Original Article

DOI: 10.5582/bst.2017.01246

Internal migration and regional differences of population aging: An empirical study of 287 cities in China

Rong Chen[1,*], Ping Xu[2], Fen Li[1], Peipei Song[1,3]

[1] *Shanghai Health Development Research Center, Shanghai, China;*
[2] *Department of Gerontology, University of Massachusetts Boston, MA, USA;*
[3] *Graduate School of Frontier Science, The University of Tokyo, Kashiwa-shi, Chiba, Japan.*

Summary **In addition to birth and death, migration is also an important factor that determines the level of population aging in different regions, especially under the current context of low fertility and low mortality in China. Drawing upon data from the fifth and sixth national population census of 287 prefecture-level cities in China, this study explored the spatial patterns of population aging and its trends from 2000 to 2010 in China. We further examined how the large-scale internal migration was related to the spatial differences and the changes of aging by using multivariate quantitative models. Findings showed that the percentage of elder cities (*i.e.* proportion of individuals aged 65 and above to total population is higher than 7%) increased from 50% to 90% in the total 287 cities within the decade. We also found that regional imbalances of population aging have changed since 2000 in China. The gap of aging level between East zone and the other three zones (*i.e.* West, Central, and North-east) has considerably narrowed down. In 2000, Eastern region had the greatest number (65) of and the largest proportion (74.7%) of elder cities among all four regions. By 2010, the proportion (87.4%) of elder cities in the eastern region was slightly lower than Central (91.4%), Western (88.2%) and North-east sectors (91.2%). Results from multivariate quantitative models showed that the regional differences of population aging appear to be affected much more by the large-scale internal migration with clear age selectivity and orientation preference than by the impact of fertility and mortality. Population aging is expected to continue in China, which will in turn exacerbate regional imbalances. Policies and implications are discussed to face the challenges that the divergent aging population may present in China.**

Keywords: Regional differences of aging, internal migration, multivariate quantitative models

1. Introduction

Aging is an inevitable path of demographic transition, as the inescapable result of low fertility and long life (*1*). China has experienced a population transition in a relatively short period, which can be divided into three phases: mortality-dominated population dynamic stage (1949-1970), fertility-dominated population dynamic stage (1971-1999) (*2*), and accelerating trend of aging stage (since 2000). After the establishment of the new government in China in 1949, medical and sanitation conditions were greatly improved, resulting in a huge mortality rate declination in China (*3*). Concurrent with Chinese economic reforms in 1978, China has experienced profound social and economic development (*4*). In addition, due to implementation of the family planning policy in China at the end of 1970s, China's total fertility rate decreased from 6 in 1970 to 2.1 in 1991, and to 1.7 in 2000 (*5*). Remaining low rates of fertility and mortality, and increased longevity has changed the age structure of the Chinese population. China's population has been aging at unprecedented levels. In 2000, the proportion of older adults aged 65 and over reached 7% (*6*), indicating that China has entered into an aging society (defined as a society with 7-14% of the total population aged 65 and over), and the

Released online in J-STAGE as advance publication April 2, 2018.

**Address correspondence to:*
Dr. Rong Chen, Shanghai Health Development Research Center, Room707 No. 122 South Shanxi Road, Shanghai 200040, China.
E-mail: chenrong8721@126.com

proportion of older population in the total population has increased to 10.8% in 2016 in China (*6*). Furthermore, it is predicted that China will become a super-aged country (a society with 20% or more of the total population aged 65 and over) in less than 20 years (*7*). The outpaced growth of aging over that of economic development and the social security system will put tremendous pressure on older individuals, their families, as well as on society (*8-10*).

In addition to low fertility rates and low mortality rates, population migration is the third major factor that determines population age structure. Accompanied with the process of urbanization and modernization in China during three decades after economic reforms, lessened restrictions for residents moving from one place to another resulted in a rapidly increased number of temporary internal migrations (also called as "floating population") (*11*). There were about 121 million floating populations in 2000. This number increased to 221 million in 2010, and reached to 245 million in 2016 (accounting for 18% of the country's population) (*6*). Internal migration often happened among young and middle-age adults (*12*), and thus exerted significant effects on age structure for both out-migration and in-migration areas (*13*). Specifically, recipient places of migration postponed or slowed down the aging process, while sending places of migration exacerbated the aging process (*3*). As changes in fertility rates and mortality rates have remained in a more stable stage, large-scale internal migration has been playing an increasingly important role in altering the regional demographic structure patterns and shaping the regional aging trends (*14-15*). Previous studies have found that internal migration have very opposite effects on urban and rural population aging: diluting the degree of aging and slowing down the speed of aging in urban areas, while speeding up aging process and exacerbating the degree of aging in rural areas, resulting in inversion of urban and rural aging (*16-1*8).

Previous research has explored spatial patterns of aging before 2000 in China. Wu and colleagues found that the degree of aging was consistent with the level of economic development in different regions, and the differences among regions were considerably large (*19*). Relatively fewer studies have, however, focused on spatial patterns of aging and its changes in more recent years. It is remarkably informative in the present study to provide more comprehensive and dynamic pictures by showing the spatial patterns of aging both in 2000 and in 2010 in China. In addition, most prior studies on regional aging trends divided the whole country into urban and rural areas (*17,18*), or three regions, *i.e.* eastern, middle, and western region (*19*), or at the level of 31 provinces (*20*). One of the limitations of previous divisions is that the spatial scope is relatively large at the rural/urban level and/or province level, as the regional aging degree may be averaged. When the spatial scale becomes smaller, the regional differences and changes of population aging will be more obvious and sharp. However, if the spatial scale is too small (for example, at the county level and below), although it can be a typical case study, it may lack generalization. Therefore, we employed our analyses at the level of prefecture-level cities.

This paper aimed to examine the new characteristics and trends of regional imbalance in aging at the level of prefecture level cities in China during the period of time from 2000-2010, and to explore how the massive internal migration as well as other demographic factors were related to spatial distributions and its trends of the aging process, utilizing data from the fifth and sixth national population census (2000 and 2010 census).

2. Materials and Methods

2.1. *Data source*

Population information of the 287 cities was from tabulations in 2000 census and 2010 census of China by county (*21,22*). Population data resources of the 31 provinces were from tabulations in 2000 and 2010 census of China (*23,24*). In order to accurately measure the role of population migration, we utilized residential population (*i.e.* the de facto population), rather than the *hukou* population (*i.e.* the de jure population). Because the internal migration population in China, also called floating population, moved to the receiving places, but their *hukou* were still in the sending places. From 2000 to 2010 census, the administrative divisions of some prefecture-level cities were adjusted. Accordingly, we modified the administrative divisions of those prefecture-level cities year by year, following the rules provided by the Ministry of civil affairs of China.

The unit of analysis in this study was 287 cities from 31 provincial units in China, including 23 provinces, 5 autonomous regions and 4 municipalities directly under the central government in mainland China. We assigned the 31 provincial units into four regions, namely East, Central, West and North-east. East included 10 provincial units: *Beijing*, *Tianjin*, *Hebei*, *Shanghai*, *Jiangsu*, *Zhejiang*, *Fujian*, *Shandong*, *Guangdong* and *Hainan* provinces. Six provinces of *Shanxi*, *Anhui*, *Jiangxi*, *Henan*, *Hubei* and *Hunan* provinces were in the Central region. West had 12 provincial units of *Inner Mongolia*, *Guangxi*, *Chongqing*, *Sichuan*, *Guizhou*, *Yunnan*, *Tibet*, *Shaanxi*, *Gansu*, *Qinghai*, *Ningxia* and *Xinjiang*. Lastly, three provinces, *Liaoning*, *Jilin* and *Heilongjiang*, were in the North-east region (Figure 1). The 287 cities in the paper are actually prefecture-level or higher cities, including four municipalities directly under the central government and 283 prefecture-level cities, excluding the other 50 prefecture-level administrative units. According to the administrative level, the 287 cities were also dichotomized into core city and non-core city. Core cities included 4 directly administrated municipalities,

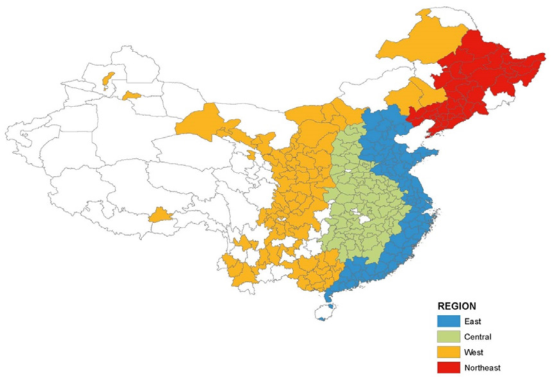

Figure 1. Cities in four regions, China, 2010.

and 31 specific plan oriented cities, sub-provincial cities, and provincial capitals. The rest of the 252 prefecture-level cities were non-core cities.

2.2. *Method*

2.2.1. *Dependent variables*

The dependent variables included two aspects of aging across 287 cities in China: the level of aging and the rate of increase in aging between 2000 and 2010. The level of aging for each city was measured by the ratio of the number of older adults aged 65+ to the population as a whole (for convenience, hereafter referred to "PA"). Based on the ratio, we categorized the 287 cities into three groups: *i*) young city where the ratio was lower than or equal to 4% (*i.e.* PA ≤ 4%); *ii*) adult city where the ratio was greater than 4% but lower than or equal to 7% (*i.e.* 4% < PA ≤ 7%); and *iii*) elder city where the ratio was greater than 7% (*i.e.* PA > 7%). We further subdivided elder cities into two categories: young old city where the ratio was between 7% and 10% (*i.e.* 7% < PA ≤ 10%) and old old city where the ratio was higher than 10% (*i.e.* PA > 10%).

The rate of increase in aging was the change in the level of aging from 2000 census to 2010 census (*i.e.* PA in 2010 subtracted by PA in 2000, hereafter referred to "ΔPA"). For the purpose of descriptive statistics, the 287 cities were assigned into 5 categories: *i*) decrease in aging (*i.e.* ΔPA < 0); *ii*) low rate of increasing (*i.e.* 0 ≤ ΔPA ≤ 1%); *iii*) medium rate of increasing (*i.e.* 1% < ΔPA ≤ 2%); *iv*) medium-to-high rate of increasing (*i.e.* 2% < ΔPA ≤ 3%); and *v*) high rate of increasing (*i.e.* ΔPA > 3%). In addition, for further exploratory analysis, continuous ΔPA was utilized in regression models. In the statistical equations, ΔPA was denoted as $agingchange_i$.

2.2.2. *Key independent variable*

The rate of net in-migration population was the average value of rates across the 287 cities in the time of 2000 census and 2010 census, denoted as $nmpr_i$. The rate of net in-migration population was equal to the number of net in-migration population divided by the number of the residential population in each city. Initially, the number of net in-migration population of the cities was calculated by the number of in-migration population minus the number of out-migration population. Due to data limitation, the number of in-migration population and out-migration population were not available at prefecture-level cities in the tabulations in 2000 census and 2010 census of China by county. Therefore, we captured the number of net in-migration population by the number of residential population subtracted by the number of *hukou* population. Although this calculation may cause discrepancies because of a small amount of unregistered people, the variance is minor.

2.2.3. *Covariates*

We also controlled for a set of relevant variables. The natural population growth rate was calculated by the average value of resident population in 2000 and 2010, indicated as $npgr_i$. The natural growth rate of residential population was captured by subtracting the number of population migration growth from population growth and divided by the number of resident population. In addition, the rate of population aging at 2000 was controlled, denoted as $agingr_i$. Furthermore, in order to explore regional differences, we assigned regions as 4 categorical dummy variables, with East as reference group, and the rest denoted as $northeast_i$, $central_i$, and $west_i$. The last control variable was a dummy variable, whether or not a core city, with 1 = yes, 0 = no, denoted as $corecity_i$.

2.2.4. *Analytical strategy*

We first presented maps to show spatial description of the level of aging in both 2000 and 2010 as well as the changes from 2000 and 2010. Maps were generated in ArcGIS 10 software. The chi-square test was carried out to compare the differences in the degree and speed of aging among the four regions. We further explored the association between population migration and the rate of increase in aging, using multivariate Ordinary Least Squares (OLS) regression models. Four models were examined step by step (see equations below). To be specific, Model 1 only included the rate of residential population growth. Model 2 added the rate of net in-migration population. Model 3 incorporated the level of aging at baseline. Model 4 was a full model, adding into regional variables and a core city variable. Analyses were conducted in SPSS version 19.

$$agingchange_i = \alpha_1 + \alpha_2\, npgr_i + u_{1i} \quad (1)$$

$$agingchange_i = \beta_1 + \beta_2\, nmpr_i + \beta_3\, npgr_i + u_{2i} \quad (2)$$

$$agingchange_i = \gamma_1 + \gamma_2\, nmpr_i + \gamma_3\, npgr_i + \gamma_4\, agingr_i + u_{3i} \quad (3)$$

$$aging change_i = \delta_1 + \delta_2\, nmpr_i + \delta_3\, npgr_i + \delta_4\, agingr_i + \delta_5\, northeast_i + \delta_6\, central_i + \delta_7\, west_i + \delta_8\, corecity_i + u_{4i} \quad (4)$$

3. Results

3.1. *Descriptive results on regional differences of population aging*

Table 1 and Figure 2 show the level of aging for 287 cities in China in 2000 in the form of table and map. In general, only 49.8% of cities were elder cities in 2000, however, this number increased to 89.2% in 2010. Most of cities entered into elder cities within a decade. Although China was, on average, considered as an aging society in 2000, each city had a different pace. In the 2000 census, about 143 cities (49.8%) belonged to elder cities, among which 4 cities' PA were higher than 10%, including *Shanghai* (11.5%), *Nantong* (12.4%) and T*aizhou* (10.3%) in Jiangsu province, and *Lishui* (10.0%) in Zhejiang province. In addition, 139 cities (48.4%) were in the adult city group. Only 5 cities were young

Table 1. The level of aging for 287 cities in China in 2000 census

Items	Young city	Adult city	Elder city		Total
			Young old city	Old old city	
Number of East cities	2	20	61	4	87
% of East cities	2.3	23.0	70.1	4.6	100
Number of Central cities	0	46	35	0	81
% of Central cities	0	56.8	43.2	0	100
Number of West cities	3	50	32	0	85
% of West cities	3.5	58.8	37.6	0	100
Number of North-east cities	0	23	11	0	34
% of North-east cities	0	67.6	32.4	0	100
Number of above cities	5	139	139	4	287
% of above cities	1.7	48.4	48.4	1.4	100

Note: Pearson χ^2 = 42.954, p = 0.000. Chi square tested regional differences on the level of aging in 2000, showing that there were significant differences among the four regions.

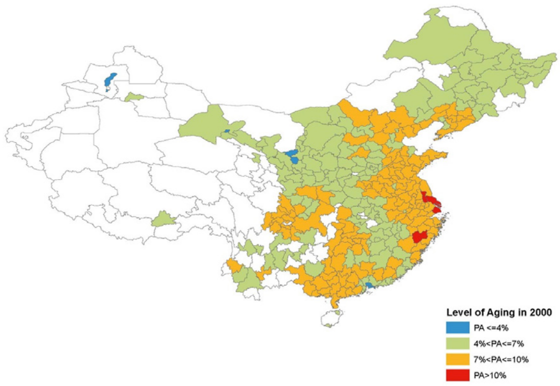

Figure 2. The level of aging for 287 cities in China in 2000 census.

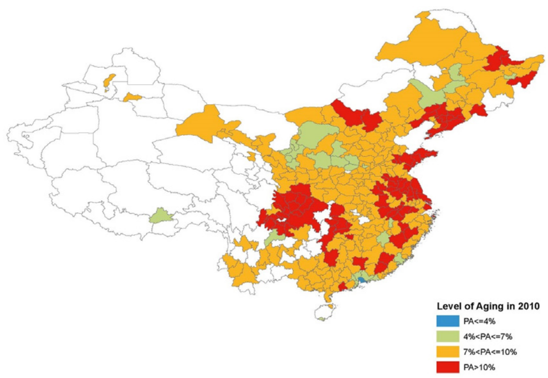

Figure 3. The level of aging for 287 cities in China in 2010 census.

Table 2. The level of aging for 287 cities in China in 2010 census

Items	Young city	Adult city	Elder city		Total
			Young old city	Old old city	
Number of East cities	2	9	50	26	87
% of East cities	2.3	10.3	57.5	29.9	100
Number of Central cities	0	7	55	19	81
% of Central cities	0	8.6	67.9	23.5	100
Number of West cities	0	10	55	20	85
% of West cities	0	11.8	64.7	23.5	100
Number of North-east cities	0	3	17	14	34
% of North-east cities	0	8.8	50.0	41.2	100
Number of above cities	2	29	177	79	287
% of above cities	0.7	10.1	61.7	27.5	100

Note: Pearson χ^2 = 14.611, p = 0.263. Chi square tested regional differences on the level of aging in 2010, showing that there were no significant differences among the four regions.

Table 3. Changes on Level of Aging for 287 Cities in China, from 2000 to 2010

Items	Decrease in aging	Low rate of increasing	Medium rate of increasing	Medium-to-high rate of increasing	High rate of increasing	Total
Number of East cities	6	30	30	16	5	87
% of East cities	6.9	34.5	34.5	18.4	5.7	100
Number of Central cities	0	12	33	25	11	81
% of Central cities	0.0	14.8	40.7	30.9	13.6	100
Number of West cities	1	2	26	23	33	85
% of West cities	1.2	2.4	30.6	27.1	38.8	100
Number of North-east cities	0	0	5	21	8	34
% of North-east cities	0.0	0.0	14.7	61.8	23.5	100
Number of above cities	7	44	94	85	57	287
% of above cities	2.4	15.3	32.8	29.6	19.9	100

Note: Pearson χ^2 = 92.739, p = 0.000. Chi square tested regional differences on the rate of increase in aging from 2000 census to 2010 census, showing that there were significant differences among the four regions.

cities, which were *Shenzhen* (1.2%) and *Dongguan* (2.1%) in Guangdong province, *Jiayuguang* (3.8%) in Gansu province, *Zhongwei* (4.0%) in Ningxia province, and *Kelamayi* (3.8%) in Xinjiang province. With regard to regional differences in 2000, East area had the greatest number of cities which belonged to elder cities (taking up about 74.7%), followed by Central area (43.2%). West area had about 37.6% of elder cities and North-east had the least proportion of elder cities (32.4%). More importantly, the regional differences were statistically significant in 2000 (χ^2 = 42.954, p = 0.009), which meant that the level of aging in East was significantly higher than that of other geographic areas.

Table 2 and Figure 3 show the level of aging across China in 2010. As shown, only two cities, *Shenzhen* and *Dongguan*, were young cities (1.8% and 2.3%, respectively). The number of adult cities reduced from 139 in 2000 to 29 in 2010. In total, only 31 cities (about 10.8%) were not elder cities across China in 2010. In comparison, the number of old old cities increased from 4 in 2000 to 79 in 2010. Specifically, *Nantong* and *Taizhou* ranked as the top 1 and 2 among the old old cities, both of whose PA increased by 4% from 2000 to 2010. The portion of senior population in *Shanghai* decreased from 11.5% in 2000 to 10.1% in 2010, indicating a slowed down pace in aging.

Regional differences in the level of aging in 2010 are also presented in Figure 3. As depicted, a notable number of cities in the Central, West and North-east areas entered into elder cities in 2010, about 91.4%, 88.2%, and 91.2%, respectively. In particular, among the 34 cities in the North-east region, about 41.2% of cities' PA were greater than 10%, which was higher than those in other regions. On the contrary, fewer cities in the East region became elder cities. The regional differences were not statistically significant in 2010 (χ^2 = 14.611, p = 0.263), indicating that the spatial gap became smaller and smaller in terms of the rate of aging, since almost all cities entered into elder cities.

Table 3 and Figure 4 present the rate of increase in aging from 2000 census to 2010 census. The three

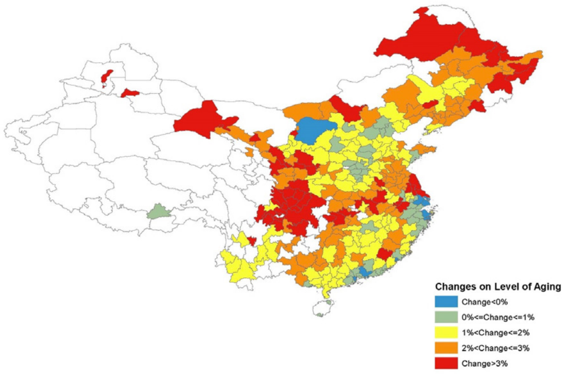

Figure 4. Changes on level of aging for 287 cities in China, from 2000 to 2010.

regions, North-east, Central, and West, had greater rates of increase in aging than the East area. And the spatial differences were statistically significant (χ^2 = 92.739, p = 0.000). In particular, the North-east area had the fastest pace of population aging, followed by West area and Central area. East region had the lowest rate of increase in aging. It is worth noting that 6 cities had negative rate of increase in the level of aging, including *Shanghai*, *Suzhou*, *Xiamen*, *Huizhou*, *Zhongshan*, *Eerduosi*, and *Ningbo*.

3.2. *Domestic population migration*

Spatial disparities in economic development have been a historical and outstanding issue in China, with East and coastal areas substantially advanced compared to other regions due to location advantages, market forces, and favorable policies. For instance, three metropolitan areas, namely triangle cities along Zhujiang, triangle cities along Yangzi River, and Jing-jin-qi cities have the most economic growth. Motivated by more job opportunities and better earnings in economically developed areas, a large-scale of working-age population internally migrate from rural areas to urban areas, from less developed cities to more developed cities, and from West and

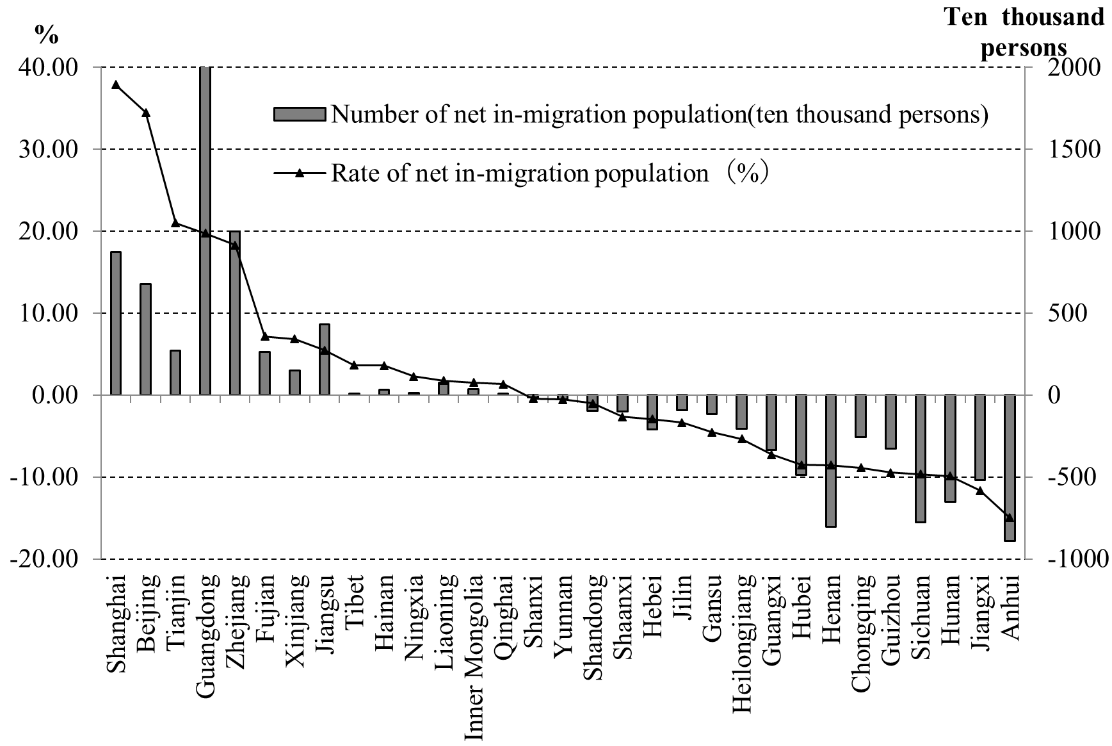

Figure 5. The number and rate of net in-migration population of 31 provinces in 2010 census. *Note*: The number of net in-migration population of the provinces calculated by the number of in-migration population minus the number of out-migration population, and the rate of net in-migration population was equal to the number of net in-migration population divided by the number of the residential population in each province.

Central areas to East areas.

From the perspective of provinces, in 2010 census, 14 provinces belonged to in-migration areas, most of which are located in the East; whereas 17 provinces belonged to out-migration areas, most of which are located in the Western and Central China. For instance, 8 out of 10 provinces in East region were in-migration provinces, particularly Guangdong province had the largest size of in-migration population, reaching to 20 million. Furthermore, Shanghai, Beijing, and Tianjin were the three cities with highest rate of in-migration population, about 37.9%, 34.5%, and 21%, respectively. On the contrary, all the six provinces in the Central region belonged to out-migration provinces; in particular Henan province and Anhui province had the greatest number of out-migration population, about 8 million and 8.9 million, respectively. Moreover, 5 out of 11 provinces in West area were in-migration provinces, with a relatively small scale of migration population though. Xinjiang province had the highest rate of in-migration, whereas Sichuan province had the greatest rate of out-migration in the Western China. Lastly, within the three provinces in the North-east area, Heilongjiang and Jilin belonged to in-migration provinces. Liaoning was an out-migration province, although both the size and rate of in-migration were low (Figure 5).

Corresponding to internal migration patterns at the province level, migration population were also concentrated to certain cities, such as capital cities, and hub cities in those three advanced metropolitan areas defined above. The number of in-migration cities decreased from 125 in 2000 to 103 in 2010, while the number of out-migration cities increased from 162 in 2000 to 184 in 2010. Loss of net population cities were mainly located in areas with agriculture and underdeveloped economic growth. During 2000 to 2010, the proportion of the 35 core cities in the national population increased from 19.8% to 22.3%, while non-core cities' percentage of population fell from 73.2% to 70.9%, reflecting population agglomeration to the core cities. Therefore, the internal massive migration has obvious directional preferences, due to regional unbalanced economic development.

In addition, internal migration in China has distinct age selectivity as well. The 2010 census showed that 65% of migration population was the aged 20-49 adult labor force, specifically about 27.2% was between 20-29 years old; and 21.3% was between 30-39 years old, and the rest 16% was between 40-49 years old. In comparison, in the whole population, about 17.1% aged 20-29, 16.1% aged 30-39, and 17.3% aged 40-49, showing that the structure of floating population was younger. Large-scale of internal migration with obvious directional preferences and age selectivity will alter the prevalence of older population in both in-migration and out-migration cities.

Table 4. The regression results from OLS models

Items	Model 1	unadjusted Model 2	adjusted Model 2	Model 3	Model 4
$npgr_i$	-0.101**	-0.142**	-0.347**	-0.232**	-0.224**
	(0.023)	(0.021)		(0.021)	(0.023)
$nmpr_i$		-0.040**	-0.480**	-0.055**	-0.042**
		(0.004)		(0.004)	(0.005)
$agingr_i$				-0.370**	-0.229**
				(0.040)	(0.047)
$northeast_i$					0.345*
					(0.197)
$central_i$					0.345**
					(0.133)
$west_i$					0.996**
					(0.144)
core$city_i$					-0.298*
					(0.165)
c	2.569**	-2.730**		5.727**	4.336**
	(0.136)	(0.121)		(0.344)	(0.448)
N	287	287	287	287	287
adj.R2	0.058	0.277	0.277	0.441	0.524

Note: *0.05 < p < 0.1; **p < 0.01. Numbers in parentheses are standard deviations.

3.3. *OLS regression results*

Table 4 shows the regression results from OLS models. As depicted in Model 1, rate of natural population growth was negatively associated with the rate of increase in aging population (b = -0.101, p < 0.001). Unadjusted and adjusted Model 2 showed that rate of net in-migration population was negatively associated with increasing rate of aging (*adj*. b = -0.480, p < 0.001). It indicates that both the increase (or decrease) of natural growth rate and net in-migration rate explained certain variances on the dependent variable, diluting (or exacerbating) the level of population aging. We noticed that the absolute coefficient of in-migration population rate was larger than that of residential population growth rate in adjusted Model 2, indicating population migration had a greater relationship with population aging than those with fertility and mortality. Jones has also pointed out that regional differences in population aging appear to be affected much more by patterns of internal migration than by differences in fertility and mortality (*25*).

Furthermore, Model 3 showed a significantly negative association between baseline rate of aging and the increasing rate of aging (b = -0.370, p < 0.001). That is, cities with a high level of aging in 2000 had a relatively slower increase in the level of aging in 2010, whereas those with low level of aging in 2000 had a comparatively faster rate of increase in aging in 2010. The results indicated a smaller gap among all cities in terms of level of older population, during the decade between 2000 and 2010. The rate of in-migration population remained significant in Model 3. Lastly, results in Model 4 demonstrated that compared to cities in the East area, those in West, Central, and North-east areas had a significantly higher rate of aging increase. Specially, West area had highest rate of increase in aging (b = 0.996, p < 0.01), followed by Central and North-east areas (both b = 0.345). Core cities had a lower rate of aging increase compared to non-core cities (b = -0.298, 0.05 < p < 0.1), indicating that administratively smaller cities had a faster pace of aging than those of hierarchically higher rank cities.

In conclusion, these results suggested that internal migration in China has noticeable patterns for directional preferences and age selectivity, which ultimately impacts the prevalence and incidence of population aging for every province and city. Migration of working-age adult labor force diluted the in-migration cities' (mostly in East area and core cities) level of aging and its rate of increase in aging population; whereas by contrast it increased the out-migration cities' (mainly in West and Central, agricultural areas) level of aging.

3.4. *Representative cities*

As stated earlier, *Shenzhen* and *Dongguan* were the two youngest cities in both 2000 and 2010, indicated by no increase in the level of aging within 10 years. Also, *Beijing*, *Tianjin* and *Guangzhou* had a lower rate than national average rate of increase in aging. Further, *Shanghai* had a negative rate of increase in aging (-1.34%). These cities shared a common reason, that is, a large scale of young labor force migrated into these places, delaying or reversing the speed of population aging. For instance, the size of in-migration population in *Shenzhen* was 5 times larger than its *hukou* population, similarly about 4 times bigger in *Dongguan*.

Take *Shanghai* for another example. The 2000 census and 2010 census showed that, in-migration population in Shanghai aged 15-59 took up 88.9% and

85.6%, respectively, among which labor force aged 20-44 made up about 70.3% and 69.1%, respectively. In 2010, the median age of *hukou* population in Shanghai was 44.1, and the proportion of older adults aged 65 and above was 15.8%. Due to the large scale of young and middle-aged labor forces moving in, the median age of resident population decreased to 37.8 years old and the percentage of older population was reduced to 10.1% (*26*). A similar situation occurred in other core cities, such as *Suzhou*, *Zhongshan*, and *Xiamen*.

There is also a compelling story for 13 cities in *Jiangsu* province, which can be divided into southern part and northern part. From 2000 to 2010, cities in the northern part had a negative growth of population, while most southern cities' population growth was positive, and the rates of increase in aging in the northern cities were significantly higher than that in southern cities, though fertility rate in the vast areas of the northern part has been relatively higher than that in the south (*27*). It is plausible that the cities in northern part of the province are economically less developed than the southern cities. A large amount of adult labor force moves out from the northern part, which ultimately results in population loss and rapidly aging process in most cities of the northern part. On the contrary, the pace of aging in these southern cities has been slowed down due to massive immigrantion.

4. Discussion

4.1. *The pattern of regional imbalance in aging has changed within a decade in China*

A population with a low fertility rate is likely to have a high proportion of older adults and vice versa (*3*). The global demographic transition over the past three centuries has been summarized as: the transition began with mortality decline, followed by fertility decline, and ended up with an aging population (*1*). At the national level, China has stepped into an aging society since 2000 and has still been experiencing a progressive process of aging, as a result of the rapid decline in fertility and persistent longevity. What is more noteworthy is that the regional aging patterns and trends vary a lot within China due to imbalanced social economic development and population transitions. This paper examined such regional differences and the changes in 287 cities from the degree of and speed of aging from 2000 to 2010.

Results show that the percentage of cities, which have entered the aging society increased from 49.8% to 89.2% in the total of 287 cities within a decade (Table 1 and Table 2), indicating the accelerated process of population aging in the country. We also found that the regional imbalance of population aging has changed in China since 2000. In 2000, Eastern region had the most number (65, Table 1) of and the largest proportion (74.7%, Table 1) of elder cities among all four regions. However, cities in Central, Western and North-east sectors had a faster pace in aging from 2000 to 2010, significantly faster than those cities in the Eastern sector. Also, the number of new elder cities was far more than that in the Eastern zone. By 2010, the proportion (87.4%, Table 2) of aging cities in the eastern region was even slightly lower than Central (91.4%, Table 2), Western (88.2%, Table 2) and North-east sectors (91.2%, Table 2). The gap of aging level between the other three zones and the Eastern zone has considerably narrowed down.

These findings have revealed dynamic relationships between economic development and population aging. In 2000, the aging level was much higher in more developed areas than that in less developed ones. However, the pattern has changed within a decade. The less developed areas (*e.g.* cities located in the north of Jiangsu province) had a faster pace of population aging from 2000 to 2010 than those of more advanced areas. We also found that the rate of increase in aging has slowed down in certain advanced areas, and the level of aging even declined in several cities, such as *Beijing*, *Shanghai*, *Shenzhen*, *Dongguan*, *Xiamen*, *Suzhou*, and *Nanjing*.

4.2. *The large-scale internal migration with obvious age selectivity and orientation preference has played a critical role in reshaping spatial patterns of population aging in China*

There is about 245 million of floating population in China, accounting for 18% of the country's whole population. The large-scale internal migration has become the most prominent population phenomenon in China's economic and social development. Gu (2014) has suggested that internal migration might have dominated population dynamics in China, and called more attention to the impacts of population movement (*27*). The results of multivariate quantitative models showed that the regional differences of population aging appear to be affected much more by the massive internal migration than by differences in fertility and mortality. It is possible that the massive internal migration since the late 1980s has been showing an apparent orientation preference, often from rural areas to urban areas, from West and Central regions to East region, and from economically less developed cities to more advanced ones. In addition, migration often happened among young and middle-age adults, exerting contradictory effects on age structure for out-migration and in-migration areas: diluting the degree of aging and slowing down the speed of aging in recipient places of migration, while speeding up aging process and exacerbating the degree of aging sending places of migration.

4.3 *How to deal with the challenges of regional aging*

and the massive internal migration has been an emerging and urgent issue for research scholars and policy makers

The massive internal migration was partially due to unbalanced regional economic development, leading to unequal level of income and access to employment opportunities. Due to a large amount of outflow labor force, some areas in Central and Western China have been facing a series of problems in economic development, such as reduction of labor productivity and total consumption, shrinkage of agriculture industry, and so forth. In addition, the massive internal migration and regional aging trends were bound to exacerbate the regional imbalance of pension funds. It is estimated that the inter-provincial floating population paid more than 50 billion *yuan* pension in the receiving regions in 2010. East region received more than 30 billion *yuan*, while the Central and West regions lost about 24 billion *yuan* and 8 billion 400 million *yuan* (*28*). For the less developed areas, pension coverages are relatively scarce, and the burden will become more and more heavy, which will inevitably hinder their economic growth.

Furthermore, internal migration in China will continue in the future. The less developed areas may encounter various challenges, as its population size is getting smaller while the portion of older adults is getting larger. Due to population reduction, aging, serious loss of labor, infrastructure lack of economies of scale, gradual depression and even abandoned phenomenon may occur in some villages, towns and even cities in the Central and Western regions (*29*). Therefore, in the near future, China not only has to face the challenges of fast aging at the national level, but also has to balance the economic gap between the sending and receiving regions and handle a series of problems raised by internal migration and a regional aging imbalance.

Our study has several limitations. There may be some variance in the measure on the rate of net in-migration population and the natural population growth rate because of data limitations. In addition, we employed data from 2000 to 2010. It would be great if we could analyze the continuous changes when more longitudinal data sets are available. Nevertheless, the present study examined data at the city level to investigate the relationship between population aging and migration, and focused on prevalence as well as changes of aging in spatial patterns. This has promising implications for the older adults' health and income security.

5. Conclusion

The findings of our study showed the patterns of regional imbalance in aging have changed from 2000 to 2010 in China. The less developed areas have faced a faster pace of population aging within the decade than those of more advanced areas. The gap of aging level between the other three zones and the Eastern zone was considerably narrowed down. It was the massive internal migration with obvious age selectivity and orientation preference, rather than births and deaths, that played the crucial role on the changes of regional aging patterns, which in turn brought up challenges and unfavorable consequences across regions.

Acknowledgements

This work was supported by a grant from National Natural Science Foundation of China (Grant No.71490734). We thank Professor Zuo Xuejin, Professor Gu Baochang and Professor Jin Chunlin for their valuable suggestions on the article.

References

1. Lee R. The demographic transition: Three centuries of fundamental change. The Journal of Economic Perspectives. 2003; 17:167-190.
2. Mu G, Chen W. Demographic transition in China: Process, characteristics and cause. Open Time. 2011; 1:92-101. (in Chinese)
3. Kincannon C L, He W, West LA. Demography of aging in China and the United States and the economic well-being of their older populations. J Cross Cult Gerontol. 2005; 20:243-255.
4. Population Reference Bureau. China's rapid aging population. Today's Research on Aging. 2010; 20:1-5.
5. U.S. Census Bureau. International programs center, international data base. *http://www.census.gov/ipc/www/idbnew.html*. (accessed June 14, 2017).
6. National Bureau of Statistics of China. China Statistical Yearbook 2017. *http://www.stats.gov.cn/tjsj/ndsj/2017/indexeh.htm*. (accessed June 14, 2016)
7. United Nations. World Population Prospects, the 2015 Revision. *https://esa.un.org/unpd/wpp/DataQuery/*. (accessed June 14, 2017).
8. Du P, Yang H. "Ageing before Affluence" Is a central feature of population ageing in China at the present stage. Population Research. 2006; 6:28-36. (in Chinese)
9. Cai F. "Ageing before Affluence" and China's sustainable economic growth. International Economic Review. 2012; 1:82-95.
10. Zhu H. Adult children's characteristics and intergenerational financial transfers in urban China. Chinese Journal of Sociology. 2016; 2:75-94.
11. Chen F, Short SE. Household context and subjective well-being among the oldest old in China. J Fam Issues. 2008; 29:1379-1403.
12. Cong Z, Silverstein M. Which sons live with their older parents in rural China? The role of migration and intergenerational exchanges. Family Science. 2010; 1:63-72.
13. Chen X, Silverstein M. Intergenerational social support and the psychological well-being of older parents in China. Research on Aging. 2000; 22:43-65.
14. Jones GW. Ageing in China, India and Indonesia: An Overview. In: Contemporary Demographic Transformations in China, India and Indonesia. Springer International Publishing, 2016; pp. 271-276.

15. Zheng Z, Yang G. Internal Migration in China: Changes and Trends. In: Contemporary Demographic Transformations in China, India and Indonesia. Springer International Publishing, 2016; pp. 223-237.
16. Zeng Yi. Urbanization and its impacts on population development in China. Population Journal. 1991; 2:1-6. (in Chinese)
17. Du P, Wang W. The difference of urban and rural ageing and its transition. Population Research. 2010; 2:3-10. (in Chinese)
18. Wang Z. The impact of rural-urban population migration on rural population aging – quantitative analysis from the view of age-rate of migration. West Forum. 2011; 6:27-33. (in Chinese)
19. Wu C, Wang L, Miao R. Process, prospects and countermeasures of population aging with Chinese characteristics. Population Research. 2004; 1:8-15. (in Chinese)
20. Zhong S, Zhao Y, Ren J. "Getting Old before Getting Rich" in China: A regional perspective. Population Research. 2004; 1:63-73. (in Chinese)
21. National Bureau of Statistics of China. Tabulation on the 2000 Population Census of the People's Republic of China by County. *http://www.stats.gov.cn/tjsj/ndsj/renkoupucha/2000fenxian/fenxian.htm*. (accessed June 14, 2016) (in Chinese)
22. Population Census Office under the State Council and Department of Population and Employment Statistics National Bureau of Statistics. Tabulation on the 2010 Population Census of the People's Republic of China by County. China Statistics Press, 2012: pp.2-407. (in Chinese)
23. National Bureau of Statistics of China. Tabulation on the 2000 Population Census of the People's Republic of China. *http://www.stats.gov.cn/tjsj/pcsj/rkpc/5rp/index1.htm*. (accessed June 14, 2017) (in Chinese)
24. National Bureau of Statistics of China. Tabulation on the 2010 Population Census of the People's Republic of China. *http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm*. (accessed June 14, 2017) (in Chinese)
25. Jones GW. Ageing in China, India and Indonesia: An Overview. In:Contemporary Demographic Transformations in China, India and Indonesia. Springer International Publishing, 2016: pp.325-328.
26. Chen R. An analysis of the floating population in Shanghai based on the census data. Manager' Journal. 2012; 19:13-14. (in Chinese)
27. Gu B. Internal migration dominates population dynamics in China. Asian Population Studies. 2014; 10:1-3.
28. Zheng B. China Pension Report 2012. Economy & Management Publishing House, Beijing, China, 2012; pp.10-11. (in Chinese)
29. Zuo X. Future scenarios of population spatial distribution in China. Social science weekly. 2016.12.8: Version 002. (in Chinese)

(Received September 30, 2017; Revised February 11, 2018; Accepted February 28, 2018)