 40, 41], which is the opposite of what we report in this study. These differences may be due to the under-treatment of osteoporosis in Australian rural areas [20], differences in how urban/rural status was measured, as well as differences between countries. Sanders et al [16] conducted an investigation of fracture rates across the Barwon Statistical Division, which includes parts of the same region encompassed by the ACDI study. That study also reported a lower rate of hip fracture in rural compared to urban areas, however, it did not include the moderately accessible LGAs and much of the "rural" areas in that study were semi-urbanised, which may have affected the observed results.

In another study by Falch et al [42] investigating Norwegian hip fracture rates in men and women, the incidence of hip fracture in the rural area was approximately two-thirds of the hip fracture incidence in the urban area. In our study, the LGAs with the lowest accessibility (i.e. moderately accessible; Yarriambiack, West Wimmera and Hindmarsh), had a combined hip fracture incidence rate of 52.3 (95%CI 45.6-59.8) per 10,000 population/year (data for men and women combined). The highly accessible LGAs had an average of 32.4 (95%CI 31.3-33.5), while for the accessible LGAs it was 36.1 (95%CI 33.6-38.8), which are 62% and 69% of the moderately accessible LGAs, respectively. Although the magnitude of the difference is similar between urban and rural areas in both this study and the Norwegian study, the pattern is reversed; we report a higher incidence in areas with higher ARIA score, while the

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Norwegian study reports a lower incidence in rural areas. The reasons for these differences are unclear, but could be due to different countries and years of data collection, as well as different definitions of urban or rural status, as well as activities of those based in the rural communities. However, one study of indigenous and non-indigenous individuals residing in Western Australia [43] reported the same result as the current study; those living in non-metropolitan areas had higher rates of hip fractures (175.0; 95% CI 168.1–81.9 per 100,000 person-years for non-indigenous persons) than metropolitan areas (141.7; 95% CI 138.8–144.7 per 100,000 person years for non-indigenous persons).

There are a number of risk factors associated with lower SES that impact hip fracture risk including lifestyle factors leading to lower BMD such as poor diet, lower physical activity, higher levels of smoking and alcohol consumption, as well as healthcare factors such as less BMD testing, poor accessibility to healthcare, inadequate built environment and lower uptake of treatment [18, 21, 44-46]. One study by Byberg et al (2015) [44] reported that diet plays an important role in hip fracture risk. The researchers detected a dose-response between daily fruit and vegetable intake and hip fracture, resulting in a plateau of five servings per day. This suggests that fruit and vegetable intake may influence hip fracture risk through increasing BMD, reducing oxidative stress, inflammation processes and diet-induced acidosis, all of which impact bone health [44]. Diet, and many of these factors are influenced by health literacy, particularly meeting the recommended daily intakes of calcium and vitamin D [47], as well as understanding the results provided by DXA scans for osteoporosis [48]. Different components of health literacy (such as health numeracy, finding and understanding health information, social support) vary throughout the population, with some groups having strengths in some areas, while being weaker in others [49]. This makes effective interventions more difficult to implement across the entire population.

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There are factors associated with urban or rural residency that impact hip fracture incidence rates, including occupation, physical activity and sun exposure (which impacts vitamin D) as well as factors such as environmental hazards, pollution and climate extremes [1, 12, 50]. In several studies, urban regions report higher rates of hip fractures [1, 15, 16, 42], while others report higher rates in rural areas [3, 17]. It is difficult to attribute increased hip fracture rates to migration of individuals because some older adults move closer to cities to have better access to healthcare, whereas others move away from cities after retirement, and those on farms often continue working well past retirement ages [1, 25]. Meanwhile, many young people migrate to cities, seeking employment, which reduces the overall incidence of chronic conditions, including hip fractures in the urban areas [1]. Rural living throughout childhood and adolescence has, however, been reported to provide health benefits, even if an individual migrates to an urban area later in adulthood [14, 15, 51]. Whilst this may occur through increased peak bone mass, additional studies are required to investigate this further.

Regarding acute length of stay in hospital for hip fracture, we observed some differences across the LGAs. Overall, length of stay was longer in the more accessible areas towards the east (Geelong, Colac) and shorter in the less accessible areas in the west of the study region. This is unlikely to be due to transfer of patients from less accessible to more accessible regions, as our data considers residential address, not the address of the hospital where the hip fracture was managed. It is possible that older individuals and those in poorer health live closer to medical services and that these patients have a longer length of stay in hospital [52]. Another possibility is that the more accessible areas have easier access to rehabilitation and are transferred to rehabilitation, rather than spending longer in acute hospital care. We have also reported a higher length of stay in men, which may be due to older age or more comorbidities. Additionally, acute length of stay may not capture the total length of stay, since some patients may have been discharged to rehabilitation [6].

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Strengths and limitations

This study has several strengths. The VAED collates data from all hospitals in the state of Victoria, which provides a comprehensive dataset for determining hip fracture incidence rates for the study region. Since almost all hip fractures are hospitalised [53], it is unlikely that we have missed many cases. Unfortunately, we did not have data regarding discharge destination after acute hospital admission and therefore the total length of hospital stay may be underestimated for persons discharged to rehabilitation or other non-acute hospital care. We were also not able to determine which patients resided in aged care and which were community-dwelling. In this study, we investigated a large geographical area, including LGAs with a wide range of ARIA and IRSAD scores. However, there are also limitations that need to be taken into consideration. In this study, we performed a direct age standardisation to the 2011 Australian population, as the numbers of hip fractures in each age group was not accessible. Implementing an indirect standardisation method with the Australian population as the reference population was not possible as Australia-wide sex-age specific hip fractures are not available. We decided to implement direct age standardisation method with a well-known reference population (i.e. Australian population) rather than performing indirect age standardisation with the study region population as reference population due to major limitations of using a local reference population, specifically being only comparable with rates from the same region, rather than Australia-wide. ARIA and IRSAD were investigated on an area-level, rather than at the individual level. Our measure of urban or rural status involved determination of remoteness and accessibility, and thus may not accurately reflect urban or rural settings. Differences in ARIA scores might not differentiate more subtle rural/urban differences in our region. Additionally, no LGAs in this study were in the "remote" or "very remote" ARIA categories, as there are no such LGAs within the state of Victoria and we have included the LGA with the highest ARIA in the state (Hindmarsh). The

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LGAs included in this study have a high level of diversity, from cities to large regional and rural centres as well as LGAs with small populations and large areas including agricultural lands. We have also used aggregated data for our analysis and cannot make any specific interpretations at an individual level.

Conclusion

The age-adjusted incidence rates for hospital admission due to hip fracture were calculated for the entire western Victoria region, in Australia. The rates across the region were higher in women than men. Three rural LGAs in the west and central areas of the study region had higher crude incidence rates than others. Across all LGAs overall, women had higher rates of hip fracture than men. Across the entire region, approximately one third of patients had an acute care length of stay longer than 14 days. This figure varied between LGAs and, overall, men had a higher proportion of acute care hospital stays with a duration longer than 14 days. Older age, lower accessibility and lower IRSAD were all associated with increasing hip fracture rates and may suggest reasons for the differences observed between LGAs. These results may have implications for the provision of care, particularly for rural and more socioeconomically disadvantaged areas, as well as providing a model which can be used by others research groups in similar environments. Future research, particularly monitoring incidence rates and the factors affecting changes, which will provide insight into the most effective way to reduce hip fractures in other areas that are similarly regional.

Acknowledgements

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Figure Legends

Figure 1: Location of the Study region. Local Government Areas (LGAs) included in the study are shaded according to the percentage of individuals aged 40 years and over; from 45.0-49.9% to 65.0-69.9%. Data for graphic was obtained from the Department of Health and Human Services, State Government of Victoria, Australia [54] (graphic prepared by MAS and KLH). Graphic from [25].

Figure 2: a) Incidence rate (per 100,000 population/year) and b) number of fractures for individuals admitted to hospital for an acute hip fracture during 2010-2013 (inclusive) across the entire western Victoria region for men (unfilled) and women (shaded), stratified by age decades. Error bars represent 95%CIs.

Figure 3: Heat map showing crude incidence rate for a) men and b) women aged >40 years admitted to hospital for a hip fracture across the study region during 2010-2013 inclusive. The legend shows the shading as incidence rate per 10,000 population/year; from <12 to 60+. AR=Ararat, BA=Ballarat, CG=Central Goldfields, CO=Colac-Otway, C=Corangamite, GL=Glenelg, GP=Golden Plains, GE=Greater Geelong, HP=Hepburn, HI=Hindmarsh, HS=Horsham, MR=Moorabool, MO=Moyne, NG=Northern Grampians, PY=Pyrenees, Q=Queenscliffe, SG=Southern Grampians, SC=Surf Coast, WA=Warrnambool, WW=West Wimmera and Y=Yarriambiack.

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Figure 4: Length of acute care hospital stay for individuals admitted to hospital for a hip fracture during 2010-2013 (inclusive) in the entire western Victoria region for men (unfilled) and women (shaded).

Figure 5: Heat map showing the proportion of a) men and b) women aged 40+ years admitted to hospital for a hip fracture who had an acute care hospital length of stay >15 days, across the study region during 2010-2013 inclusive. The legend shows the shading as percentage of individuals from each LGA with hip fracture, who had a length of stay in hospital of 15 days or more. AR=Ararat, BA=Ballarat, CG=Central Goldfields, CO=Colac-Otway, C=Corangamite, GL=Glenelg, GP=Golden Plains, GE=Greater Geelong, HP=Hepburn, HI=Hindmarsh, HS=Horsham, MR=Moorabool, MO=Moyne, NG=Northern Grampians, PY=Pyrenees, Q=Queenscliffe, SG=Southern Grampians, SC=Surf Coast, WA=Warrnambool, WW=West Wimmera and Y=Yarriambiack.

Figure 6: Bubble plots for association between age (proportion of the population aged 70 years or over), ARIA (Accessibility/Remoteness Index of Australia) and socioeconomic status (SES; Index for Relative Socioeconomic Advantage and Disadvantage; IRSAD) and crude hip fracture rates occurring during 2010 to 2013 (inclusive) in the region of western Victoria. LGAs population are visualised in the scale of their circular bubbles. Size of bubbles indicate LGAs population size.

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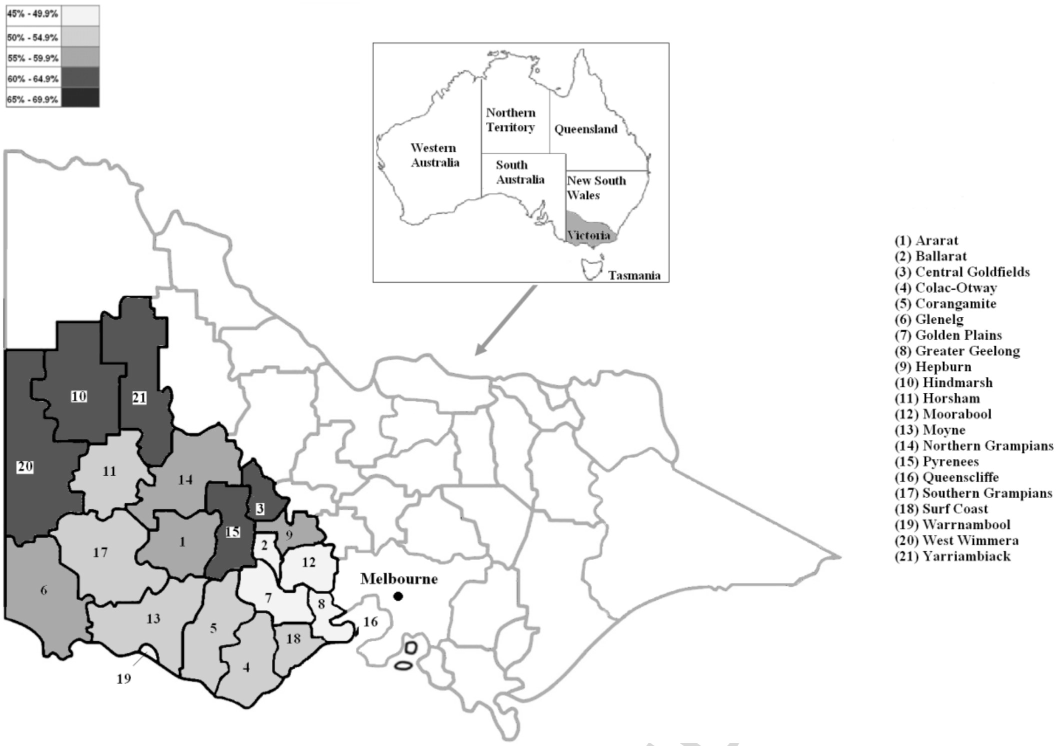

Fig. 1

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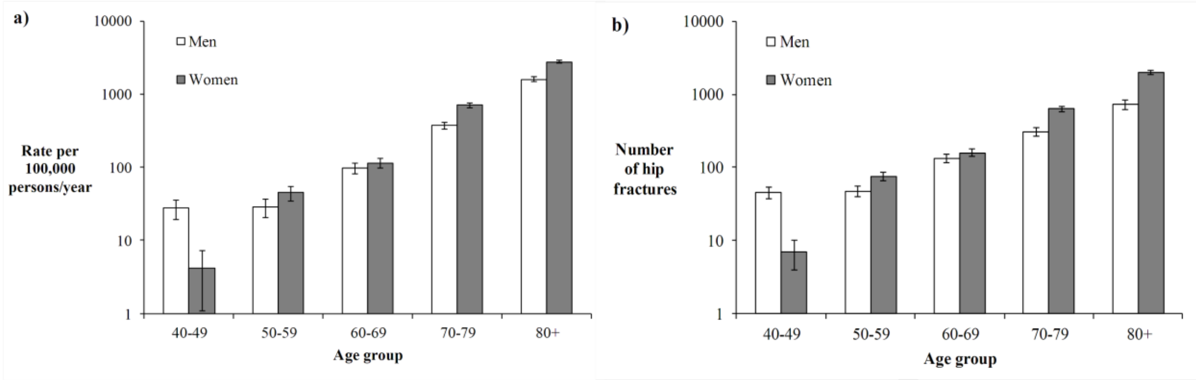

Fig. 2

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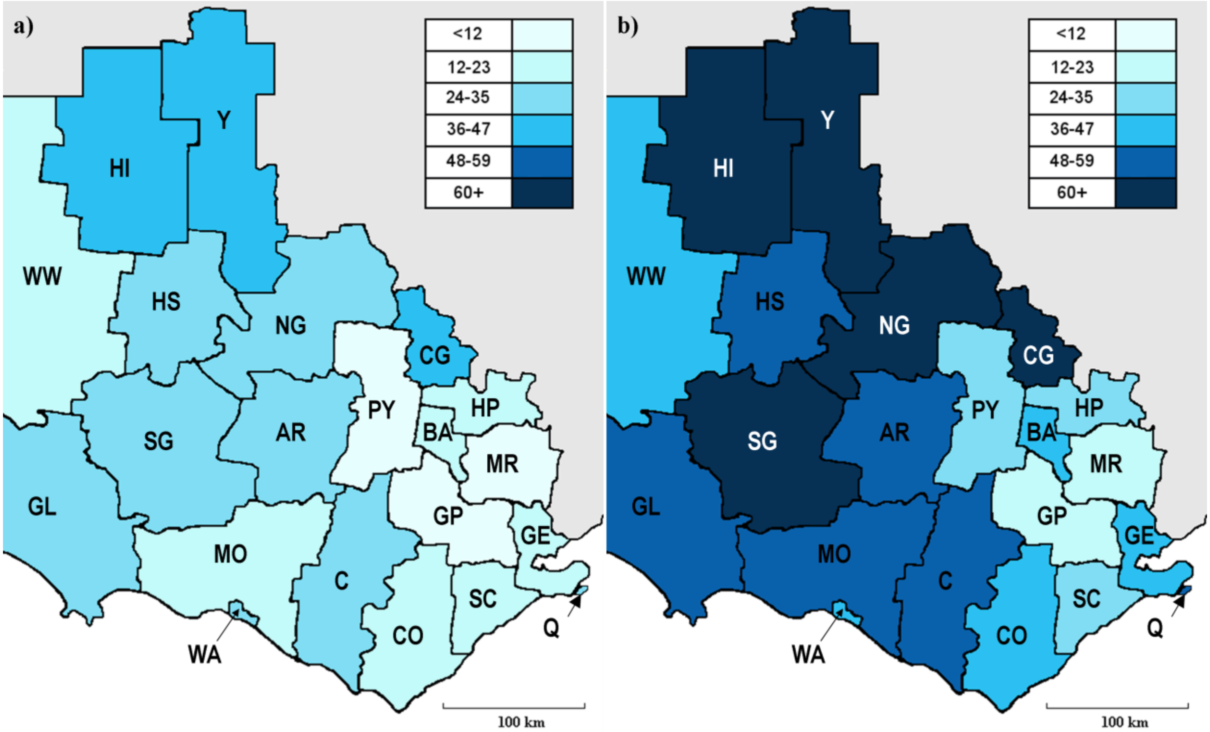

Fig. 3

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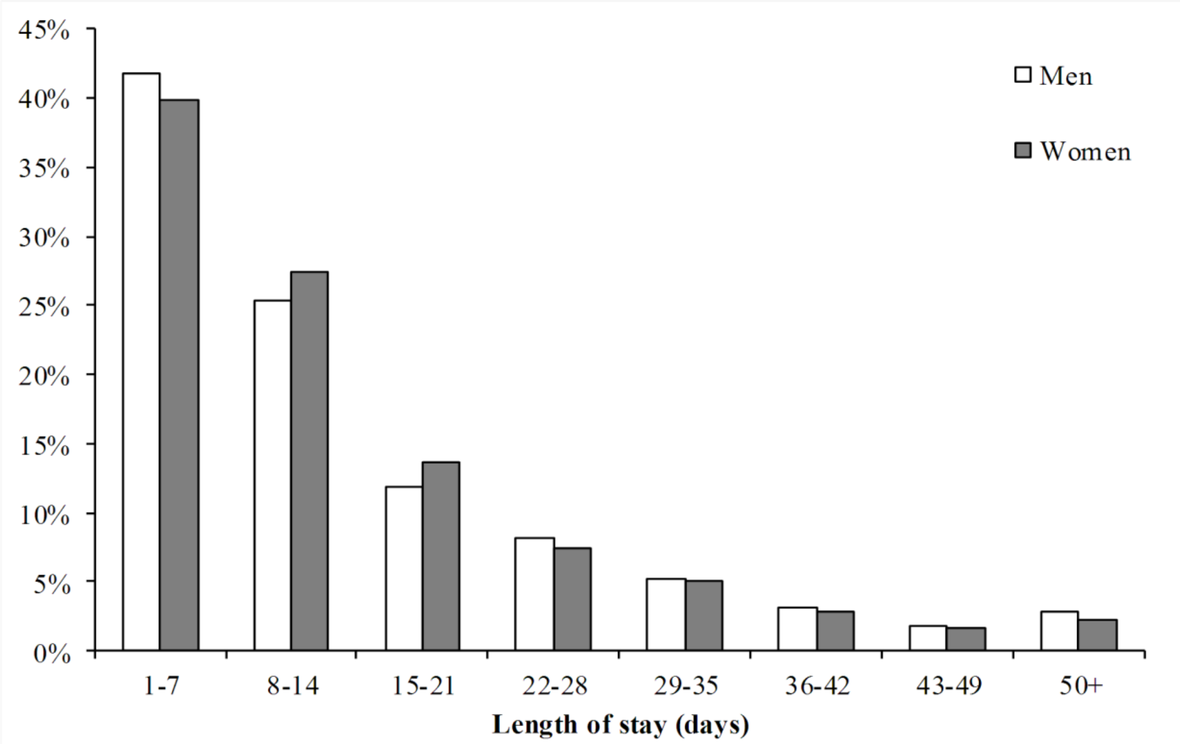

Fig. 4

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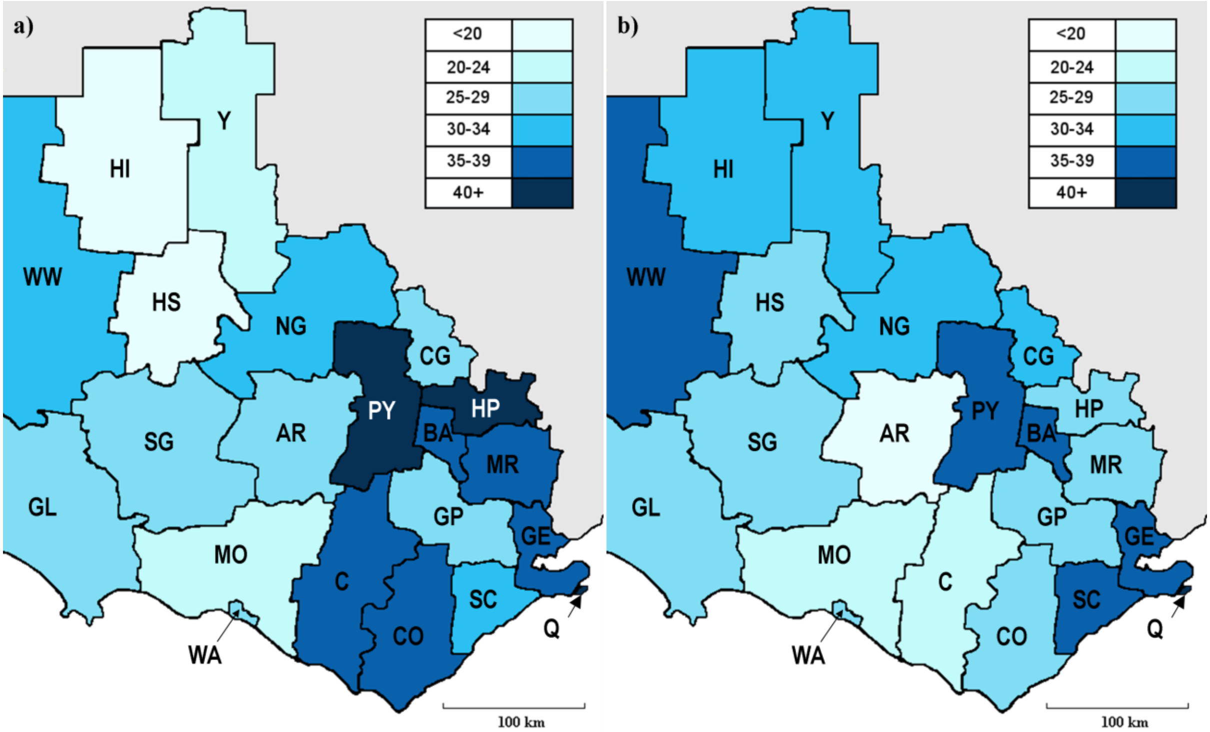

Fig. 5

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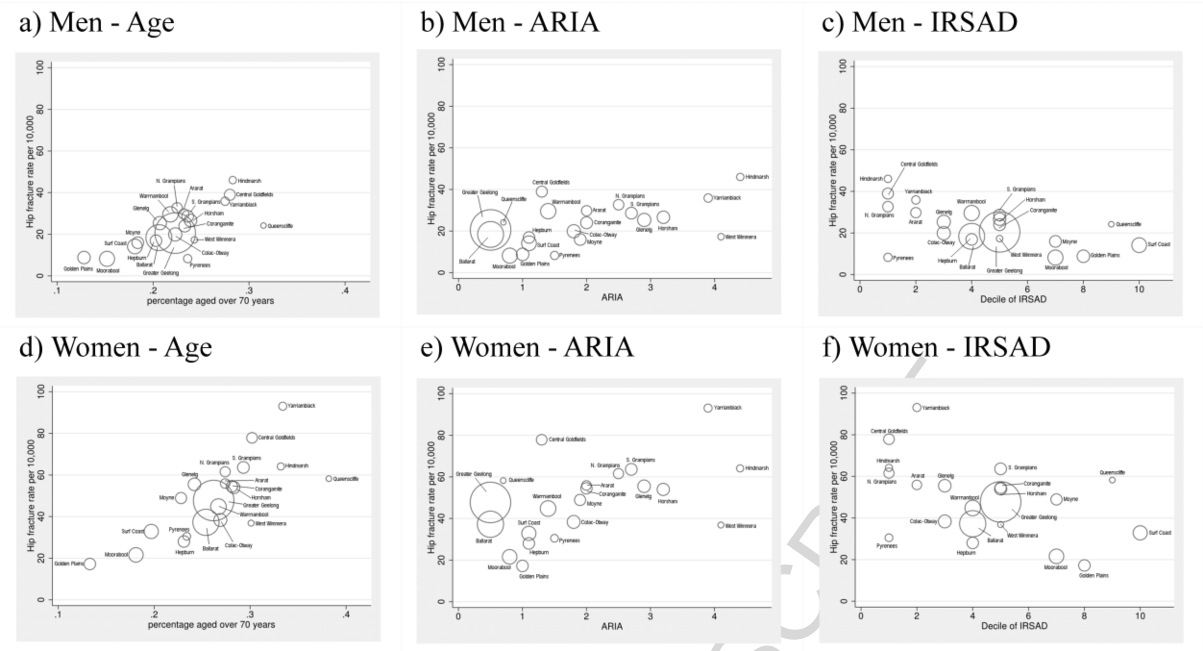

Fig. 6

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Table 1: Incidence rates for hip fracture across the ACDI study region during 2010-2013, stratified by Local Government Area (LGA) and sex. Data presented as rate per 10,000 persons per year (95%CI).

LGA	Men	Women
Ararat	29.8 (21.2-40.7)	55.9 (43.5-70.7)
Ballarat	18.4 (15.6-21.5)	37.3 (33.5-41.4)
Central Goldfields	39.0 (29.6-50.3)	77.9 (64.6-93.0)
Colac-Otway	19.9 (14.4-26.7)	38.4 (30.7-47.3)
Corangamite	24.0 (17.3-32.4)	54.5 (44.2-66.5)
Glenelg	25.3 (19.1-33.0)	55.5 (46.0-66.4)
Golden Plains	8.8 (5.1-14.1)	17.2 (11.7-24.4)
Greater Geelong	20.6 (18.6-22.6)	47.7 (44.9-50.7)
Hepburn	16.9 (11.2-24.4)	28.0 (20.9-36.9)
Hindmarsh	46.0 (31.3-65.3)	64.1 (46.8-85.7)
Horsham	26.6 (19.8-35.0)	54.0 (44.4-65.0)
Moorabool	8.2 (5.2-12.3)	21.6 (16.6-27.7)
Moyne	16.0 (10.5-23.2)	48.9 (39.0-60.6)
N. Grampians	32.7 (23.7-43.8)	61.6 (49.3-76.0)
Pyrenees	8.3 (3.3-17.1)	30.5 (19.8-45.0)
Queenscliffe	24.2 (11.1-45.9)	58.2 (38.1-85.2)
S. Grampians	28.6 (21.2-37.8)	63.6 (52.7-76.1)
Surf Coast	14.1 (10.0-19.4)	32.9 (26.4-40.4)
Warrnambool	29.6 (23.7-36.5)	44.8 (37.9-52.6)
West Wimmera	17.3 (7.9-32.8)	36.9 (21.9-58.2)
Yarriambiack	35.9 (24.4-50.9)	93.1 (74.1-115.4)

† Standardised to the Australian 2011 Population.

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Table 2: Length of stay (LoS) for men and women aged 40+ years admitted to hospital for a hip fracture across the study region during 2010-2013 inclusive. Data presented as percentage (%) of individuals in each Local Government Area (LGA) with a LoS of 1-7 days, 8-14 days or 15+ days.

LGA	Men			Women		
	1 - 7 days	8 - 14 days	15 + days	1 - 7 days	8 - 14 days	15 + days
Ararat	46	26	28	58	28	14
Ballarat	36	27	38	38	25	37
Central Goldfields	50	24	26	47	23	30
Colac-Otway	44	19	37	49	24	26
Corangamite	38	26	36	57	22	21
Glenelg	49	22	29	45	25	29
Golden Plains	41	29	29	42	32	26
Greater Geelong	34	28	38	33	29	37
Hepburn	32	25	43	45	29	25
Hindmarsh	55	26	19	42	24	33
Horsham	55	27	18	40	32	28
Moorabool	43	22	35	45	27	27
Moyne	63	15	22	47	29	24
Northern Grampians	48	20	32	47	20	34
Pyrenees	57	0	43	40	24	36
Queenscliffe	22	11	67	19	38	42
Southern Grampians	41	31	29	50	24	26
Surf Coast	50	16	34	27	36	38
Warrnambool	43	28	29	43	30	28
West Wimmera	22	44	33	33	28	39
Yarriambiack	48	29	23	40	27	33

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Table 3: Coefficients and Incidence Rate Ratios (IRR) for analysis of association between hip fracture incidence rates for 2010-2013 in western Victoria and; age (proportion of the population aged 70 years or over) and ARIA (Accessibility/Remoteness Index of Australia). IRRs presented as mean (95% confidence interval).

	Coefficient		Incidence Rate Ratios	
	Men	Women	Men	Women
Age	0.0765	0.0929	1.079 (1.077-1.082)	1.097 (1.096-1.099)
ARIA	0.509	0.739	1.664 (1.622-1.708)	2.095 (2.060-2.130)

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