A Virtual Earth Model of the Dementias in China

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Abstract

This developmental project was undertaken to explore how applying spatial science analysis and visualisation methods might inform societies undergoing significant structural and demographic change. China is rapidly transitioning to an aged society. It already exceeds all other countries in its population aged 65 years and over. Dementia is closely correlated with ageing and intersects with a variety of physical and cognitive disabilities. Information dashboards are a growing part of health and social policy data environments. These visual data applications increasingly include mapping capabilities. In this paper, we explore the utility of a geographic modelling approach to exploring the complex nature of population ageing and the dementias in China.

Keywords:

Geographic Mapping; Ageing; Dementia

Introduction

China's population is ageing rapidly. Current esitmates indicate an increase in total population from 1.304 billion people in 2010 to 1.402 billion in 2020 (https://populationpyramid. net/china/). In 2015 China's 65+ population overtook the entire population of Japan, which is still the most aged society on earth. And further to this, China's ageing is expected to accelerate from around 2025 as both the overall 65+ group increase and the more dependent oldest old cohorts, aged 80 and over, grow faster still [1]. Average life expecancies increased from just under 72 years in 2000 to almost 76 in 2014 in what is a continuing upward trend (http://data.worldbank.org/). China may even exceed Japan as the *most* aged society by 2030.Figure 1 depicts the rapid expansion and changing composition of China's ageing population. In particular, by 2050 almost one third of the 65+ population will be 80 years and over. This means that the 'old-old' will be a major feature of China's population ageing, as they are in Japan and many European countries. This is a positive outcome for the population given that it reflects rising life expectancies for a huge group of people (120 million by 2050). However, this group is also much more likely to experience a dementia in association with a variety of other age-related health problems, meaning that the prevalence and incidence of sub-acute and acute will conditions rise proportionally.
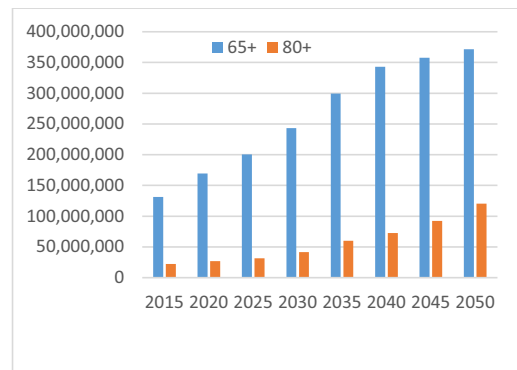

Figure 1- Projected Population Ageing in China, 65+ and 80+ Cohorts. Source: UN Population Projections, 2015 Revision – Medium Variant

Population ageing is generally associated with rising rates of chronic disease and disabling conditions – including both physical and cognitive disabilities. As a result, China can expect rapid expansion in the need for age-related care of all kinds. The dementias, in particular, are likely to prove very challenging because they impair cognitive capacities and intersect with other acute and chronic health problems in older people. In addition, China is a very large country with major structural and resource differences between urban and rural areas. In other words, the geography of ageing in China will be an important consideration in responding to these pressing demographic trends.

This project takes these issues as a starting point and examines them from a spatial health informatics perspective. Health informatics is a growing sector for research and investment globally in a process driven by demographic changes, urbanisation and systemic developments. One of the important roles of health informatics is in informing governments, funders and health providers about how such systems are performing as well as where, how and why variations emerge. In countries with very large populations, such as China, effective health informatics requires a spatial perspective in order to respond adequately and appropriately across distances and at different scales (e.g. provincial, municipal, county, village).

This paper explores one of the options for visualising the complexities of demographic change in equally complex geographic and systemic environments. The value in this approach lies in its capacity to inform a broad audience about growing complexities in an explicitly visual environment. The shift to data visualisation is already an important process in

other industries and we can see how health, aged care and disability – all complex social informatics domains – will benefit from the application of visualisation methods. This is one example of such an information strategy.

Methods

We used age and sex data for all Chinese counties (2872) from the 2010 Chinese census for our demographic modelling. The data were extracted in csv. file formats and manipulated in Microsoft Excel. The population data were sourced from the China Data Center online project at the University of Michigan (http://chinadatacenter.org/) through our institutional library subscription. We applied dementia rates to selected cohorts (aged 55+), by age and sex, of these data from the results of the study by Chan et al (2013) to this county population modelling. These rates only included the prevalence rates for the 85-89 age group as the top estimate. This was because the Chinese Census data was only available at the aggregate level for 85 years and above (see Limitations below). The results of this analysis were then mapped onto China's county-level geography using standard geocoding methods to link the data to a latitude and longitude.

We initially mapped these results using a geographic information systems (GIS) package (Maptitude™). The results were then visualized in a secondary analysis stage using Google Earth™ to create a Keyhole Markup Language (KML) format file of the data. This is a method that many GIS packages support internally (i.e. export to KML or Google Earth format) or users can use a free software application like GEGraph (http://www.sgrillo.net/googleearth/gegraph.htm). The growing development of three-dimensional mapping is seeing a much closer integration between traditional GIS, and mapping functionality, and these emerging data visualisation methods.

Virtual earth technologies are a growing area of application in China in addition to many other countries, and thus congruent with current research and planning applications [2]. This later stage produced a more dynamic visual information in a three-dimensional (3D) format with which users can engage. The focus here was on applying contemporary spatial methods to health-related information and its visualization. Another consideration was the use of non-proprietary software options to enhance potential accessibility of the results. We note that this is an area undergoing rapid developments and other options are emerging at regular intervals. However, Google Earth™ has the added utility of high recognition outside of the spatial sciences, making it a useful introduction to potential applications in the health and aged care sectors.

Results

The first stage in the analysis developed a detailed estimation of dementia prevalence by age and sex cohorts in the 2010 population at the county level for the whole of China. This method produced a dementia-affected population of just over 10.2 million people, higher than the Chan et al [3] estimate (9.2 million people) but probably lower than actual numbers due to the cut-off estimation at 55 years and over, our inability to access detailed cohorts for the over 85 groups, and the use of a combined rate for males and females.

These results are therefore indicative only and designed to illustrate the relationship between population ageing, geography and a progressive and innovative health information strategy for China – an area which requires further development. It is possible, for example, that

prevalence and incidence rates may differ between urban and rural areas. Chan et al have suggested this is not a major differentiator in their meta-analysis but they also note the limitations of the studies they utlised and suggest more detailed research is warranted.
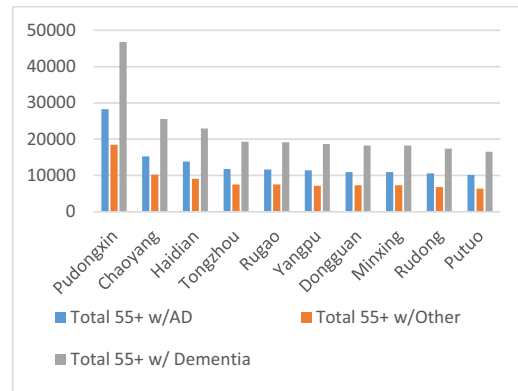

Figure 2: Top 10 Counties by Major Dementia Categories

The chart above shows that the top ten counties in China with the largest dementia population estimates account for less than 250,000 patients (222,869). Of these, 134,917 are likely to have Alzheimer's disease while the remainder have vascular or other dementias. This might seem an unusually low impact weighting for a top ten listing but there are another 2,862 counties, many with similar population sizes and demographic compositions. This also indicates that the geographic impact of the dementias in China is not restricted to specifc regions but is a nation-wide phenomenon, even taking into account the massive rural to urban migrations of the past several decades [4].

China's population is ageing and there is a distinct geographical pattern to this process. The illustrations below were generated using the data we modelled in conjunction with the GEGraph software package and Google Earth™. The result is a Keyhole Markup Language (KML) file including dementia estimate data for all counties in China. The data range has been scaled down to reduce the differences between the highest and lowest county data. The image below is a JPEG image but the output is an active file that any user can engage with if they have Google Earth™ installed on a device – desktop, portable device or tablet.
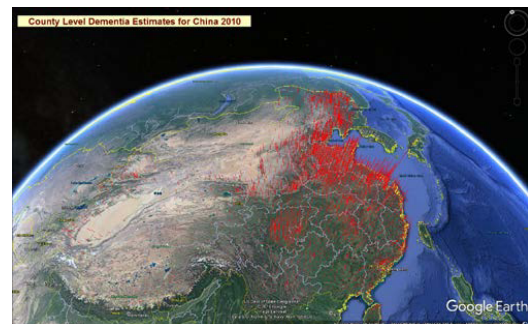

Figure 3: County Level Estimates of Dementia Prevalence in China 2010

The illustration above, Figure 3, shows the results for county-level dementia prevalence in 2010 for the whole of China. This illustrates not only the population distribution by county but also emphasises the eastern coastal and north-eastern

regional density patterning of China's ageing population. Each county's data is illustrated in red for easier visibility and the actual KML file is fully accessible in Goolge Earth™ which greatly enhances its visual accessibility compared to this reduced detail JPEG image.

Figure 4: County Level Estimates of Alzheimer's Disease in China 2010

In the second Google Earth™ image above, we have segmented out the data estimates for Alzheimer's Disease (AD) specifically, and visualised these in green to avoid any confusion between the different images. As with a geographic information system (GIS) these KML files can be supplemented with files of other data, such as hospital locations or pharmacies, to illustrate and explore the relationships between a specific health condition and health services infrastructure. As health systems and health informatic progress globally, we suggest that these types of additions to the health informatician's toolkit will greatly enhance the utility of health information datasets and health informatics modelling practices. All health and disease problems exhibit a spatial dimension and this type of visualisation can support understanding of these problems and our efforts to manage and resolve them.

In a third Google Earth™ image below, we have combined the AD prevalence estimates with a KML file of counties in China sourced from GDAM (http://gadm.org/). The resulting output shows the coloured polygons of the counties in association with their projected AD prevalence as vertical data columns. This obviously contextualises the data and China's physical geography more effectively than the data columns alone. In addition we turned off the borders and labels for other countries in Google Earth so that the user can focus more directly on China and its data in preference to supporting contextual geographic data. This further illustrates the importance of careful methods selection and use in communicating complex health information, esepcially so when using a spatial health informatics environment. Too much information, if not absolutely essential, can be as confusing as too little.

Figure 5: Dual Layer Map of Counties and AD Prevalence Estimates for 2010

Finally, it is important to note that as more health systems develop and utilise 'big data' strategies, new tools and methods will be necessary to inform non-health audiences of the findings of such studies. In this context data visualisation is a relatively new but rapidly expanding field. Spatial data visualisation, as illustrated in these examples, is a key aspect of these emerging changes in the health informatics environment. The drive towards strategies such as tele-health and m-health, including methods such as the remote-monitoring of patients, will add to the necessity of having spatially-informed data that can be used to lobby for funding, resources, workforce and so forth.

Discussion

This project explores the likely impact of dementia and dementia sub-types in the People's Republic of China which is now the largest ageing society in the world. China is already utilis-ing spatial science and technology to address age-related problems from a planning and service delivery perspective (e.g. Cheng et al, 2012) [5]. In addition, Yang et al [6] state that health and medical geography research is growing rapidly in China, indicating that ageing research and spatial methods will continue to converge. Lastly, several studies, such as the China Health and Retirement Longitudinal Study (CHARLS), are researching the prevalence and progression of the dementias in China [7]. This project adds to that complex emerging picture by modeling and visualising, in a spatial form, the scale of the issues that rapid population ageing presents for China and where its effects will be felt most strongly.

The value in this first iteration of our research is to make the totality of population ageing and its clinical and social effects accessible to a wide audience including various levels of government, policy developers, service planners, service providers and the broader citizenry. The need for societal level responses to the complexities and challenges presented by population ageing need to be supported by new and innovative instruments for monitoring and understanding the implications of current and future interventions. One such area of support lies in the new geographic and allied data visualisation tools becoming available to governments, planners, service providers and insurers.

The scale and speed of population ageing in China is profound and of an order of magnitude unlikely to be seen anywhere else except perhaps India. The multi-dimensional capacities of spatial science and technology represent a key domain for supporting societal-level responses to population ageing that aim for humane and sustainable outcomes. Ageing is fundamentally linked to space and place including the

connections people have to spaces and places as they age [7]. The future of population ageing requires a spatially informed and enabled approach to health information if such outcomes are to be achieved.

While the data we present here is shown at the county level, other administrative geographies can be utilised, such as province or prefecture. This means that, within the one information environment, data can be visualised for multiple scales and at different administrative levels. In addition, maps with more than one variable can be produced to example factors such as demography versus healthcare expenditure data, utilization of acute care services or the rates of other health conditions or events (cardiac, stroke, cancer etc.). Change is not only a feature of population ageing; it is a central feature of these spatial technologies. Their potential contribution to managing the complexity of health systems and health information management is on an upward developmental pathway. Which software to use and for what purposes will be highly contingent on the rate of change in this sector but the potential utility of such approaches remains clear and we can expect to see spatial methods added to other data visualisation environments.

Limitations

This is a point-in-time estimation of dementia prevalence and has the limitations of any similar modeling exercise. The aim of this model is not one of absolute accuracy, and we make no claims to that, but rather the application of spatial analysis and visualisation to a demographic trend with major implications for the Chinese government, healthcare systems, economy, and society. We have used the year 2010 as our reference year because of the production of the official Chinese census for that year, and recent revisions of dementia prevalence in China produced for the same year [8]. This makes the model reasonably accurate in a county-level approximation under those conditions, and a starting point for further investigation.

It is important to note, as indicated earlier, that research on dementia and their population-level effects is ongoing in China. Consequently, between this present work and the 2020 Chinese Census, we can expect to see a growing research information base come on stream. Simply put, because demography is so dynamic in China and researchers are working rapidly to build their understanding of population change and its effects, new data will almost certainly alter this picture and do so very soon. Its value lies in the visual dimension and in the technology's flexibility for exploring complex phenomena at the national level and below (provinces, counties etc.), all within the one virtual environment.

Conclusion

This developmental paper supports the growing awareness of the challenges that population ageing presents to China's health and social policy domains, as well as its rising number of elderly. The increasing survival of older people is a key achievement of China's health and economic developments of the past few decades, but systemic change will be necessary to meet the challenges posed by these successes. One key concern will be addressing the geographic scope of the inevitable challenges presented by population ageing and the rise of dementia across the country. These will co-occur with many other chronic and acute health conditions, making for new levels of complexity in identifying and treating the health needs of an ageing population.

We have presented a spatial virtual earth approach that makes a link between population ageing and dementia, which supports planning and response activities, as well as research and interventional programs. While this is a pilot project, it seems clear that the complexities of China's physical geography, its population dynamics, and governance structures (central, provincial, city, local etc.) would benefit from a spatial strategy in order to cope with health and social care implications of ageing and dementia. In addition, we suggest that a spatially informed health informatics strategy can support policy design and applied responses to the challenges presented by population ageing. The future of health information management and population ageing responses are, we suggest, highly spatial, if current and emerging challenges are to effectively be addressed.

Acknowledgements

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