Chapter

Geographies of Ageing: A Visuospatial Approach to Demographic Change in Australia

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Abstract

The global phenomenon of population ageing is both complex and multi-layered. We know at a global level that different countries are progressing towards becoming aged societies at different rates. We know that within national borders some regions, mainly rural, are affected by ageing more than others. We also know the health and social care systems struggle to respond effectively to ageing because it is complex and, often, runs counter to the structural design of healthcare systems with their emphasis on clinical and organ-specific problems. Ageing challenges these conventional approaches and is compounded by the prevalence of wide-spread ageism at the societal and systemic levels. Therefore, if we are to adapt to population ageing and care for older people effectively, we need to better understand them and their situational contexts. This includes where they live and how their social, biological and clinical trajectories are progressing. Synthesising this kind of multi-layered information also presents challenges because many health and social care systems operate in silos, with limited information exchanges and limited service coordination. One strategy is the concept of a visuospatial data-informed approach. Here we present a conceptual basis for this approach drawn from our work in the Australian health and ageing contexts.

Keywords: data visualisation, spatial, ageing, dementia, complexity

1. Introduction

The global phenomenon of population ageing is both complex and multi-layered. We know at a global level that different countries are progressing towards becoming aged societies at different rates [1]. We know that within national borders some regions, mainly rural, are affected by ageing more than others, especially as younger people leave for urban opportunities in education and employment [2]. We also know the health and social care systems struggle to respond effectively to ageing because it is complex, sometimes messy and, often, it runs counter to the structural design of healthcare systems with their emphasis on specific clinical and organ-specific problems (e.g. heart, lung, kidney, brain etc.). In this context, it is or certainly should be seen as a driver for systemic change.

Ageing challenges these conventional approaches and is compounded by the prevalence of wide-spread ageism at the societal and systemic levels [3]. Therefore, if we are to adapt to population ageing and care for older people effectively, we need to better understand them and their situational contexts. This includes where they live and how their social, biological and clinical trajectories are progressing. Synthesising this kind of multi-layered information also presents challenges because many health and social care systems operate in silos, with limited information exchanges and equally limited service coordination. One approach, explored here, is the concept of a visuospatial data-informed approach. In this paper we present a conceptual basis for this and outline a data visualisation project the authors have developed to address some of these complexities. The data and analysis presented are specific to the Australian context, but we anticipate the applications could be readily modified for other countries.

2. Trends in population ageing

It has become something of a truism to note that populations are ageing globally, which does not diminish the scale of this phenomenon. It is also the case that even within countries, population ageing tends to be unevenly patterned. In many countries, rural populations are ageing faster than urban areas due to out-migration as well as economic factors, climate change, service availability and so on [4]. In the Australian context, this issue can be seen in the way population ageing is moving differentially across states and territories. Major urban areas such as Melbourne, Sydney and Brisbane are less prone to overall ageing because they are major immigration intake centres but even then, specific areas may age faster than others [5]. In other words, the general trend of population ageing can vary by speed and location. This makes it a complicated phenomenon to respond to in health and social care environments because planning and response mechanisms are often slow, while infrastructure funding and construction cycles can run to decades.

3. Demography and destiny

The distribution and composition of the Australian population is highly variable. Across the country, local and state/territory populations are ageing at different rates and on different spatial and temporal trajectories. Current conditions indicate that some major urban areas will have increasing numbers of older people, but the proportions will be lower than many regional and rural areas where outmigration is already a problem. Such conditions may be exacerbated by other factors such as climate change [6]. In addition, Australia already has a pattern of migration away from major urban centres by 'younger' retirees, as people seek lifestyle changes and/or lower cost of living situations [7]. These sea-changers can have their own impact on smaller coastal settlements for example, as they buy property, invest and consume goods and services. Such patterns are likely to change as these people age in situ and later the local need for home support services, general medical and specialist medical care [8]. Thus, the epidemiological patterns associated with ageing bring their own challenges to these sea change locations.

4. Epidemiological considerations

While demography is a major driver of epidemiology in general, it is also a powerful influence on factors such as shifting patterns of chronic disease and late-life acute care demands [9]. These can range from the complexities associated with co-morbidities through to the relatively predictable consequences of fall-related injuries in community-dwelling older people [10]. Some of these epidemiological phenomena are distinctly age-related (e.g. macular degeneration) and others can be seen as a consequence of current systemic and clinical arrangements.

As we have noted elsewhere [11], population ageing is characterised by rising *multimorbidity* at a global level. This is a major consideration for analysing the intersectional nature of co-morbidities often experienced by older people that can include the complexities associated with physical ill-health and associated sensory and cognitive impairments. In addition, the side-effects of treatment options for one condition may have implications for co-morbidities including polypharmacy [12]. As well as this, we already know that polypharmacy is highly correlated with negative outcomes in older people, especially when irregularly reviewed and/or poorly managed. Our position here is that the complexities associated with progressive population-level ageing and the treatment patterns associated with these conditions require increasingly sophisticated data modelling and analysis if population-level health management is to be improved. The scale of this concern is already significant, but it can only become more important as population ageing progresses at the global, national and sub-national levels [13].

Our knowledge of the complex interactions between, for example, a dementia diagnosis and a mix of sensory and physical impairments is well-developed but continues to grow in scope [14]. Conventional models, often based on younger age cohorts, of living with a particular condition are inadequate for managing the twin concerns of population ageing and rising chronic disease, a pattern no longer restricted to the more affluent economies [15]. Data from projects such as the Global Burden of Disease Study (GBD) illustrate the consequences of these convergent circumstances in increasing detail [16]. In addition, the development of a variety of international ageing studies and, more specifically, centenarian research projects, have illustrated just how variable these patterns can be, not only between countries but within them as well. Our position here is that our knowledge about age and ageing is still highly developmental and, consequently, improving our capacity to model and respond to particular conditions can only grow in importance (**Figures 1** and **2**).

The two figures above show the fast-growing urban area of greater Melbourne is likely to experience a decrease in the proportion of people with a dementia between 2020 and 2032, even as the numbers of older people continue to grow. This

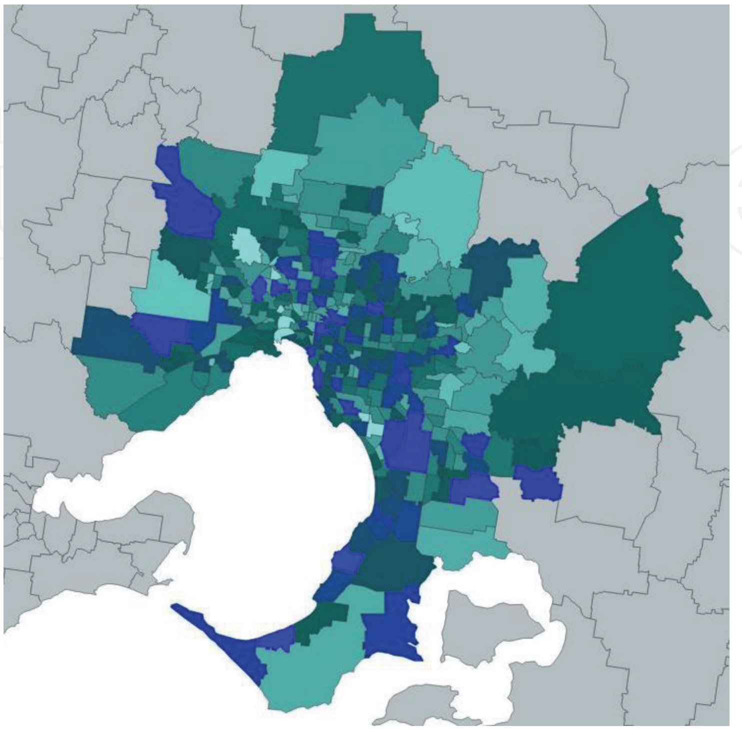

Figure 1.
Map of dementia projections for Melbourne in 2020.

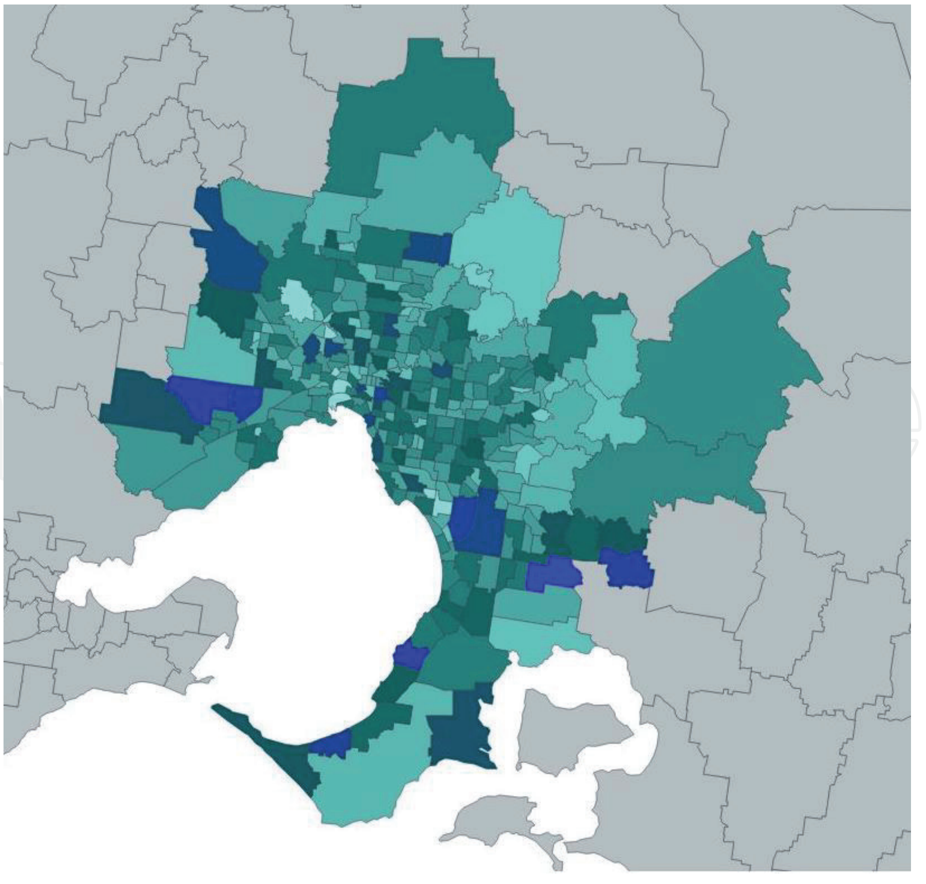

Figure 2.
Map of dementia projections for Melbourne in 2032.

visual environment, backed by quantitative data, tables and associated analytical tools, provides the service planner with a clearer understanding of where and how resources might be better allocated between 2020 and 2032. And of course, if a new Census improves and alters our understanding of population dynamics, that data can be added to the Power BI environment and alterations made accordingly. This approach has the power to greatly improve planning for both shorter and longer-term resources, from workforce needs such as specialist dementia care nursing staff through to where new aged care facilities would be best located sustainably.

5. Service provision and service providers

There are two general considerations in relation to service providers identified here. The first is the issue of *where* service providers are located, especially relative to population-level need (and estimates of such needs). The second is the issue of future *gaps* in service provision and population ageing and its associated complexities progress. In other words, where are we at now and how is this scenario likely to change at some future point or points? While these problems are not unique to Australia, here we focus on the Australian situation as emblematic of how difficult these issues can be when dealing with a large and unevenly populated geography. We also propose that this is yet another reason for more and better modelling of these variables because the issue of scale can be more efficiently addressed within a data modelling environment that acknowledges the importance of location from the outset.

An additional consideration is the skills of the available workforce and how evenly or unevenly skilled workers are distributed relative to current and emerging need. Currently, the demand for clinical and personal care staff is growing at pace in health, aged and disability services [17]. However, getting workers to take employment across areas of geographic need is another matter entirely. In Australia, this issue is especially problematic and remains unresolved. How then do we incorporate many, or all, of these factors in a single data environment? How do we 'capture' the complexities associated with these varied interactions and their dynamic nature? Even if we can achieve this sophistication in our modelling, it is no guarantee that policies and funding will necessarily flow in the right direction – but without it, there is a finite evidence base for prioritisation, planning and the evaluation of funded service provision.

6. Modelled data elements

While the data elements included in this model are limited, this is not to say that the model or the modelling process in necessarily as finite as presented. By this we mean that additional variables or measures can be added as can new data sets or related inputs, such as service providers by type and classification. The point here is that in order to address the issues identified above, we have undertaken a selection process with a view to establishing a base model of the geography of population ageing in Australia and its key correlates.

These data elements identified include:

- population estimates and projections by age and sex for the period 2017–2032, based on official data releases from the Australian Institute of Health and Welfare (AIHW, 2019);

- estimated prevalence rates for three dementia sub-type categories – Alzheimer's disease (AD), vascular dementia (VaD) and the mixed dementias (a category being reassessed at regular intervals as our research and data-informed knowledge grows);

- sub-type severity estimates including mild, moderate and severe with a view to identifying the type and level of resource needed to support such individuals in the community;

- key health service providers such as acute care hospitals and residential aged care facilities.

These data were connected using the Microsoft Power BI data visualisation software package (https://powerbi.microsoft.com/en-us). All data sets were either geocoded on access or integrated into a spatial frame of references so that the data visualisation capabilities of Power BI permitted the user to see all data elements in a spatial or map-like context. This essentially means that the user can explore, using the zoom function, the whole country on down to a particular state or territory and then to even smaller areas such as a city or local suburb. At every point, because of this geographically enabled data architecture, the data viewed is consistent with the scale at which the user views it.

7. Data visualisation

We make a distinction here between spatial analysis, of the kind conducted using geographic information systems software, and spatial data visualisation. The first relates to specialist software environments that provide a variety of spatial analysis tools and produce explicitly spatial data analyses. In this instance, we focus instead on the latter concept of spatial data visualisation of the kind available within current data visualisation software environments including, for example, Tableau and Microsoft Power BI. While the capabilities of these two software types may appear similar, their actual applications tend to differ at the present time. There is the perhaps obvious likelihood that these environments may become increasingly similar over time as, in particular, data visualisation software providers add a growing range of spatial analysis capabilities to their packages. In addition, many GIS providers are shifting to dashboard and dashboard-like capabilities as well (e.g. ESRI's ArcGIS).

8. Results

These results are developmental and intended to illustrate both the importance and viability of managing the concerns discussed above in an accessible visual data environment. One of the considerations we had in approaching this effort was to develop resources that could support researchers and service providers from different backgrounds. Thus, a key principle of the data visualisation is to provide a mutually intelligible information environment that can be used and enhanced to meet the needs of groups whose interests may all be focused on aged care but who come from different backgrounds (e.g. planners versus clinicians) and who may have different priorities. For practical purposes, we have used the Microsoft Power BI data visualisation software in this discussion. A key result here is all data included are accessible within the one 'frame' of inquiry but also, each data element can be reviewed separately. This provides a flexible basis of data inquiry and analysis for different types of user and their associated purposes (**Figure 3**).

The dashboard below illustrates how geographic location, year (past, current and projected), dementia estimates and likely severity (mild, moderate and severe) can all be modelled within the same visual environment. The severity measure gives a sense of the relationship between prevalence and likely clinical and support service need as the dementias tend to be progressive in nature. The

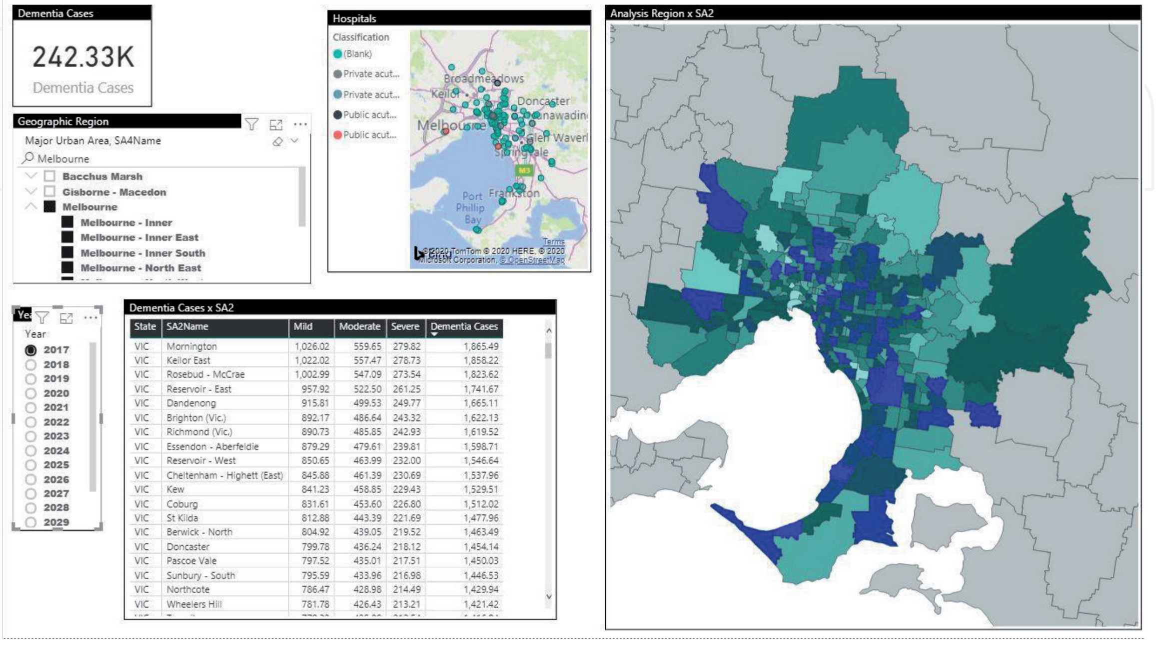

Figure 3.
Dementia data dashboard.

estimate of *total* cases is shown in the top-left of the dashboard and this figure adjusts for each year of estimates and projected population data. This is underpinned by the use of official age and sex population projections in the model. All of these data are provided at the SA2 level of the official Australian geography developed by the Australian Bureau of Statistics (see below) but, in doing this, larger geographic areas can be compiled or visualised to meet the needs of specific user groups e.g. local government, state government and so on. With the data all modelled to a base geography that can scale hierarchically, this extends the utility of this visual modelling from a relatively local small area level right through to the national picture (**Figure 4**).

Each data element can be examined more closely by separating it out from the dashboard for inspection. Thus, the map above shows the location of healthcare facilities within the same area currently visualised. This is also scalable so different users in the greater Melbourne area can inquire on their own particular area of interest or zoom out to explore the spatial relations between their local picture and a larger geographic catchment.

8.1 Small area visualisation

In this data visualisation model, the smallest official geography for which we had data available was the Statistical Area 2 (SA2) level of the official Australian Standard Geographical Classification (ASGC) (https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Standard+Geographical+Classification+(ASGC)). The Australian Bureau of Statistics (ABS) does provide some data at smaller areas but only under more confidential data access conditions. Also, all of the data sources utilised here were available at the SA2 level, so they were fully compatible at that geographic level. This simplifies the data structuring and integration processes as well as providing a quick and consistent data analysis and visualisation environment. The issue of speed means that new data at the same geographic level can easily be integrated to update and improve modelling capabilities.

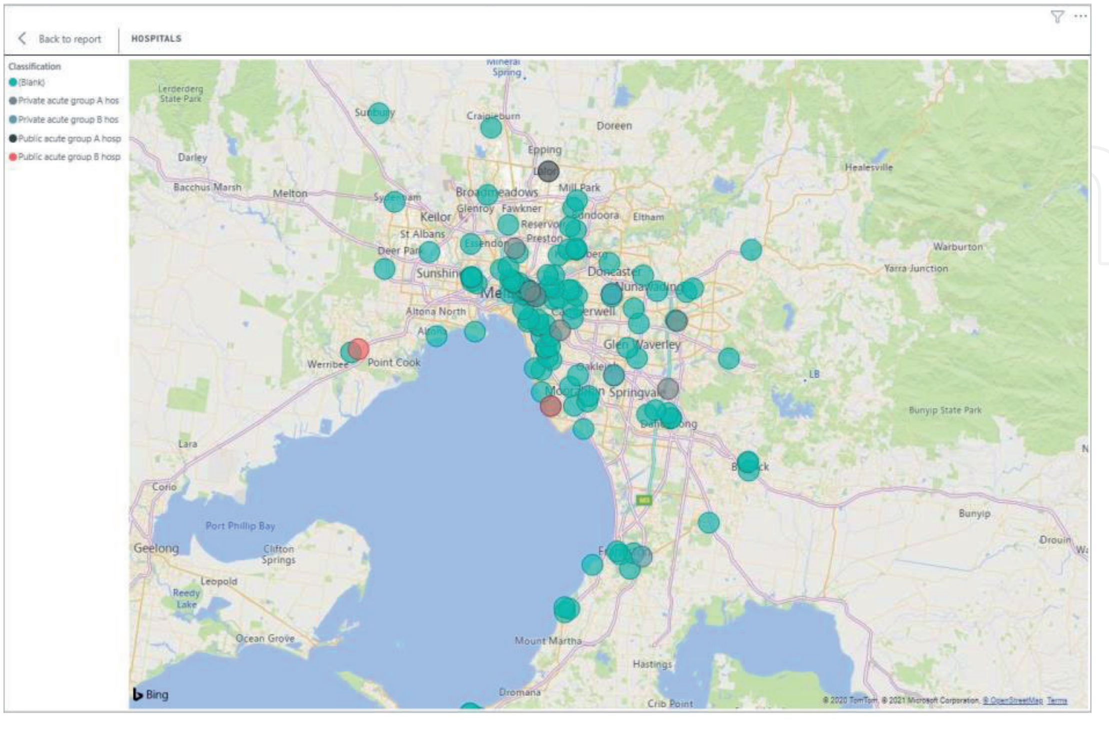

Figure 4.
Health services in Greater Metropolitan Melbourne.

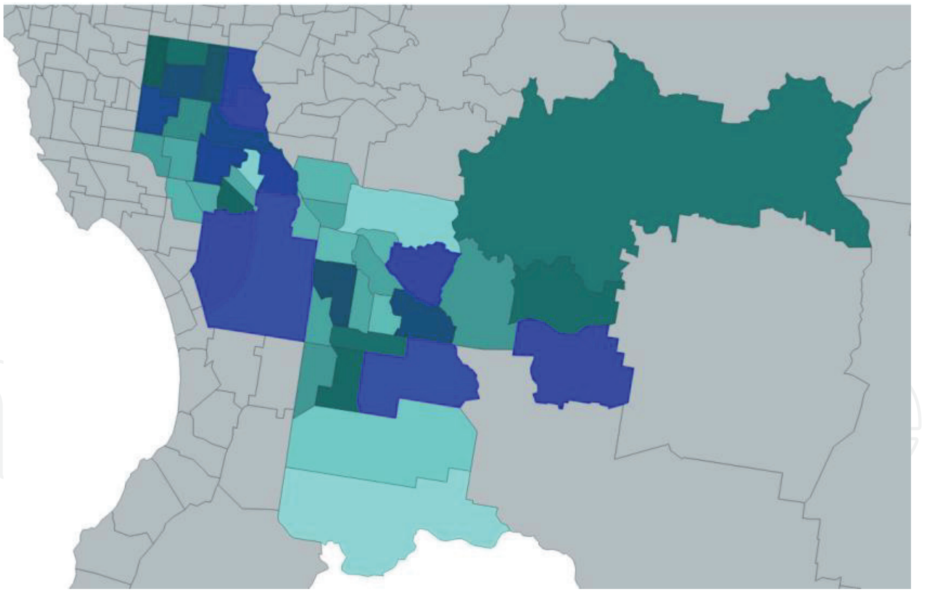

Figure 5.
South East metropolitan Melbourne SA2 dementia estimates 2020.

What this means is that small areas can be selected and examined in closer detail to explore particular epidemiological and/or service provider issues or concerns. This is useful for, say, a hospital service planner, a residential aged care service developer, or a provider of in-home support services. They can all examine the same consistent visual data environment at the same or different geographic levels, as required, to anticipate and plan for both population-level needs and business potential. Potentially, small area modelling below the SA2 level could be developed but we have not attempted that here at this time, as a key requirement for such work would be to examine a specific problem or concern of service planners, for example. Nonetheless, several individual SA2s can be selected, highlighted and examined to explore their similarities and differences. This means that smaller 'catchment' areas can be produced by individual users.

Figure 5, above, provides a brief illustration of this segmentation approach that permits the user to explore a specific catchment area in more detail. An additional benefit is that by selecting this region in the dashboard, the relevant data for that catchment is explicitly shown only for the relevant SA2s in that catchment. If this was not adequate for a particular purpose, such as plotting a series of patient home visits, the same data can readily be exported to a geographic information systems (GIS) software environment to permit route planning, for example. Thus, both scalability and interoperability are facilitated by the core data visualisation strategy.

9. Implications and limitations

It is necessary to emphasise here that this modelling approach is incomplete, as is any model of a complex existing environment in which the full scope of relevant causal and influencing factors may be unknown. This can be seen as a sub-set of the ongoing *incompleteness* debate in the philosophy of science (e.g. Gödel, Popper etc.) [18]. Many other data sets, and improving/improved data quality, could increase the utility, accuracy and actionability of this modelling approach. A key consideration is that such visual modelling environments cannot necessarily improve their validity simply by adding *more* data but rely on analytical processes to refine how particular age-related problems are framed, explored and appropriate responses developed. While population ageing and associated factors are sometimes framed as a 'wicked problem' [19], the proposal here is that such complexities can be better managed through visuospatial strategies and tools such as these.

In this example, the visualisation is not a fixed or static attempt to describe a known complex situation, in this case dementia prevalence and its impacts, but for the visualisation *process* to be developed over time as an explanatory tool with 'what-if' capabilities. This makes it a deliberately adaptive modelling environment, one which can be updated as new or improved data sets become available. In this sense, if concepts and methods used are adapted to better address such scenarios, then the perceived intransigent complexity of 'wicked' problems may become more amenable to evidence informed understanding and analysis. Certainly, the idea that differential patterns of ageing can be analysed using visuospatial approaches is already well-established [20].

For example, the currently available Australian Census data was collected in 2016 and is now quite dated (hence the use of more recent official projections data in this chapter). Assuming a high-quality Census is carried out in 2021, the resulting data will likely require modifications to this current visual environment. This is not the problem it might first appear, since a foundational concept in this modelling strategy is that of an ongoing and progressive updating and refinement process. The use of software such as Microsoft Power BI also means that this type of updating and adjustment can be quick and effective – taking far less time than traditional approaches. An implication of this is that users of the model can adapt their strategies, planning, programs and funding models accordingly. In this sense, the dynamism of the real world, which exists outside the computer-generated model, is more easily and quickly accommodated. This has obvious benefits for both service providers and their older clients since systemic adjustments and changes can be accelerated.

10. Conclusions

In this chapter we have discussed and illustrated some of the key concerns we see associated with progressive population-level ageing at the sub-national level in the Australian context and the value of a visuospatial data strategy in addressing these concerns. The differential geographic nature of population ageing across Australia means that age-related problems, such as the dementias and associated clinical and social support needs, have a level of complexity not currently manageable, in our view, by other, especially aspatial, means [21]. The capacity illustrated here to connect spatial information to demography, epidemiology and service infrastructure (and allied information from service providers, such as pharmaceutical usage or financial performance), makes this complexity much more manageable in the current moment and into the foreseeable future. The kind of visual data environment illustrated here provides one approach but far from the only one. Many jurisdictions are already utilising visualisation techniques to make both data and its analysis more readily accessible to their audiences (e.g. https://www.census.gov/topics/population/older-aging/library/visualizations.html).

Key factors here include the scalable nature of the information visualisations shown – that is, the user can look at the national, state and even local area all within the same information framework and toggle between these 'views' to inform discussions, analysis, policy development and even service provision. Different service providers can be highlighted, or minimised, to explore different questions, and local data can be added to improve small area knowledge and understanding such as frailty [22]. While much, if not most, of this current data is quantitative in nature, this does not preclude the inclusion of qualitative data or findings from qualitative analyses. In other words, this pilot model is potentially extensible in scale, temporality, and data types. Microsoft Power BI already has a text analytics capability (not explored by the researchers at this time) that could connect such analysis to the data architecture developed for this modelling exercise. That is, qualitative client or provider data could be connected directly to geography.

As well as being useful for the Australian situation, the concept is replicable elsewhere. In the context of global population ageing and the variable health and social care systems available to older people [23], this concept could be extended to inform these jurisdictions about how to more effectively manage age-related complexities. And while this might suit, for example, national government organisations in the first instance, the same capacity is potentially available to sub-national jurisdictions, municipal governments, direct care providers and not-for- profits or advocacy organisations. While we acknowledge that data visualisation is only as good as the data sources it relies on, the potential of these types of tools to improve the accessibility and efficiency of age-related care is considerable. As population ageing progresses, the position of this chapter is that such tools will become increasingly useful and relevant to ensure that the health and wellbeing of ageing populations is supported, and that established systems of care can be both sustainable and adaptive to shifting conditions.

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