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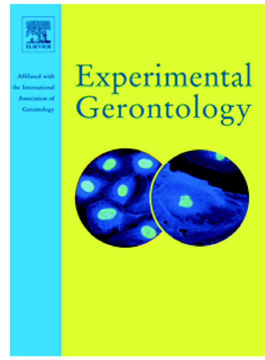

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Geospatial Modelling of the Prevalence and Changing Distribution of Frailty in Australia – 2011 to 2027

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Conflict of Interest

The authors have no competing interests to declare.

ABSTRACT

Background and Objectives:

Detailed information about the current and future geographic distribution of Australia's frail population provides critical evidence to inform policy, resource allocation and planning initiatives that aim to treat and reverse frailty. Frailty is associated with poor health outcomes, including disability and death. It is also characterised by increased health care usage and costs. Understanding the distribution and growth of frailty is important for planning and budgeting service provision and health interventions aimed to support the needs of Australia's growing ageing population. The objective of this research is to provide baseline mapping and area level population estimates of Australia's current and future frail and pre-frail populations.

Research Design and Methods:

Geospatial modelling was applied to national frailty prevalence rates to provide estimates of the size, distribution and potential growth of Australia's frail and pre-frail population.

Results:

It is estimated that in 2016 approximately 415,769 people living in Australia aged 65 years or more are frail and almost 1.7 million people are pre-frail. In future years, as the population ages, these figures will increase rapidly, reaching 609,306 frail and 2,248,977 pre-frail by 2027, if prevalence continues at current levels. The geographic distribution of this projected growth is not uniform and while the largest frail populations will continue to be located in the major cities, the fastest growth will be in the outer metropolitan, regional and remote areas.

Discussion and Implications:

The projected growth of frail populations in outer metropolitan, regional and remote areas may be reduced by targeting health interventions in these areas and improving access to support services. Frailty is a dynamic condition that is amenable to intervention. Reducing frailty will lead to benefits in wellbeing for older Australians in addition to reductions in health care costs.

Keywords: ageing; mapping; planning; population; Geographical Information Systems; aged care services

1. Introduction

In 2016 there were over 3.6 million Australians aged 65 years and older, accounting for 15.7% of the total Australian population (Australian Bureau of Statistics 2016a), and this percentage is projected to increase to 18% by 2027 (Australian Institute of Health and Welfare 2017). These changes are being driven by the ageing of Australia's large baby boomer (1946-1964) cohort the increasing longevity of the population and low fertility rates. Associated with the ageing population, the estimated number of older Australians that are frail or pre-frail is increasing rapidly, although the geographic distribution of the frail population in Australia is hidden.

Visibility might assist policy makers and service providers' better target frailty services to those in need. In keeping with this, a recent report commissioned by the Australian Department of Health has also recommended Geographic Information Systems (GIS) mapping of frailty prevalence as a key component of the strategy to better facilitate healthy ageing, identifying this information as an indispensable resource for both researchers and policy makers (Benetas 2017). Geographic information about local frail and pre-frail populations may provide the opportunity to better target services to the locations of most need. Local information on the number of frail and pre-frail people in an area, together with information on their particular social and environmental context is likely to achieve a more informed needs based model which is both more equitable and efficient.

Frailty is a state of increased vulnerability to adverse health outcomes such as loss of mobility, falls, hospitalisation, disability and death (Collard et al. 2012). Pre-frailty refers to the intermediate state between robustness and frailty, representing an intermediate level of elevated vulnerability. Frailty is not an inevitable consequence of ageing (Arendts et al. 2017). Not all people will develop frailty, and importantly, an individual's severity of frailty can change, resulting in declines or improvements in frailty status (Thompson et al. 2018). In addition to the personal, family and social impacts of frailty, it is also associated with increased health service use, health costs (Ilinca and Calciolari 2015), and reliance on hospital emergency services (Dent et al. 2017). Frailty is treatable and multifactorial interdisciplinary interventions, tailored to individual circumstances, can be effective at treating and preventing frailty (Fairhall et al. 2008, Cameron et al. 2013).

Facilitating healthy ageing and preventing frailty is an issue of national and international importance, which will not only benefit the wellbeing of older populations, but also result in broader social and economic benefits to families, communities and society (Morley et al. 2013). The World Health Organisation recognises the importance of "age-friendly environments" as an important contributor to healthy ageing (World Health Organisation 2015). If frailty is to be better managed and where possible prevented, it is important that planners, policy makers and service providers have information regarding the size and location of Australia's vulnerable ageing population in order to be able to allocate resources where they are required and shape environments so that they may best support ageing in place.

Variations in the reported prevalence of frailty can be the result of the different methods of frailty measurement (Thompson et al. 2018), for example, measures that focus only on physical measures, such as the Fried frailty phenotype (Fried et al. 2001) generally have a lower prevalence than those that also consider a broader range of factors, such as the frailty index (Mitnitski et al. 2001). A recent analysis by Thompson et al. (2018), which used the Fried frailty phenotype (Fried et al. 2001), has determined the likely prevalence of frailty for community dwelling women and men in defined age groupings from the results of four pooled Australian population studies. The data used by Thompson et al. (2018) was drawn from the North West Adelaide Health Study (NWAHS) and three population based samples contained within the Dynamic Analysis to Optimise Ageing Project (Dynopta), the Australian Longitudinal Study of Women's Health (old Cohort) (ALSWH), the Australian Diabetes and Obesity Lifestyle Study (AusDiab) and the Blue Mountains Eye Study (BMES). The NWAHS and the BMES were focused on the populations located in north-western Adelaide and western Sydney respectively, while the ALSWH and AusDiab data collections were nationally focused. Three of the four studies included data for both community dwelling men and women, while the ALSWH data included data only for women. While ALSWH records data for both community and institutional dwelling individuals, Thompson's study only used those that were identified as living in the community. The resulting pooled frailty prevalence reflects frailty prevalence among the community dwelling Australian population. These Australian frailty prevalence rates are broadly consistent with the findings of an international systematic review of frailty prevalence (Collard et al. 2012), although the frailty prevalence among the Australian community dwelling population over 75 years of age was lower than the rates identified in this systematic review. Age and gender are key intrinsic factors associated with frailty prevalence and incidence, although lifestyle, socio-economic and environmental influences have also been identified as modifying influences (Woo et al. 2010).

The aims of this study were to apply the frailty and pre-frailty prevalence findings, based on age and gender differences, of Thompson et al (2018) uniformly to Australian population statistics to estimate and map frailty and pre-frailty prevalence across Australia. No regional or area level variations in prevalence have been estimated. The geospatial modelling and mapping of frailty will produce national age and gender based frailty estimates, showing the geographic distribution of frailty and pre-frailty for the first time across Australia, both now and with projections for the future. We have been unable to find other national or international examples of frailty prevalence mapping at an equivalent scale or extent and believe this study could be the first of its type.

2. Research Design and Methods

This study used national age and sex frailty and pre-frailty prevalence (Thompson et al. 2018) (Table 1.) and geospatial demographic modelling applied to the 2011 and 2016 Australian Bureau of Statistics (ABS) Census of Population and Housing (census) data and to the Australian Institute of Health and Welfare (AIHW) 2027 population projections (Australian Institute of Health and Welfare 2017). The primary spatial unit of analysis, the Statistical Area 2 (SA2), is a medium sized statistical unit defined by the ABS to represent communities. Within urban areas they generally represent suburbs (Australian Bureau of Statistics 2016b). SA2s have an average population of 10,000 persons and their boundaries are reviewed and refined by the ABS for each census, every five years. This research uses 2011 and 2016 SA2 census data and boundaries and 2011 SA2 boundaries for the AIHW projected population estimates for 2027.

The population projections referenced in this study have been produced by the Australian Bureau of Statistics (ABS) for the Australian Government Department of Social Services (Australian Institute of Health and Welfare 2017). Population projections are not absolute forecasts, but indicate how the population could change given certain assumptions and historical trends. The SA2 level projections, used by this study, are derived from estimated residential population counts by single year of age and sex, at 30 June 2012 (Australian Bureau of Statistics 2013a) and used the cohort-component method (Australian Institute of Health and Welfare 2017). The projections combine the medium scenario State/Territory assumptions (Australian Bureau of Statistics 2013b) with historical patterns observed in each SA2 (Australian Institute of Health and Welfare 2017). The projections commence from 30 June 2013 to 30 June 2027, with this study using the final projection year in the series. These projections were the only national small area population projections suitable for the calculation of national frail and pre-frail prevalence available at the time of the analysis.

Broader level analysis is also presented for ABS Greater Capital City Statistical Areas (GCCSA) (Australian Bureau of Statistics 2016b) and Accessibility/Remoteness Index of Australia Plus (ARIA) Remoteness Areas (Australian Bureau of Statistics 2018), shown in Figure 1a and 1b. The GCCSA areas are aggregated from the smaller SA2 areas and allow comparisons to be made between each of the eight state and territory capital cities and the areas outside the capital city areas (Australian Bureau of Statistics 2016b). The remoteness areas have been derived from average SA2 ARIA scores for 2011 and 2016 (Hugo Centre 2013, Hugo Centre 2018) classified using the ABS Remoteness Areas classification.

Age Cohorts	**65 to 69 years**		**70 to 74 years**		**75 to 79 years**		**80 plus years.**	
	M	F	M	F	M	F	M	F
Frail %	3	6	4	10	8	20	14	27
Pre-Frail %	37	39	39	43	47	51	42	50
Not Frail %	60	55	57	48	45	30	44	23

Source: Thompson et al. (2018)

Table 1 Australian Frailty Prevalence Rates by Aged and Gender

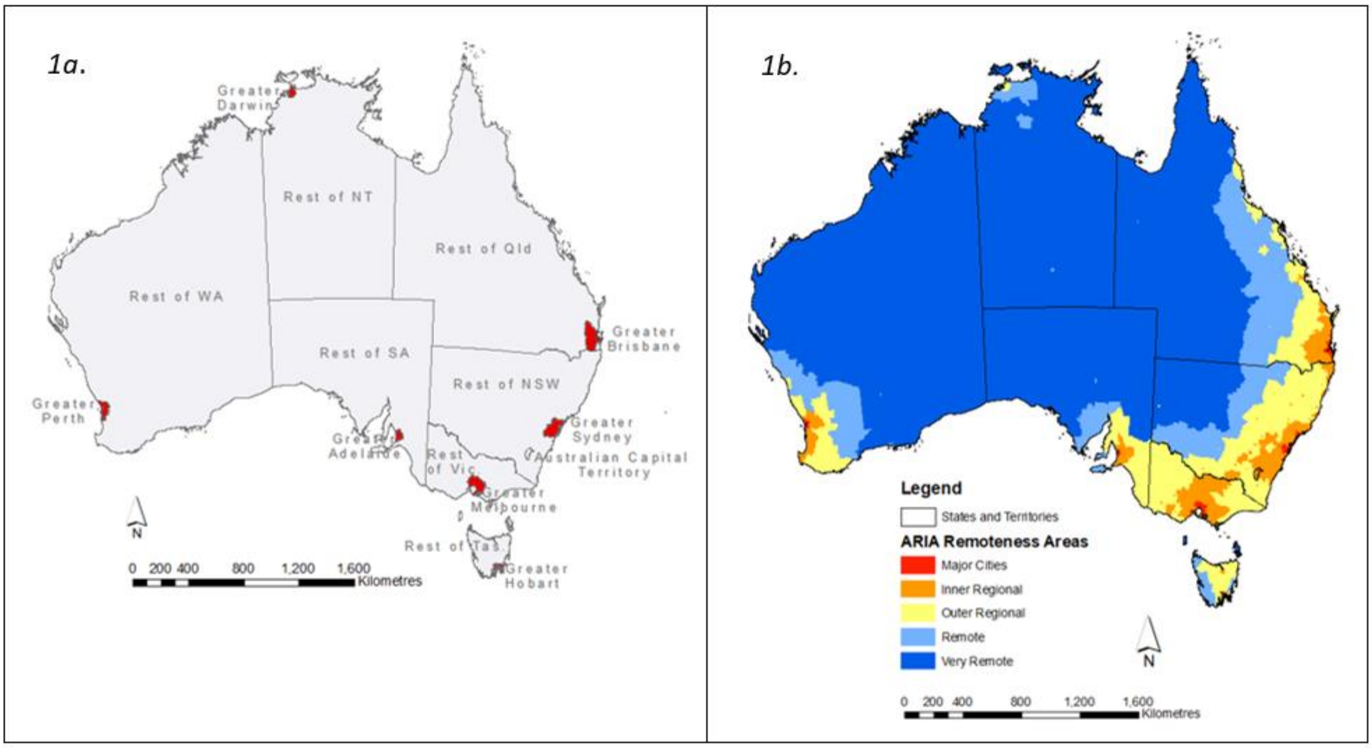

Figure 1. Geographic Classifications (a.) Greater Capital City Statistical Areas 2016 (b.) 2016 ARIA Remoteness Areas

Estimated frailty and pre-frailty figures were calculated for the total population aged over 65 years for the 2011 and 2016 census data and the 2027 population projections. The frailty estimates in this study are conservative, as frailty prevalence was based on community dwelling older people, despite rates for aged care residents typically being higher than community dwelling populations (Theou et al. 2016). However, in the absence of any current Australian phenotype frailty prevalence for nursing home residents, it was not possible to make any informed adjustment to the rates to account for nursing home residents.

To facilitate the detailed exploration, examination and use of the frailty and pre-frailty estimates, an interactive web mapping application has been developed and accessible at http://www.spatialonline.com.au/frailtyestimates. The application includes four web maps. The first two maps show the geographic distribution of frail and pre-frail populations in 2016 and allows comparison, using a map slide bar, between total population and community dwelling population estimates, at SA2 level. The community dwelling population estimates exclude populations over 75 years that at the time of the census resided in a non-private dwelling, such as an aged care facility. While included in the web maps, community dwelling population estimates are not further discussed in this paper as the focus here is on total population estimates. The second two maps display the frail and pre-frail estimates for 2011 and 2027. Each map includes a slide bar, which facilitates comparison of the rates for 2011 and 2027 for different SA2 areas. Numerical frail and pre-frail estimates for areas of interest can be accessed by clicking on the area, which will initiate a popup window with details about the selected region. Caution needs to be applied when interpreting the results of the modelled frailty estimates, particularly those with small numbers. In addition to the influence of respondent and processing errors which may have a larger influence on small numbers, the ABS uses randomisation of small numbers to protect individual confidentiality (Australian Bureau of Statistics 2016c), resulting in small estimates being less reliable than those that are larger.

3. Results

3.1 Modelled Frailty Estimates 2011 and 2016

Calculated frailty estimates from 2016 census data found that over half of the 3.7 million Australians aged 65 years or more were either frail (415,769) or pre-frail (1,577,362). This represents an increase of 20.5% in the combined frail and pre-frail populations in Australia since 2011, an average annual growth of approximately 68,000 people. When analysed by remoteness the largest numbers of frail and pre-frail populations are found within major cities with numbers declining with increasing remoteness. In 2016 approximately 64% of the estimated frail and pre-frail populations were located within major city areas.

The estimated numbers of frail and pre-frail populations by GCCSA areas for 2011, 2016 and for the 2027 population projections are seen in Figure 2. The largest estimated frail and pre-frail populations within capital city regions are in Greater Sydney and Melbourne (Figure 2), with each area estimated to have been home to approximately 350,000 frail or pre-frail individuals in 2016. The remainder of NSW (the Rest of NSW, outside Sydney) had the largest estimated frail and pre-frail population outside the capital city regions and is estimated to have had almost 300,000 frail or pre-frail individuals in 2016. Darwin and the Northern Territory have the smallest estimated frail and pre-frail populations, reflecting the smaller and younger population of this territory.

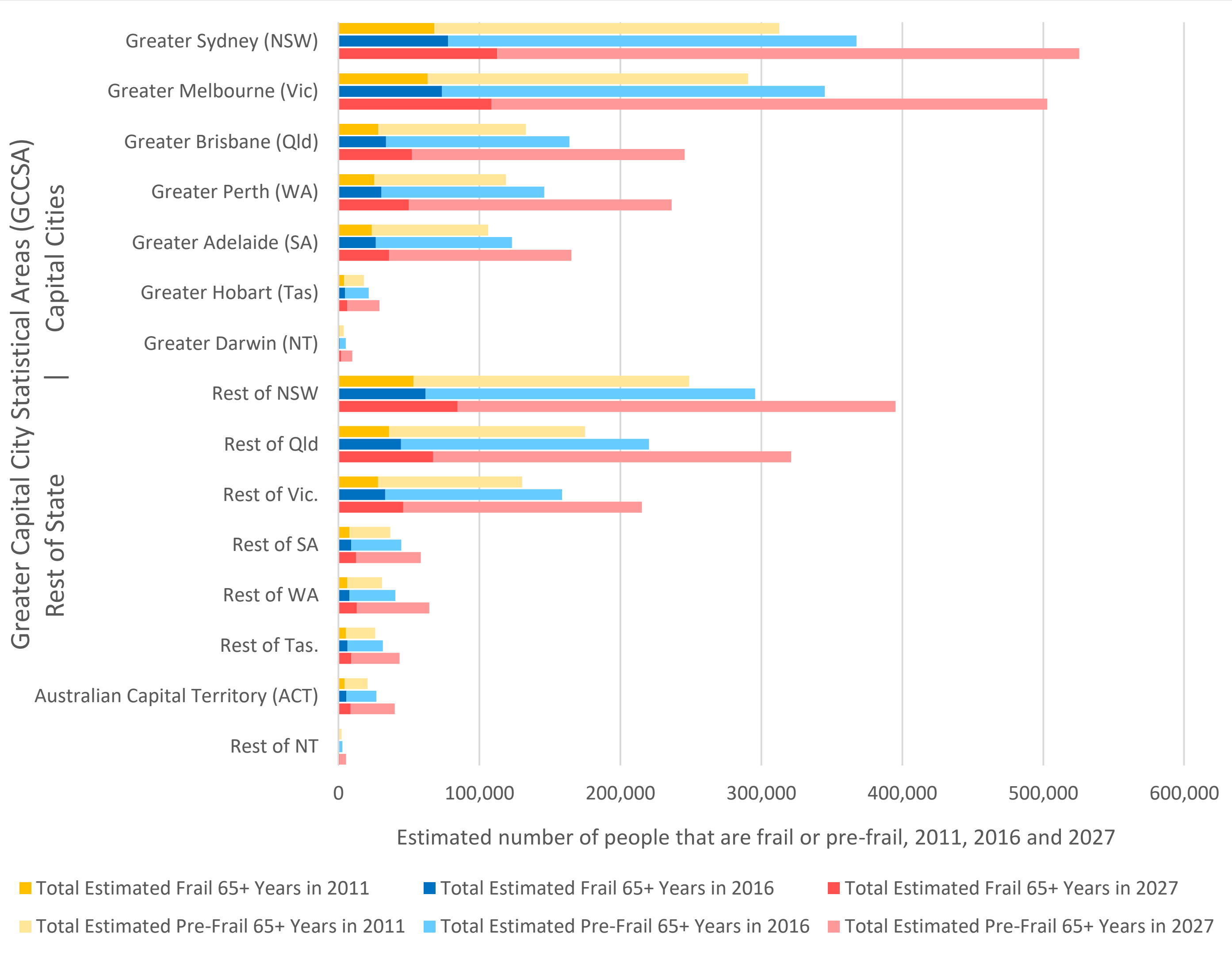

Figure 2. Estimated Frail and Pre-Frail Population by Greater Capital City Statistical Areas (GCCSA) for 2011, 2016 and 2027

Figure 3 shows the estimated national distribution of frailty among the population aged 65 years or more in 2016 by SA2 areas. The SA2 areas with the largest estimated frail populations, each with more than 800 frail people in 2016 are: Rosebud-McCrae (Vic); Port Macquarie-East (NSW); Mornington (Vic); and Bribie Island (Qld). For frail and pre-frail estimates for other SA2s the reader is referred to the interactive web map.

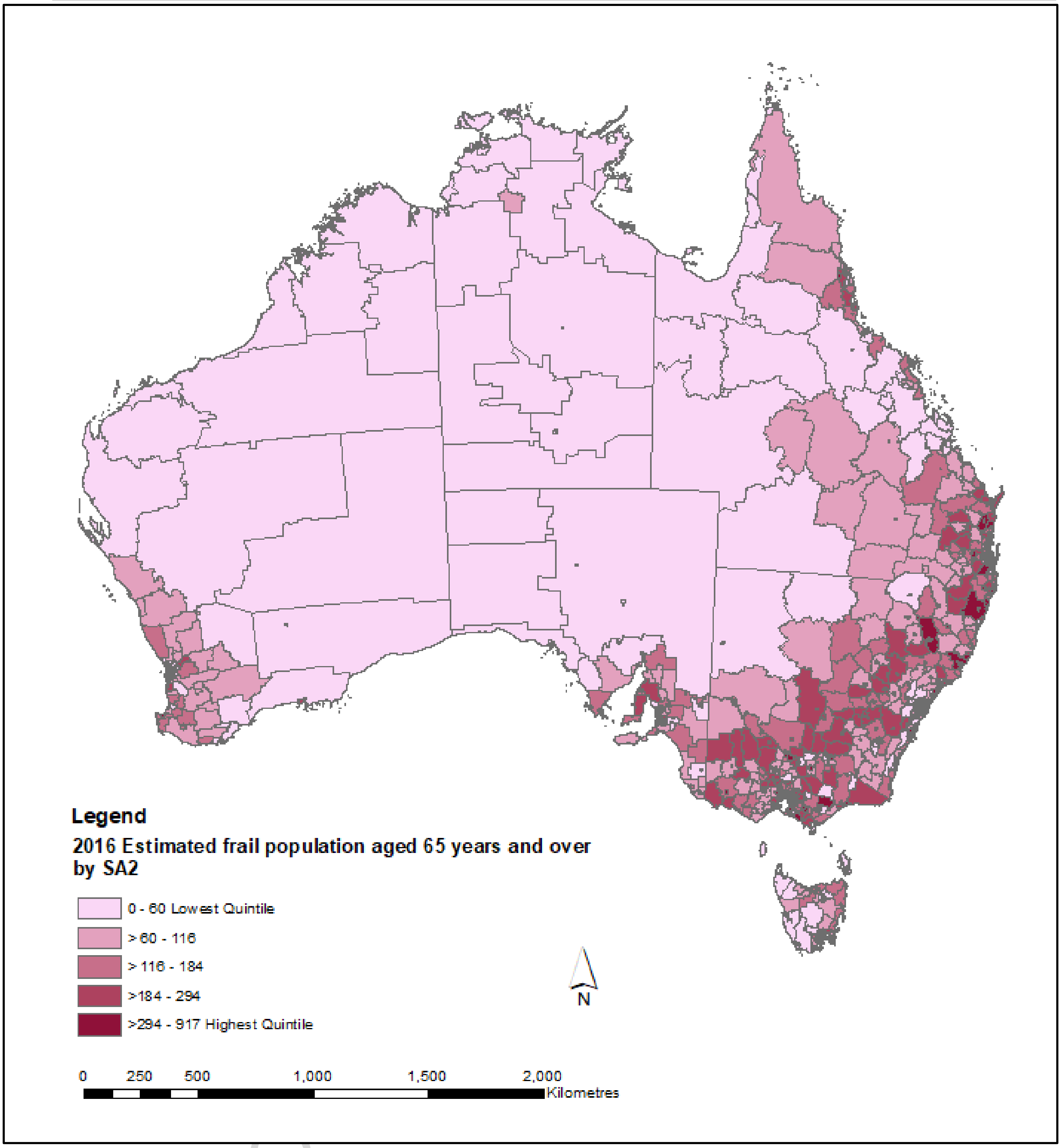

Figure 3. Australian Estimated Frail Population Aged 65 Years or Over in 2016 by Statistical Area 2 (SA2)

Within Australian states some areas have a larger proportion of the population that is older and likely to be frail. While Greater Adelaide and Hobart have smaller estimated numbers of frail and pre-frail individuals than Greater Sydney or Melbourne, the frail and pre-frail populations in these areas are proportionally a larger component of the total population. This is illustrated in Figure 4 which graphs the frail and pre-frail populations as a percentage of total population for each GCCSA area for 2011, 2016 and for the 2027 population projections. The population modelling indicates that in 2016 over 9% of the population of the greater capital city areas of Adelaide and Hobart were estimated to have been frail or pre-frail. The disproportionate ageing of the areas outside the capital cities is reflected in the high percentages of the estimated frail and pre-frail populations in these areas. For example, in 2016 over 11%of the population outside of Adelaide, in the Rest of South Australia, were estimated to be either frail or pre-frail. Analysis of SA2 areas has found ten SA2s with a populations over 4,000 people where over 20% of the population is estimated to have been frail or pre-frail in 2016. The seven of these ten areas are located in ARIA inner regional areas and include, Tuncurry (NSW),Tea Gardens-Hawkes Nest (NSW), Bribie Island (Qld), Point Lonsdale-Queenscliff (Vic), Victor Harbor (SA), Sussex Inlet-Berrara (NSW) and Goolwa-Port Elliot (SA).

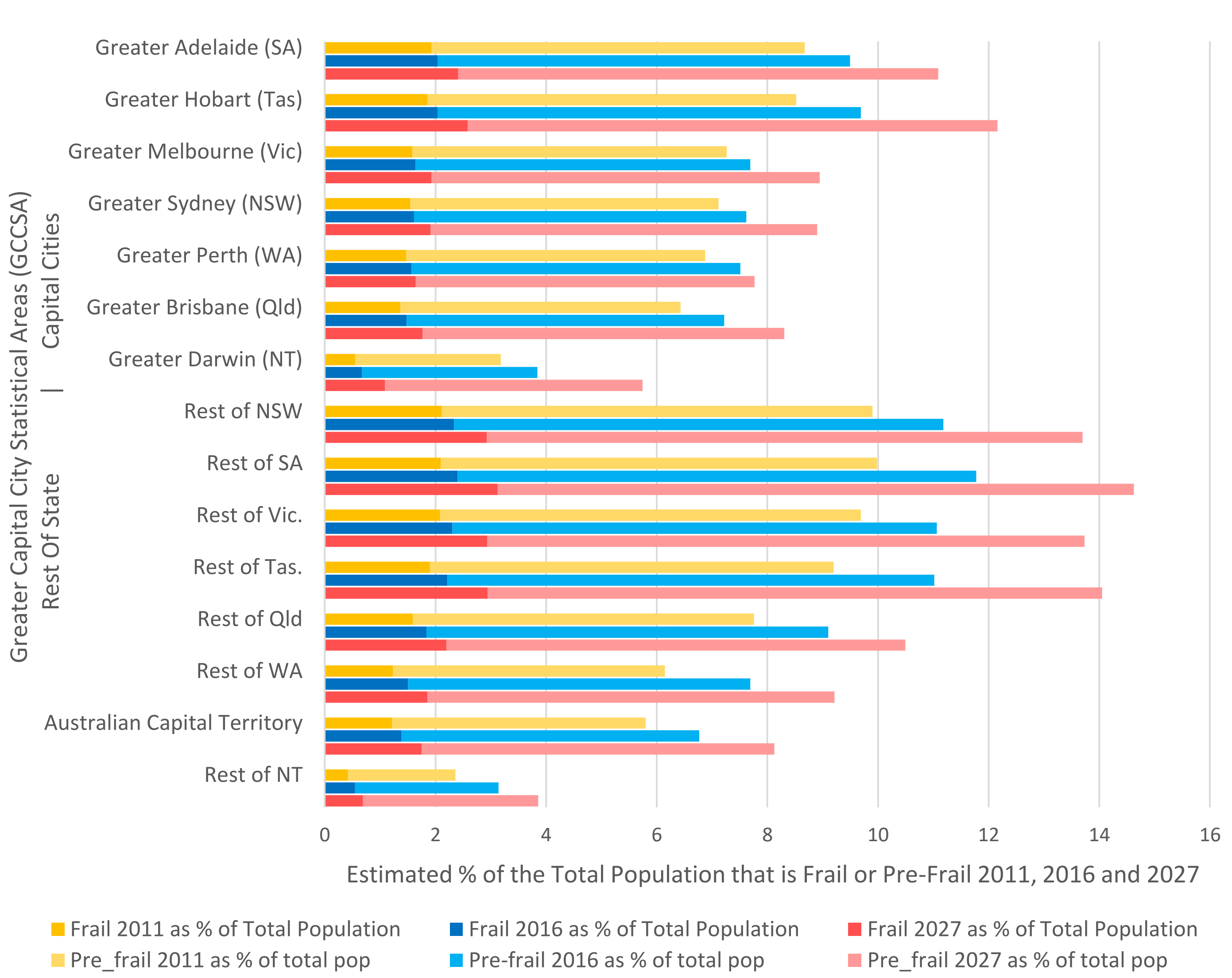

Figure 4 Estimated Frail and Pre-Frail as a Percentage of the Total Population 2011, 2016 and 2027 by Greater Capital City Statistical Areas (GCCSA)

3.2 Frailty Estimates 2027 – Projected Changes

If frailty prevalence remains unchanged it is projected that by 2027 there will be 609,306 frail and 2,248,977 pre-frail people in Australia, representing an increase of 43% since 2016. Between 2016 and 2027 the average annual growth in the combined frail and pre-frail population is projected to increase to over 78,000 people, a rate of 10,000 people a year higher than the period between 2011 and 2016. Population ageing is driving the growth although the growth is not uniform across all areas. Areas with larger older populations, particularly those aged over 75 years, have correspondingly the largest modelled frail populations. Figure 2 shows that frail and pre-frail populations are projected to increase for all GCCSA areas. The greater capital city areas of Sydney and Melbourne will have the largest increases, with their combined frail and pre-frail populations increasing over 150,000 people by 2027. The rest of Queensland, outside Brisbane, will also have a large increase of over 100,000 frail or pre-frail people. In 2027 it is projected that the majority of the frail and pre-frail population will continue to be located in the major cities, accounting for 1,806,565 or 63% of the national combined frail and pre-frail population.

As the population ages it is projected that there will be increases in the percentage of the population within all GCCSA regions that are frail or pre-frail (Figure 4). While Perth will have a relatively small change, it is projected that over 12% of Hobart's population will be frail or pre-frail. Outside of the capital city areas a larger proportion of the states total population is expected to be frail or pre-frail. Over 14% of the populations outside the capital city areas in South Australia and Tasmania are projected to be frail or pre-frail by 2027 and over 13% in New South Wales and Victoria.

Temporal analysis of frailty by remoteness areas estimates that between 2016 and 2027 there will be large increases in the frail population across all remoteness classes and the percentage increase will increase with increasing remoteness. Major cities are estimated to have a 44% increase in the frail population over the 11 year period, while inner and outer regional areas will increase 50% and 52% respectively. Remote and very remote areas are projected to have a combined increase over 90%, although projected population counts in these regions are relatively small.

The SA2 frailty web maps also show the substantial expansion of the frail and pre-frail populations in outer metropolitan and regional areas between 2011 and 2027. Figure 5 shows the distribution of the frail population in the Sydney area for 2011, 2016 and 2027, an area projected to experience substantial growth in the frail and pre-frail populations in the outer metropolitan area.

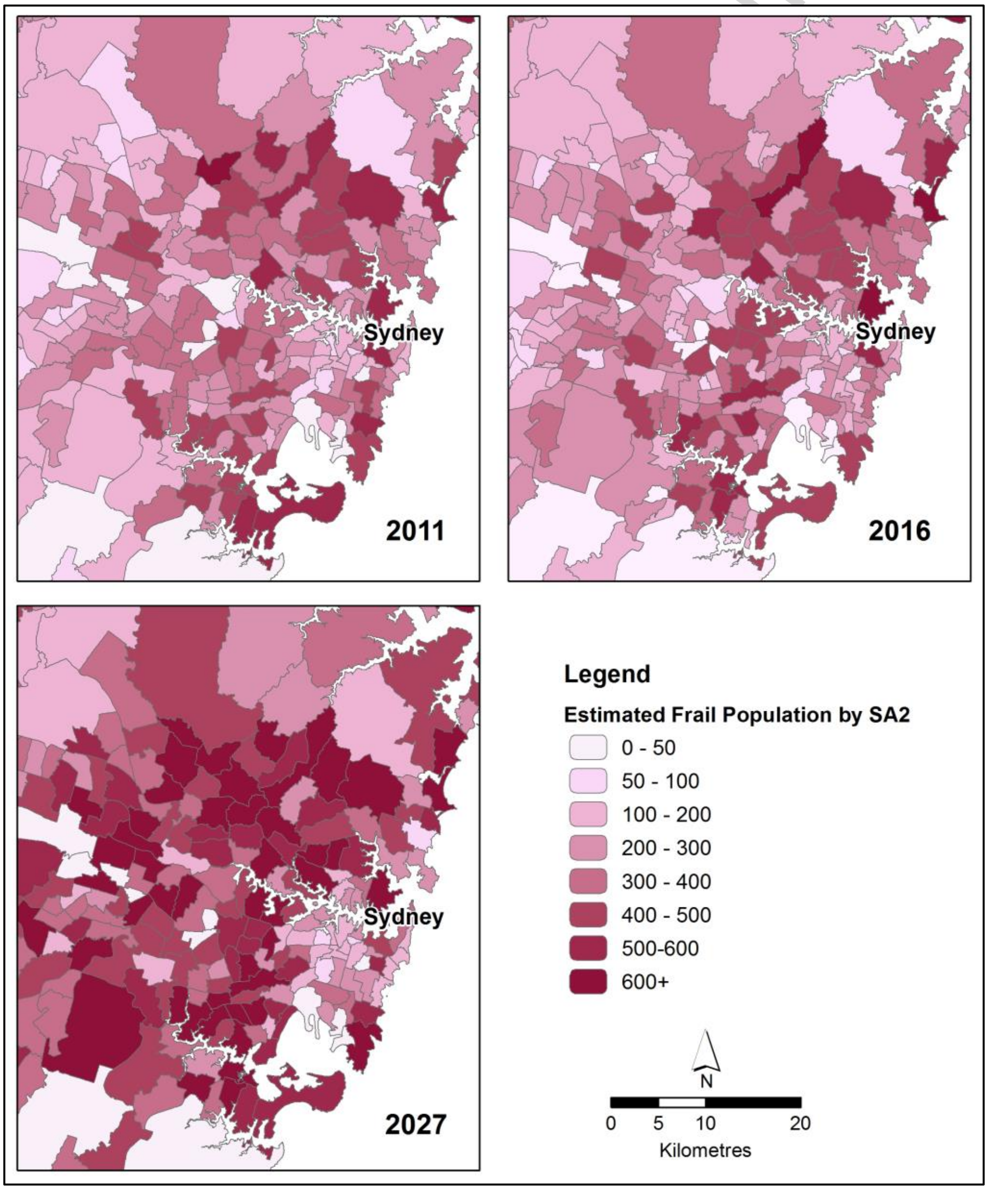

Figure 5 Distribution and Growth of the Frail Population in Sydney 2011, 2016 and 2027

4. Discussion and Implications

This study has produced area level estimates of the number of frail and pre-frail individuals in Australia and has given insight into the geographic distribution of frailty and its potential future growth. Australia's combined frail and pre-frail population is projected to increase by approximately 90,000 people per year to reach 2.9 million by 2027, if frailty prevalence continues at current levels. All GCSSAs are projected to increase both in terms of the total number of frail and pre-frail individuals and the proportion of the total population that is frail and pre-frail. Australia's capital cities will continue to have the largest concentration of Australia's frail and pre-frail populations in future years, although the rate of growth of these populations is expected be faster in the outer metropolitan, regional and remote areas. Given that most specialist services for older people (e.g. geriatric and psychogeriatric medicine) are predominantly based in metropolitan areas, there is an imperative for planning to commence now to meet the expanding needs of older Australians in regional and remote regions. The migration of younger populations from regional and remote areas to larger cities to find work has contributed to the more rapid ageing of these areas (Smailes et al. 2014). Sea change and tree change migration of older populations is also influencing the rate of growth of older populations in some regions (McGuirk and Argent 2011). With the first of the baby boomer cohort about to reach 75 years in 2021 and the incidence of frailty increasing as the population ages, there is a clear need to implement frailty intervention strategies, such as FIT (Cameron et al. 2013), to reduce frailty prevalence. Associated with this is the need to ensure services are available and accessible to those who are likely to need them.

Geographic modelling and spatial analysis which combines population and service information at a local level is likely to be a key part of any strategy which seeks to address the emerging challenges, as state and national figures can often mask inequalities that can been seen when smaller local areas are used for analysis. The SA2 level analysis incorporated into the web mapping application can be used to identify areas where large increases in the frail and pre-frail populations are likely to occur or where there might already be needs that require services.

An example of the data integration capabilities of GIS and how this might benefit service planning and policy is shown in Figure 6, which overlays General Practice (GP) locations onto frailty prevalence mapping for the Central Adelaide Local Health Network (CALHN) area in South Australia. The map allows the distribution of the frail population to be visualised in relation to GP services and suggests that there may be some mismatch between the location of general practices and frail populations. For example, the coastal suburbs of West Lakes Shore and Grange have large frail populations, although relatively few GP locations in comparison to the number of GP locations to the east of the CALHN region in areas such as Burnside. While further research is required before conclusions about the adequacy and equity of service provision can be made, the example illustrates how geographic visualisation of frail populations integrated with service information can inform local service planning both in terms of general practice as well as public hospital services.

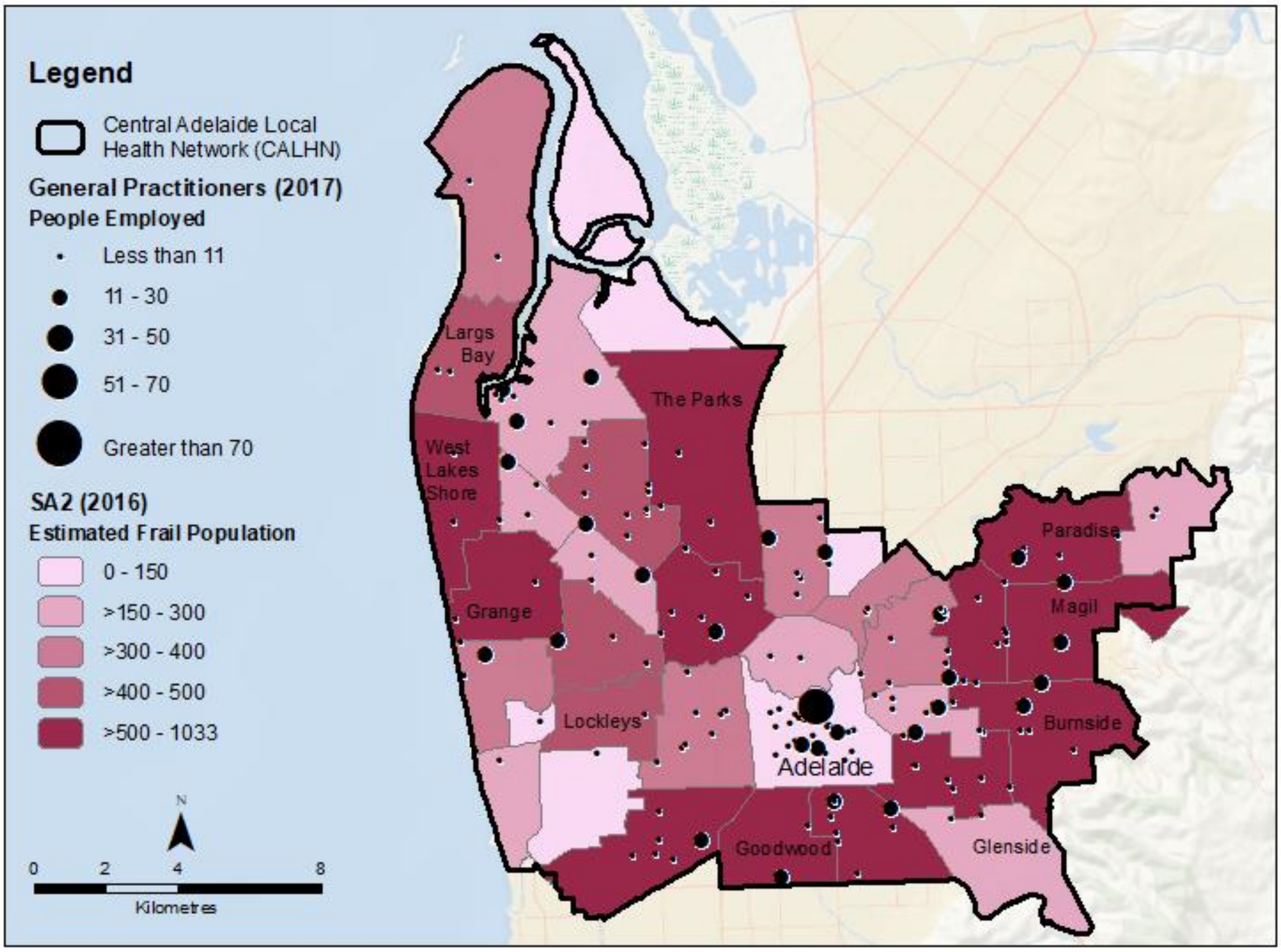

Figure 6. Estimated Frail Population 2016 and General Practice Locations 2017 for the Central Adelaide Local Health Network

Another example is the area of Mount Barker, an SA2 on the outskirts of Adelaide, which is projected to have a large increase in the combined frail and pre-frail populations. The web map shows that between 2011 and 2027 the increase will be over 220%, well above state averages. In 2016 Mount Barker had 133 aged care beds and an estimated frail population of 304 people, the projected increase in this figure to 740 by 2027 would suggest that an increase in aged care beds, home care services, general practitioners and access to specialist services are likely to be needed in the future to support this ageing and increasingly frail population. Additionally, the large combined frail and pre-frail population in this area, projected to be 3,311 by 2027, may make Mount Barker an area suited for preventative programs aimed at preventing and reducing frailty prevalence to reduce future demand on health and aged care services.

A key strength of this research is that it provides comparable frailty estimates for all areas across Australia, thereby providing valuable information to guide policy and planning initiatives, which seek to deliver equitable resource allocations to local areas. Better targeting of services to the people that need them is likely to achieve the best health outcomes while also being the most cost effective. The frailty estimates also provide a useful baseline against which measures of local frailty can be compared, to determine if the measured frailty of the local population is higher, lower or the same as these estimates. This type of analysis may enable the identification of other factors, such as socio-economic and environmental factors, that contribute to frailty risk. In this way this research provides the first step in developing a better understanding of the current and future local distribution of frailty in Australia.

A limitation of this modelling was that it did not adjust for the influence of local socio-economic and environmental circumstances, which can influence the frailty prevalence (Woo et al. 2010). Nor did the modelling include frailty estimates for populations younger than 65 years or frailty estimates for residents in residential aged care services (or nursing homes). The use of prevalence based on the Fried frailty phenotype is also known to be conservative in its identification of those that are frail (Thompson M. Q. et al. 2018), however the inclusion of the additional category of pre-frail is useful to indicate the number of people that may benefit from frailty screening to initiate early interventions. The ABS randomisation of small numbers to protect confidentiality makes those SA2s with small numbers of frail and pre-frail populations less reliable than those with large numbers. It is possible also that the migration of older populations, possibly to seek a different lifestyle in retirement, as well as government policies to encourage migration to rural regions, may influence the accuracy of the area level estimates for the 2027 population projections, although the ageing of the Australian population is inevitable.

Future research plans to address the first of these limitations and combine this mapped prevalence information with information on local socio-economic and environmental risk factors to refine these initial frailty estimates into a geospatial model that can identify areas which have both a large estimated frail population and a local social and environmental context which is characterised by conditions associated with a higher risk of developing frailty, such as low socio-economic status and social isolation.

Initiatives to reduce frailty prevalence and more efficiently manage the expected increased demand for health and age care services are needed. Geospatial information regarding the size and distribution of frail and pre-frail populations can improve the efficiency and effectiveness of service planning and delivery though matching resources with populations that need them, thereby providing the best possible chance of allowing people to age healthily and delay, treat or prevent the onset of frailty. This may make a potentially life changing improvement to the lives of older people as well as a significant financial saving in providing health and aged care to the estimated 415,000 frail Australians.

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Geospatial Modelling of the Prevalence and Changing Distribution of Frailty in Australia – 2011 to 2027

Highlights

- Mapping frail populations can assist matching services to patient needs
- Australia's frail and pre-frail populations are expected to grow rapidly
- The frail population is projected to grow more quickly in regional and remote areas
- Implementing preventative strategies may reduce the projected frailty burden