Understanding the spatial disparities and vulnerability of population aging in China

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Abstract
Understanding the regional pattern of population aging in China enables rational policy making to address the challenges of inequity in social welfare and care resources among the east–central–west regions and rural–urban areas of China. This study uses census data in 2000 and 2010, and aging population ratios, annual increase rates, and spatial autocorrelation analysis to examine spatial disparities in population aging in China. The results show that the population is more aged and aging more rapidly in rural areas than in urban areas. Spatial clusters of population aging expanded from the east coastal region in 2000, to inland provinces such as Sichuan and Chongqing in 2010. The vulnerable regions in terms of population aging, health status of the elderly population, and economic level at the prefectural level were also identified.

KEYWORDS
China, population aging, rural and urban areas, spatial disparities, vulnerable regions

Abbreviations: APR, Aging population ratio; AIR, Annual increase rate; HS, Health status; GDP per capita, Gross domestic product per capita; IoV, Index of vulnerability

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INTRODUCTION

In global comparisons, China has more elderly people, and the population is aging more rapidly than any other country. The older population aged 65 and above reached 118.83 million (88.11 million in 2000), which accounted for 8.87% of the total population in 2010 (7.10% in 2000; National Bureau of Statistics of People's Republic of China, 2003, 2012). On the one hand, the socioeconomic development and improvements in health care services enabled the increase in people’s life expectancy from 73.04 in 2000 to 78.17 years old in 2010. On the other hand, the uneven development in China in recent decades has created enormous demand for labor in urban areas and eastern areas resulting in the net-out migration of young people from rural to urban areas to access education and employment. The population migration across provinces increased from 32.28 million between 1995 and 2000 to 54.99 million between 2005 and 2010. Megacities such as Beijing, Shanghai, and Guangzhou were the main destinations of the internal migrants, whereas central and western provinces such as Henan, Sichuan, Anhui, and Jiangxi were the main emigration sources (Wang, Pan, & Lu, 2012). For these reasons, regional disparities exist among provinces and between urban and rural areas in China in both the level and rate of population aging. The population in the coastal regions aged 10 years earlier than in the central and west regions of China. Before 2000, the annual increase in the aging population was faster in the coastal regions than the inland regions. As the internal migrants continued moving from inland regions to coastal regions between 2000, and 2010, the patterns of population aging changed with faster annual increases in the inland regions than the coastal regions after 2010 (Wang, Sun, & Li, 2013).

With regard to the rural–urban differences, the number of elderly people was 52.25 million in urban areas and 66.56 million in rural areas. Meanwhile, the aging population ratio (APR) was higher in rural areas (10.10% in 2010) than in the urban areas (7.8% in 2010). The rural APR increased from the east coastal region to the inland regions, and the rural population in the central and west regions was rapidly aging. The level of rural economic development and people’s level of education were major factors correlated with regional inequality in the rural–urban difference in population aging. However, the rural–urban pattern reversed with socioeconomic development, and rural–urban differences have declined over time (Du & Wang, 2010; Liu & Chen, 2012; Yuan, Wu, & Wu, 2007). These rural–urban differences are similar to those found in other countries, such as Japan, the United States, the United Kingdom, and Australia (Du & Wang, 2010; Shiode, Morita, Shiode, & Okunuki, 2014).

The regional differences in population aging come along with the inequity in socioeconomic development among the regions and social welfare benefits for the elderly. China has achieved enormous economic growth after its economic reform at the end of 1970s. However, uneven development exists among different provinces, rural and urban areas, and different regions within the same province. Central and western China have fallen behind the eastern region in socioeconomic development, and the gap widened especially after the 1990s. The large majority of Chinese population are aging but not yet rich. Compounded by population migration and the one-child policy, the challenges that population aging brings to Chinese society are complex and enormous.

Prior to the one-child policy, the major demographic policy concern of the government was the booming Chinese population. The Chinese government faced challenges in providing jobs and services for the rapidly growing population, which is the classic dilemma of developing countries. The economic reforms and opening-up policy changed China from a centrally planned economy to a more liberal, market-oriented system. To slow down population growth,
the one-child policy was implemented around the same time as the economic reform in China at the end of 1970s, which basically prohibited most couples from having more than one child. The two policies were both successful in turning China into a global economic power and rapidly reducing population growth. In 1980, the per capita fertility rate was 2.4, but by 2003, that number had fallen to 1.8, and even lower in the urban areas. However, rapid population aging and growing geographical differences as the side effects of the two policies create challenges for economic development and social security provisions for elderly people (Feng, Wang, & Jones, 2013). Adult children have fewer siblings to support their older parents, and the relative size of the working age population is declining. Many elderly people and children were left behind in the rural areas as the working age population migrated to urban areas (Liu & Griffiths, 2011).

The central government of China has endeavored to develop plans and policies to meet the challenges resulting from population aging. For example, the Construction Plan of Social Elderly Care System (2011–2015) issued by State Council of China recommended the development of an elderly care system that mainly depends on traditional family and community care, supplemented by residential care. The goal was to set up community service centers for all urban communities, 80% of the townships and 50% of the rural communities, and also provide 30 residential care beds for every 1,000 elderly people (General Office of the State Council, 2011). In the recent report delivered by President Xi at the 19th National Congress of the People’s Republic of China, President Xi emphasized the implementation of the “Healthy China Initiative”. The Chinese government aims to ensure the childbirth policy meshes with related economic and social policies and respond proactively to population aging. The report also calls for governments at various levels to provide integrated elderly care and medical services and accelerate the development of old-age programs and industries (Xi, 2017). However, the national policies need to be supplemented by local policies to meet the challenges created by the geographical disparities in population aging and the health status (HS) of elderly people. It is critically important to measure the regional differences at various scales in population aging and HS of the elderly people.

Internationally, researchers have applied various indices for measuring the degree of population aging, such as APR, aging population density, the old-age dependency ratio, and the dynamic aging index (Długosz & Kurek, 2009; Kurek, 2011; Shiode et al., 2014; Yuan et al., 2007). Recently, there have been debates about using a single index to measure aging, and it has been argued that using a single measure can result in an incomplete or even distorted understanding of population aging (Shiode et al., 2014). Shiode et al. (2014) suggest the use of multiple indices, and methods to ensure population aging is understood properly. For example, Shiode et al. (2014) used APR and aging population density in correlation and bivariate local spatial statistical analyses to study the spatial distribution of elderly people in Japan. They identified various types of aging communities including depopulated rural areas, pockets of aging communities in urban areas, and growing concentrations of aging populations in suburban areas of Aichi prefecture, Japan. Related Chinese studies have focused on regional differences in population aging, rural and urban differences, and factors associated with the differences (Du & Wang, 2010; Liu & Chen, 2012; Yuan, 2013; Yuan et al., 2007). There is, however, a lack of research, which comprehensively studies population aging patterns at various scales and identifies vulnerabilities faced by the various regions across China resulting from the combination of population aging, the HS of the elderly population and economic level of the regions.

This study aims to address the demographic challenges of rapid population aging in China. Specifically, it focuses on the analysis of the spatial disparities of the rural and urban elderly
population. Understanding this trend enables rational policy making to address the challenges of inequity in social welfare and care resources among the east-central-west regions and rural–urban areas of China. The following section introduces the data and methods that are used in this study. The third and fourth sections present the regional differences of rural and urban population aging at the provincial and prefectural levels, respectively. The subsequent sections identify the spatial clusters of population aging, the change and vulnerability of regions. The conclusions are summarized and discussed in the last section.

2 | DATA AND METHODS

Population data are from the fifth (2000) and sixth (2010) population census of China, which include the urban and rural elderly population at the prefectural and provincial levels in 2000, and 2010 (National Bureau of Statistics of China 2003, 2012). The data of the permanent resident population are used for analysis, which includes the household registered population and the internal migrants who have lived in an area for more than 6 months. The data on migration population within 6 months are not available. We define the elderly population as the population aged 65 and above. The 2010 census data also provide the HS of the rural and urban elderly population, however, were only available for the population aged 60 and above at the prefectural and provincial level. China is composed of 22 provinces, five autonomous regions, four municipalities, and two Special Administrative Regions (Figure 1, Table 1). Data from Taiwan, Hong Kong, and Macau are not available; therefore, we only include 31 provincial administrative divisions in this study. Administrative divisions changed in some provinces from

![FIGURE 1](https://ssrn.com/abstract=3341018)
2000 to 2010. The data of 337 and 338 prefectural statistical units were included in 2000 and 2010, respectively.

Three indices, the APR, the annual increase rate (AIR), and HS, are applied to examine population aging at the provincial and prefecture levels. Choropleth mapping is applied to show the spatial distribution patterns.

The APR with a threshold of 65 years old has been most widely used for measuring the spatial distribution of the elderly population (Hodge, 2008). In this study, we define the APR as the percentage of the elderly population aged 65 years old to the total population.

The AIR was measured by the annual change rate of APR during the 10 years, which was calculated as Formula 2.

\[
\text{APR}_{2010} = \text{APR}_{2000} \times (1 + \text{AIR})^{10} \quad (1)
\]

\[
\text{AIR} = \left( \frac{\text{APR}_{2010}}{\text{APR}_{2000}} \right)^{0.1} - 1 \quad (2)
\]

In the 2010 census, HS of the elderly population aged 60 and above was classified as good health, fair health, poor health with self-care ability, and poor health without self-care ability. As the elderly population with poor health and without self-care ability is the group who needs much more care resources than their counterparts, this study maps the regional difference of the proportion of the elderly population with poor health and without self-care ability to reflect one aspect of the care burden. We also aggregate the first two types as good health and the last two types as poor health. The proportion of the elderly population with good health and poor health were used for analysis for levels of vulnerability.

Spatial autocorrelation analysis includes global and local measures. The former is used to evaluate if there is spatial autocorrelation in the entire study area, whereas the latter is applied to identify the clusters of population aging at the prefectural level. Moran’s I is calculated to measure global spatial autocorrelation. The value of Moran’s I is positive when nearby objects tend to be similar in attributes, whereas the value is negative when the objects tend to be dissimilar in attributes. When the value is zero, the objects are arranged randomly and independently in space (Anselin, 1995; Charreire & Combier, 2009; Tsou, Hung, & Chang, 2005). Local Indicator of Spatial Association (LISA) cluster maps provide information on the relative importance of four types of spatial association. In this study, High High refers to high APR in a prefecture and also high APR in the neighboring prefectures (positive association); High

### Table 1: Regions of China (Lv, 2012)

| Region             | Provinces/Autonomous Regions/Municipalities/Special Administrative Regions                                      |
|--------------------|----------------------------------------------------------------------------------------------------------|
| Northeast China    | Heilongjiang, Jilin, Liaoning                                                                          |
| North China        | Beijing, Tianjin, Shanxi, Hebei, Henan, Shandong                                                        |
| Central China      | Shanghai, Zhejiang, Jiangxi, Jiangsu, Anhui, Hunan, Hubei                                               |
| South China        | Fujian, Guangdong, Guangxi, Hainan, Hong Kong Special Administrative Region, Macao Special Administrative Region, Taiwan |
| Northwest China    | Shaanxi, Inner Mongolia, Gansu, Ningxia, Xinjiang                                                     |
| Southwest China    | Chongqing, Sichuan, Guizhou, Yunnan                                                                    |
| Qinghai–Tibet Region | Qinghai, Tibet                                                                                  |

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Low refers to high APR in a prefecture whereas low APR in the neighboring prefectures (negative association); Low Low refers to low APR in a prefecture and also low APR in the neighboring prefectures (positive association); Low High refers to low APR in a prefecture whereas high APR in the neighboring prefectures (negative association). All analyses and mapping were carried out using the SPSS 16.0, OpenGeoDa0.9.9.9, and ArcGIS 9.3.

The concept of “vulnerability” is frequently used in the study of health risks and outcomes associated with global environmental change (Cheng & Rosenberg, 2014). Vulnerability is affected by various factors, including the aspects of population aging, HS, economic development, etc. In this study, the index of vulnerability (IoV) was measured by APR, HS, and gross domestic product per capita (GDP per capita) in 2010. The IoV was calculated at the prefectural levels. HS was measured by the proportion of elderly people with poor health. Because the variables have different units of measurement, standardization procedures were applied to normalize the data. Standardization transformed the raw variable scores by applying the Equations 3 and 4:

\[
X' = \frac{X - \min(X)}{\max(X) - \min(X)},
\]

where \(X\) is an original value, and \(X'\) is the normalized value. This normalization procedure converts the indicators to a common scale range in \([0, 1]\). This study applied the Equation (3) for the standardization of APR and HS, whereas the Equation (4) was applied for the standardization of GDP per capita.

The IoV was calculated by the Equation (5).

\[
\text{IoV} = \text{standardized APR} \times \text{standardized HS} \times \text{standardized GDP per capita}
\]

The level of vulnerability was classified into three levels based on the values of IoV by using natural breaks.

3 | SPATIAL DISPARITIES OF POPULATION AGING

According to the United Nations, a country begins to age when more than 7% of its population is 65 years old and above (Hodge, 2008). At the provincial level, in 2000, the APR in urban areas was highest in Shanghai (11.31%) and lowest in Tibet (3.10%). The urban population in seven provinces (municipalities) can be labeled as “aged,” and six out of the seven provinces (municipalities) were located in the east coastal region. The APR was generally higher in the rural areas, where the ratios were over 7% in 17 provinces. The ratio was highest for the rural population of Shanghai (12.62%) and lowest in Ningxia (4.40%).

In 2010, the population in the majority of regions became aged with the urban APRs of 23 provinces and rural APRs of 27 provinces (municipalities) being over 7%, respectively. In the urban areas, other than the east coastal regions, the population was also aged in northeast China and central and southwest China including Sichuan, Chongqing, and Hunan. The urban APR was highest in Liaoning (10.30%) and lowest in Tibet (3.45%). In the rural areas, the ratios were generally higher in the south region than in the north region with the highest in Chongqing (14.51%) and lowest in Xinjiang (5.57%).

A rural–urban reverse effect, which refers to the APRs of rural areas, are higher than the value for the urban areas occurred in most of the provinces in both 2000 and 2010, and the gaps
increased in most of the provinces during the 10 years. Especially in the east coastal region, the gap of APR between rural areas and urban areas was largest among all these regions as a result of the net migration of labor from rural to urban areas in the more developed regions of China.

More details in the spatial differences in APR show up at the prefectural level (Figure 2). In 2000, the APRs in urban areas at the prefectural level ranged from 1.23% (Shenzhen in Guangdong province in south China) to 12.14% (Neijiang in Sichuan province in southwest China). There were 51 prefectures (15.13% of the prefectures) with urban APRs over 7%, and most of them were located in Liaoning in northeast China, Beijing and Tianjin in the north China, Sichuan and Chongqing in the southwest China, and the east coastal regions (Figure 2a). In contrast, the APRs in rural areas ranged from 1.15% (Shenzhen in Guangdong province in south China) to 13.8% (Nantong in Jiangsu province in central China). Over half of the prefectures were aged (178 prefectures) and distributed across the east and south coastal regions, the central region of Inner Mongolia, and central region in south China. Clusters of rural population aging were found in Jiangsu, Zhejiang, Shandong of the east coastal region, and Guangdong in the south coastal region (Figure 2b).

In 2010, the urban population was aged in most prefectures of the north, central, south, southwest, and northwest China (234 prefectures, 69.23% of the prefectures). The APRs ranged between 1.79% (Shenzhen of Guangdong Province in south China) and 13.39% (Nantong of

![FIGURE 2](https://ssrn.com/abstract=3341018)
Jiangsu in central China). In the rural areas, the ratios were over 10% in 142 prefectures and over 7% in 285 prefectures (84.32%) with the highest in Nantong of Jiangsu province in central China (20.43%) and lowest in Naqu of Tibet (2.14%). The rural urban reverse effect of APRs was shown in 286 prefectures, especially in Shandong, Zhejiang, Jiangsu of the east coastal region, Sichuan in southwest China, and Shanxi province in north China. The spatial disparities within provinces are also notable. The distribution of APR at the prefecture level helps understand the regional differences within each province. For example, in Sichuan province located in southwest China, it was classified as an aged province at the provincial level, but the aged region was located in the east and central part of the province, whereas the age structure was relatively young in the west and north regions of Sichuan province. With regard to the rural and urban differences, a higher ratio of rural APR occurs in the east and north regions of Sichuan, whereas a higher ratio of urban APR occurs in the south region in 2010 (Figure 2c,d). The differences of APR within a region and between rural and urban areas implies the differences in population structure and demands for social services for the elderly people among various regions, which is important for the allocation of care resources and policy making for elderly support at the provincial and national level.

**FIGURE 3** Local Indicator of Spatial Association cluster maps of aging population ratio in China in 2000 and 2010 (a) Local Indicator of Spatial Association cluster map of urban aging population ratio in 2000; (b) Local Indicator of Spatial Association cluster map of rural aging population ratio in 2000; (c) Local Indicator of Spatial Association cluster map of urban aging population ratio in 2010; (d) Local Indicator of Spatial Association cluster map of rural aging population ratio in 2010
In addition, a spatial autocorrelation analysis was carried out to identify the spatial clusters of APR. The values of Moran’s I range from 0.6076 to 0.7086 in 2000 and 2010, in the urban and rural prefectures and the entire country, which indicate that the nearby APRs tend to be similar, and the APRs are spatially autocorrelated in the whole country and both urban and rural areas in 2000 and 2010. The LISA cluster maps show that the expansion of clusters of urban and rural population aging between 2000 and 2010, have different spatial patterns. The clusters of the urban elderly population expanded in northeast China and the southeast region of Sichuan province in southwest China, whereas the cluster in the east coastal regions expanded to most of Jiangsu province and the east region of Anhui province from 2000 to 2010, (Figure 3a,c). The clusters of the rural elderly population located in east coastal areas were similar in 2000 and 2010, but the cluster expanded in the east region of Sichuan in southwest China, and a new cluster formed in the west region of Hunan province in 2010 (Figure 3b,d). Hainan also became a cluster of the urban elderly population in 2010, as many elderly people migrate there to enjoy the pleasant climate and living environment.

4 | CHANGES IN POPULATION AGING

The increasing rate of population aging is worth analyzing to understand the trend of population aging. AIR is applied to measure the rate of change in population aging. Between 2000 and 2010, the APR in rural areas increased from 7.50 to 10.06%, with an AIR of 2.98%. Meanwhile, the ratio in urban areas increased from 6.42 to 7.80%, with an AIR of 1.96%. The population aging process was more rapid in the rural areas than in the urban areas.

At the provincial level, the AIR in the urban areas was highest in Xinjiang in northwest China (5.5%). The population aging process slowed down in Shanghai, Tianjin, and Zhejiang in the east coastal area from 2000 to 2010 (AIR<0). In the rural areas, the population aging process was most rapid in Chongqing in southwest China (5.9%) and Gansu in northwest China (5.1%) and slowed down in Shanghai (−0.4%). At the prefectural level, the population aging process increased most rapidly in the urban areas of northeast and northwest China and in the rural areas of northwest and southwest China. The AIR was greater in the rural areas than in the urban areas in the east coastal region and southwest China, such as the north part of Shaanxi, Chongqing, parts of Guizhou and Zhejiang. A possible reason for the relatively high

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percentages and increasing rates is the rural working age population who migrated to urban areas in the east coastal and central regions of China and the elderly population who remained in the rural areas. While in north China and Qinghai–Tibet region, lower proportions of the rural population migrated to urban areas, the proportion of the elderly population increased in urban areas because of improvements in health care services and relatively low birth rates than in the rural areas (Figure 4a,b). Further investigations are, however, needed to provide definitive reasons for the changes noted here. The governments at various levels should take into account the trend of population aging at the provincial and prefectural levels when allocating or planning for the social services for the elderly and be aware of the challenges that the population aging may create.

5 | VULNERABILITY OF POPULATION AGING

In terms of the HS of the elderly population, the proportion of elderly people with poor health and without self-care ability is used for reflecting the differences in care burden among prefectures and provinces. The HS of rural elderly people is worse than their urban counterparts (Figure 5a,b). The proportion of urban elderly people with poor health and without self-care ability ranges from 1.02 to 8.58%, whereas the proportion ranges from 1.38 to 12.02% in rural areas at the prefectoral level (Figure 5). Generally speaking, the elderly people living in the south China enjoy better HS than the elderly people living in the southwest and north China.

This study takes into account the APR, HS, and economic level for understanding the vulnerability of population aging in a region. The values of IoV ranges from 0 to 0.35. There are 110 (32.45%) prefectures classified as regions with low vulnerability with the IoV ranging from 0 to 0.09. Most of these prefectures are located in the east and southeast coastal regions, central region in Inner Mongolia and west regions of China. There are 159 (46.90%) prefectures classified as regions with medium vulnerability with the value of IoV ranging from 0.091 to 0.160. In contrast, 70 (20.65%) prefectures are with high vulnerability of population aging with the value of IoV ranging from 0.161 to 0.350. The regions with high vulnerability of population aging are located in northeast China, central China, west China, and Hainan (e.g., north region of Hebei province, southwest region of Qinghai, east region of Gansu, east region of Sichuan, Chongqing,

**FIGURE 5** Proportion of elderly people with poor health and without self-care ability in urban and rural areas of China in 2010 (a) Elderly people in urban areas; (b) Elderly people in rural areas
south region of Shannxi, west region of Hubei, north region of Guizhou, central and north region of Hunan, west region of Guangxi, Anhui, east region of Henan, and Hainan (Figure 6).

Our measure of vulnerability in terms of APR, HS, and GDP per capita shows the differences in levels of population aging, economic development, and elderly people’s HS at the prefectural level. The mapping helps visualize and highlight the most vulnerable areas that can be helpful in policy making at various levels of governments. The central government and local governments of the regions with high vulnerability should be aware of the status and trends of population aging in these regions and its implications to the socioeconomic development at the local and regional levels, in order to better allocate the resources to improve the adaptive capacity to population aging in these regions.

6 | DISCUSSION AND CONCLUSION

The Chinese population is rapidly aging with great regional disparities. Inequities in income and social welfare exist among rural and urban residents, as well as the residents in the east developed regions and inland developing regions of China, which affects the adaptive capacity to population aging of various regions. The indexes of APR, AIR, and levels of vulnerability are helpful tools for understanding regional disparities of population aging at various scales and contributing knowledge for related policy making to better meet the challenges of rapid population aging in China.
The results of this study show that APRs are higher in the rural areas than the urban areas. In the urban areas, the population is more aged in the east coastal region and northeast, northwest, and central China such as Sichuan and Chongqing. In contrast, the rural population is more aged in the south and central regions than the north region. The analysis of population aging at the prefectural level provides a finer lens of detail of population aging than at the provincial level. However, analysis at both scales is important for policy making.

Spatial clusters of urban population aging were identified in northeast China, east coastal regions, the east region of Sichuan in southwest China, and Hainan in south China. In the east coastal regions including Shandong, Jiangsu, Zhejiang, Anhui, the east region of Sichuan in southwest China, and the west region of Hunan in central China, clusters of rural population aging were identified. These clusters were formed because of the relatively low birth rate and increased life expectancy in urban areas, whereas the reasons for rural clusters were mainly due to the emigration of labor force to urban areas.

This research also found that regional disparities exist in terms of the increasing rate of population aging. The increasing rate of population aging was relatively high in urban areas of northeast and northwest China, although it was high in the rural areas of northwest and southwest China. The spatial pattern of the increasing rate of population aging draws attention to the need to understand the reasons of disparities in AIR, which might then lead to suggestions for regional policy making.

The patterns of population aging also reflect the patterns of vulnerability of population aging measured by APR, HS, and GDP per capita. Heilongjiang, Jilin, and Liaoning in northeast China, Sichuan, and Chongqing in southwest China and Anhui, Hunan, and Hubei in central China are the most vulnerable regions with high APR, proportion of poor health, and relatively low GDP per capita among the aging populations.

Population aging is affected by three key factors, namely, births, deaths, and migration. The average age for giving birth to a child and life expectancies are higher in urban areas than rural areas, and the birth rate is lower in urban areas compared with the rural areas, which have more effects on population aging in urban areas than in rural areas. The effects of large-scale population migration of younger workers from rural to urban areas has a greater impact on population aging in rural areas than in urban areas. These trends combined most likely explain the rural–urban reverse pattern of population aging in most of the regions in China (Du & Wang, 2010). Based on forecasts, after 2020, both the aging population rate in rural and urban areas will rapidly increase, and the number of elderly people in urban areas will double the number in rural areas. As urbanization of the Chinese population continues, rural–urban differences will decrease, and the aging population rate in urban areas will be higher than in the rural areas in 30 years (Du & Wang, 2010).

These regional differences and rural–urban differences are important for the provision of family and social care in China. Meanwhile, the geographical disparities in economic development increase the possibility of labor migration, which has an impact on population structure and care resources (Phillips & Feng, 2015). Household arrangements have also recently changed dramatically in China. Fewer elderly people are living with their children for various reasons. In many cases, younger people are moving to other places within provinces or to other provinces for education and job opportunities. Even those who migrate from rural to nearby urban areas and those who live separately within the same city as their parents are unable to provide daily support to their older parents considering their care responsibilities for young children, living distance from their older parents and their busy urban life styles. The increase in the living distance between adult children and their older parents makes the daily instrumental support for
older parents less likely, but adult children somehow compensate for the decline in social support to their parents by providing more financial support. The oldest-old in the rural areas are mostly cared for by the young-old. In urban areas, especially megacities such as Beijing and Shanghai, the elderly are expected to be more independent and depend less on their adult children for care because of the decrease in family care resources. Aging in place and community care are the preference for the elderly. Improvements in community care resources are urgently needed as the parents of the first generation of the one-child policy are entering their elderly life (Du & Du, 2002; Zhang & Wang, 2005). To understand the regional and rural–urban disparities of population aging is crucial to policy making to reduce regional and rural–urban inequality in the quality of life of the elderly population recognizing that policies and programs need to take into account whether elderly people live in urban or rural areas or what the region of China.

The household registration system is also important for understanding rural–urban disparities in China. It is used to identify whether someone is a resident of a certain administrative area and restricts population migration between rural and urban areas. A family is registered as a rural or urban household of a certain place, and a resident’s health care insurance, education, pension, and other social security benefits are all determined by where the person’s household registration is located. The rural elderly receive less social welfare such as pensions and health care insurance than their urban counterparts as the social welfare system is tied to the household registration system in China. For a long period of time, rural residents, urban unemployed residents, and urban employees enjoyed different pension benefits. In 2009, a new pension plan called the “New Rural Social Pension System” was set up in rural regions. For unemployed residents in urban areas, the Chinese State Council set up a basic pension in 2011, combining a funded pension financed by individual payments and subsidies from the government. In 2014, the State Council decided to merge the Urban Residents Pension Plan and the New Rural Social Pension System into a unified basic pension insurance plan for both urban and rural residents. Most rural residents and unemployed urban residents are now covered by one national social pension plan. However, the benefit amount of this plan is very low, with a country average of 81 RMB (13 U.S. dollars) per month. In 2015, the government also established a universal noncontributory pension plan covering urban unemployed workers and rural residents, combined with an old-age insurance program covering urban employees (Liu & Sun, 2016). The average annual income for the urban elderly were 11,963 and 19,892 RMB in 2006 and 2010, respectively, compared with 2,722 and 4,756 RMB for the rural elderly.

With regard to the health care insurance, urban employed workers, unemployed residents, and rural residents were covered by different health care insurance plans. The Chinese government promulgated “establishment of the basic medical insurance system for urban employees” in 1998, whereas the Urban Resident Basic Medical Insurance Scheme was set up by the government in 2007, for unemployed urban residents. For rural residents, the New Rural Cooperative Medical Scheme was set up by the government in 2003. By the end of 2013, 95% of urban and rural residents were covered by one of the medical insurance schemes, namely, Urban Employee Basic Medical Insurance, Urban Resident Basic Medical Insurance, and New Rural Cooperative Medical Insurance. The Chinese government has conducted reforms to improve the equity in access to pension and health care insurance by all citizens. Great disparities still, however, exist between urban and rural residents in various regions, and the rural elderly are placed at the more vulnerable positions in terms of social welfare benefits. Rapid population aging brings challenges for both the pension system and health care insurance. Gaps, however, exist between the demands of elderly people, provision of services, and service utilization.
As the rural elderly gain fewer benefits from pension and health care insurance than the urban elderly, the rural elderly are more dependent on support from their families than the urban elderly, especially when they lose the physical ability to work or care for themselves (Feng et al., 2013). The change in traditional values, smaller family sizes, the growing number of “empty nesters,” limited pension, and health care system all create more challenges for elderly care in rural areas now and in the next few decades in the absence of policy and planning changes. In the urban areas, both the APRs and the numbers of elderly people are high, which create many challenges for the provision of public facilities, health care facilities, and social welfare for the elderly. For instance, Beijing municipal government plans to develop the “9064” model for elderly care by 2020, which is predicated on 90% of the elderly depending on family care with the assistance of community services, 6% of the elderly depending on community care funded by the government, and 4% of the elderly depending on residential care. To improve community care, the Beijing municipal government has also implemented nine specific actions since 2009, which include providing meals to the elderly and the disabled in communities, and building senior centers, day care centers, and community residential care facilities for the elderly in communities (Beijing Municipal Civil Affairs Bureau, 2009). Gaps, however, exist between the demands of elderly people, provision of services, and service utilization (Cheng, Rosenberg, Yu, & Zhang, 2016).

Based on the 2008 National Health Services Survey in China, the rural population had worse HS than the urban population. HS of the elderly population was worse in the western region and best in the eastern region, and such differences were more profound in rural areas. In urban areas, HS was best in middle-sized cities. In rural areas, HS increased with the economic development level of a county (Sun et al., 2011). The increase in regional disparities in population aging in rural areas creates more challenges for policy makers trying to reduce the inequity in access to social welfare and care resources. Meanwhile, as rapid urbanization continues, the migrants moving from rural areas to urban areas will become the elderly population in 30–40 years. Those migrants who plan to move back to their hometown when they are older will increase the aging population in rural areas, whereas those who plan to settle down in the urban areas will create challenges for population aging in the destinations. The rapid increase in both the urban and rural elderly population will demand more social and health care resources in the future. All the trends discussed above create challenges of how to reduce the inequity in access to social and health care resources among the urban and rural areas in various regions and how governments need to take into account the rapid increasing demands for resources that will result from the aging of the population.

APR and AIR are useful indices for understanding the regional disparities in population aging at various scales. The vulnerability of population aging measured by APR, HS, and GDP per capita helps identify the areas with highest level of vulnerability, where the aging population experiences high APR, relatively poor HS, and the region produces relatively low GDP per capita, which affects its capacity for meeting the challenge of population aging. Understanding the spatial disparities and rural–urban differences in population aging and identifying the vulnerability of each region helps in understanding the challenges of population aging and provides a reference point for the allocation of resources and policy making.

For policy implication, governments at various levels should plan for the residential care facilities and social services for the elderly based on the level and vulnerabilities of population aging. Recently, various large cities in China such as Tianjin, Chengdu in Sichuan province, Xi'an in Shaanxi province, and Zhengzhou in Henan province announced a set of local polities to attract the labor force with high education to register their households in such cities taking
into account the impact of rapid population aging on the development of local economy. To actively respond to the population aging, governments can also conduct some pilot projects to improve the quantity and quality of elderly care services based on local knowledge and apply the successful ones in other regions, such as social welfare reform and provision of community care services. Both the top-down policy and bottom-up actions are important for reducing the rural–urban differences and active response to population aging. In recent years, Chinese governments encourage the construction of age-friendly communities for the elderly, which is a good example for local actions as community is the main activity space for the elderly people. For individual families and elderly people, active aging are encouraged. With the support of policies and community care resources, individual-based care services are important for the improvement in the quality of life for the elderly.

There are, however, some limitations that should be addressed when interpreting the results. First, the differences in the spatial patterns at the provincial and prefecture scales may relate to the modifiable areal unit problem (MAUP) and have impacts on interpretation of the results of the spatial analyses. Generally, if MAUP exists, there is increasing correlation as unit size increases. The aggregation effect causes variation in correlation statistics when regrouping data into different configurations at the same scale (Openshaw & Taylor, 1981). Comparing the outcomes of empirical analysis using different scale units help gain a deeper understanding of the actual distribution (Fotheringham, Brunsdon, & Charlton, 2000). Secondly, this study presented the spatial pattern of population aging, but the reasons for population aging need to be analyzed in more detail on a prefecture by prefecture basis. For example, the APRs are low in Shenzhen and Dongguan in Guangdong province in south China as they are newly developed cities with high percentages of migrants from other regions. The rural population is aged in Sichuan and Chongqing in southwest China because of the “floating” population emigrating in this region. The factors of population aging are different among various regions even though many regions share high APR or AIR. This study did not link health care resources to understand the population aging process and vulnerability of the elderly population, which is part of our future plan in the study of population aging in China. Even with these limitations, this study develops an index to measure the levels of vulnerability of population aging and provides a macro picture to understand population-aging patterns in China, a starting point for future studies on this topic and provides knowledge for policy making and planning for the elderly population of China.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Yang Cheng contributed to the design and analysis of the study and writing of the manuscript. Siyao Gao, Shuai Li, and Yuchao Zhang contributed to the data collection, mapping, and data
analysis, and Mark Rosenberg contributed to the design of the study and revising the manuscript. All authors read and approved the final manuscript.

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REFERENCES

Anselin, L. (1995). Local indicator of spatial association-LISA. Geographical Analysis, 27, 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Beijing Municipal Civil Affairs Bureau (2009). Suggestions on the implementation of "measure of ageing in place for Beijing citizens". Available online: http://shbz.beijing.cn/fuwu/bjsylfw/n214093399.shtml (accessed on 25 December 2017). (In Chinese)

Charreire, H., & Combier, E. (2009). Poor prenatal care in an urban area: A geographic analysis. Health & Place, 15(2), 412–419. https://doi.org/10.1016/j.healthplace.2008.07.005

Cheng, Y., & Rosenberg, M. (2014). Health risks and response of vulnerable population in Beijing, China. In W. Wang, T. Krafft, M. Rosenberg, & E. Pilot (Eds.), Health and environmental change in urban areas (pp. 194–213). Beijing: China Environment Press.

Cheng, Y., Rosenberg, M., Yu, J., & Zhang, H. (2016). Food security for community-living elderly people in Beijing, China. Health & Social Care in the Community, 24(6), 747–757. https://doi.org/10.1111/hsc.12255

Długosz, Z., & Kurek, S. (2009). Population ageing and its predictions for 2030 in the Malopolskie Voivodship compared to Poland and Europe. Moravian Geographical Reports, 17(1), 2–18.

Du, J., & Du, X. (2002). Rural–urban migration and its impacts on family elderly care in the emigration areas. Population Research, 26(2), 49–53. (In Chinese)

Du, P., & Wang, W. L. (2010). The difference of urban and rural ageing and its transition. Population Research, 34(2), 3–10. (In Chinese)

Feng, Z., Wang, W. W., & Jones, K. (2013). A multilevel analysis of the role of the family and the state in self-rated health of elderly Chinese. Health & Place, 23, 148–156. https://doi.org/10.1016/j.healthplace.2013.07.001

Fotheringham, A. S., Brunsdon, C., & Charlton, M. (2000). Quantitative geography: Perspectives on spatial data analysis (ed., Vol. 50(1) (pp. 143–163)Sage Publications, ppXI - XII Isaaks E. and R. Mohan Srivastava.

General Office of the State Council (2011). The construction planning of social elderly care system (2011–2015). Available online: http://www.gov.cn/xxgk/pub/govpublic/mrlm/201112/t20111227_64699.html?keywords=%C0%CF%C1%E4 (accessed on 25 December 2017). (In Chinese)

Hodge, G. (2008). The geography of ageing: Preparing communities for the surge in seniors. Montreal, Canada: McGill-Queen’s University Press.

Kurek, S. (2011). Double transitions? Regional patterns of population ageing in Poland. Geografiska Annaler, 93(2), 163–184. https://doi.org/10.1111/j.1468-0467.2011.00367.x

Liu, N., & Chen, Y. (2012). Study on spatio-temporal distribution features of rural elderly population in China with GIS. Resource Development & Market, 28(4), 325–328. (In Chinese)

Liu, S., & Griffiths, S. M. (2011). From economic development to public health improvement: China faces equity challenges. Public Health, 125, 669–674. https://doi.org/10.1016/j.puhe.2011.08.004

Liu, T., & Sun, L. (2016). Pension reform in China. Journal of Ageing & Social Policy, 28(1), 15–28. https://doi.org/10.1080/08959420.2016.1111725

Lv, L. C. (2012). Geography of China (1st ed.). Beijing, China: Science Press. In Chinese

National Bureau of Statistics of People’s Republic of China (2003). Tabulation on the 2000 population census of the People’s Republic of China. Beijing, China: China Statistics Press. (In Chinese)
National Bureau of Statistics of People’s Republic of China (2012). Tabulation on the 2010 population census of the People’s Republic of China. Beijing, China: China Statistics Press. (In Chinese)

Openshaw, S., & Taylor, P. J. (1981). The modifiable areal unit problem. In N. Wrigley, & R. J. Bennett (Eds.), Quantitative geography: A British view (pp. 60–70). London: Routledge & Kegan Paul.

Phillips, D. R., & Feng, Z. X. (2015). Challenges for the ageing family in the People’s Republic of China. Canadian Journal on Ageing/La Revue Canadienne du Vieillissement, 34(3), 290–304. https://doi.org/10.1017/S0714980815000203

Shiode, N., Morita, M., Shiode, S., & Okunuki, K. (2014). Urban and rural geographies of ageing: A local spatial correlation analysis of ageing population measures. Urban Geography, 35(4), 608–628. https://doi.org/10.1080/02723638.2014.905256

Sun, S., Chen, J., Johannesson, M., Kind, P., Xu, L., Zhang, Y., & Burström, K. (2011). Regional differences in health status in China: Population health-related quality of life results from the National Health Services Survey 2008. Health & Place, 17(2), 671–680. https://doi.org/10.1016/j.healthplace.2011.01.007

Tsou, K. W., Hung, Y. T., & Chang, Y. L. (2005). An accessibility-based integrated measure of relative spatial equity in urban public facilities. Cities, 22(6), 424–435. https://doi.org/10.1016/j.cities.2005.07.004

Wang, G. X., Pan, Z. H., & Lu, Y. Q. (2012). China’s inter-provincial migration patterns and influential factors: Evidence from year 2000 and 2010 population census of China. Chinese Journal of Population Science, 32(5), 3–13. (In Chinese)

Wang, Z. B., Sun, T. S., & Li, G. P. (2013). Regional differences and evolutions of population ageing in China. Population Research and Policy Review, 37(1), 66–77. (In Chinese)

Xi JP (2017). Secure a decisive victory in building a moderately prosperous society in all respects and strive for the great success of socialism with Chinese characteristics for a new era. Available online: http://news.xinhuanet.com/politics/19cpcnc/2017-10/27/c_1121867529.htm (accessed on 25 December 2017). (In Chinese)

Yuan, J., Wu, D. T., & Wu, Z. Z. (2007). Analysis on regional disparity and contributing factors of rural population ageing in China. Chinese Journal of Population Science, 1, 41–47. (In Chinese)

Yuan, T. F. (2013). China’s ageing population and its spatial features in city areas (2000-2010). Urban Planning Forum, 6, 58–66. (In Chinese)

Zhang, W. J., & Wang, S. Z. (2005). The impact of intergenerational support from the adult children on the life satisfaction of the rural older people. Population Research, 29, 73–80. (In Chinese)

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