Quantitatively evaluate the environmental impact factors of the life expectancy in Tibet, China

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Abstract  Life expectancy is influenced by both innate human self-factors and external environmental factors. Due to the individual difference of self-factors, the external environment impacts on life expectancy are especially important under the geoscience perspective. However, few studies discussed impacts of various socioeconomic and environmental factors comprehensively, and quantitative analysis of multi-factors is lacking. We chose 13 potential factors of socio-economy, ecological environment, geological environment and geographical environment to quantitatively analyze their impacts and their interactive influences on Tibet’s life expectancy in 2010 by using geographical detector (Geodetector) algorithm, and figure out their suitable ranges or types. Our results indicated that the high life expectancy at birth in Tibet are distributed like a strip; the main control factor of life expectancy in Tibet is socioeconomy, followed by geological environment; furthermore, the highest range of socioeconomic factors and the igneous rock exposed areas correspond to the maximum value of life expectancy at birth; factors of ecological environment have a certain impact on the life expectancy of Tibetan residents, while factors of geographical environment have few effects on the life expectancy. Lower radiation, moderate temperature and rainfall may have favorable effects on the increase in the life expectancy. The life expectancy of Tibet is mainly affected by socioeconomy, geological and ecological environment; interactions between these factors can increase the impact on the life expectancy of Tibet. Consequently, this study can better understand the impact factors of the life expectancy in Tibet and could provide a reference basis for local government’s policy making of relocation and population management.

Keywords  Life expectancy · Environmental impact factor · Geodetector · Tibet

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Introduction

Lifespan has been paid high attention by all the nations; furthermore, life expectancy has been the most important demographic research (Olshansky et al. 2001; Fontana et al. 2010). Life expectancy is not only a comprehensive indicator reflecting the health status of the population (Murray and Lopez 1997), but also a major parameter for calculating the Human Development Index (PNUD 1990).

Life expectancy is influenced by both innate human self-factors and external environmental factors (Oeppen and Vaupel 2002; Medvedev 2010). Due to the individual difference of human self-factors, such as biology heredity and lifestyle, the external environmental impacts on life expectancy are especially important under the geoscience perspective. Some studies have researched the socioeconomic impact on life expectancy, such as public health care and resident income (Wilkinson 1992; Kawata 2009; Ay wa et al. 2014). Meanwhile, some scholars analyzed the effects of geographical environment (elevation, geomorphic type) (Ezzati et al. 2012; Wang et al. 2015) and ecological environment (such as vegetation type, temperature, moisture, rainfall and solar radiation) (Davis et al. 2015; Hajat et al. 2014; Juckett and Rosenberg 1993; Kaba 2009; Lowell and Davis Jr. 2008; Lv et al. 2011; Mcinnes et al. 2017) on life expectancy. Human health is profoundly affected by the content and distribution of the unique trace elements in geological environment (Komatina 2004; Warren 1989; WHO 1997). The structure and composition of soils are determined by rocks because rocks are the parent materials of soils development. The enrichment and deficiency of trace elements in the stratum can lead to the enrichment and deficiency of the elements in the weathered soil and then affects the nutritional status of the population via the food chain, preventing or leading to the occurrence of certain endemic diseases, thereby influencing the life expectancy of local residents (Anke et al. 1990). At present, scholars have tended to agree that life expectancy is influenced by multiple socioeconomic and environmental factors; however, these studies have mostly focused on the independent effect of individual factor or simple compound effect of two factors and failed to conduct a quantitative analysis and figure out interactive effects of the socioeconomic, ecological, geographical and geological environmental factors on life expectancy. Because of special environmental condition, Tibet autonomous region was once regarded as one of the most unlivable areas (Wang et al. 2004), and the life expectancy at birth of the Tibetan people in 2010 is 6.66 lower than that of the national average (NHFPCPRC 2014). Consequently, we can understand the influence of the impact factors on Tibet’s life expectancy through quantitative analysis and moreover figure out the main impact factors and suitable types or ranges of them.

Based on the theory of spatial stratified heterogeneity, the geographical detector (Geodetector) (Wang and Xu 2017) can used to quantify the relative importance of independent factors and their interactions with response variables. It can measure the spatial consistency and statistical significance between life expectancy and impact factors (Zhao et al. 2017; Fei et al. 2018). In this paper, 13 impact factors of the life expectancy in Tibet autonomous region were quantitatively analyzed by using the Geodetector, namely gross regional product (GRP), gross regional product per capita (GRPPC), vegetation type (VEG), vegetation regionalization (VEGR), annual average radiation (RAD), annual average temperature (TEM), annual average precipitation (PRE), moisture index (MI), geomorphic type (GEO), elevation (ELE), soil type (SOI), tectonic division (TEC) and stratum lithology (STR) (Fig. 1), and we attempted to solve the following problems: (1) What are the main factors affecting the life expectancy in Tibet. (2) Do these factors operate independently, or are they interconnected. (3) What are the suitable ranges or types of each impact factor.

Study area

The Tibet Autonomous Region is located in the Qinghai–Tibet Plateau of the southwestern border of China, extending about 900 km in width from south to north and 2000 km in length from east to west, the average altitude is approximately 4000 m, and the main ethnic group is the Tibetan (Zhang et al. 2002); the location of study area is shown in Fig. 2. Geological structure and stratigraphic lithology are complex in Tibet, as well as natural geographical differentiation is existed, and regional differences in environmental types and their combinations are obvious (Shen and Zhou 2011). The total population
of Tibet is approximately 3.00 million at the end of 2010, based on the data of the National Bureau of Statistics of the People’s Republic of China (http://www.stats.gov.cn/).

**Data and method**

**Data sources**

The population and death population of each age group for counties in Tibet were obtained from the Tabulation on the 2010 Population Census of Tibet Autonomous Region (OSPCTAR et al. 2012); life expectancy in Tibet.
Life expectancy at birth was calculated from population data. The gross regional product (GRP) and GRP per capita in Tibet were obtained from China Statistical Yearbook for Regional Economy (DCSNBS 2012). The annual average precipitation and annual average solar radiation data were collected from 55 meteorological monitoring stations in the Qinghai–Tibet Plateau from 1982 to 2015. The data were interpolated with the ANUSPLINE software (Hutchinson 2004) and then were extracted with ArcGIS 10.2 (https://www.esri.com); the data are obtained from the National Meteorological Data Sharing Service Platform (http://data.cma.cn).

Elevation (ELE) data were extracted from the 90 m Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) using ArcGIS 10.2. Vegetation type (VEG) data were available from the vegetation type map of China (scale 1:1,000,000). Soil type (SOI) data were digitized from the soil type map of China (scale 1:1,000,000). Vegetation regionalization (VEGR) was drawn by the vegetation type map of China (scale 1:1,000,000), which is the comprehensive regional division of vegetation communities under the influence of climate and geographical environment. Geomorphic type (GEO) data were derived from geomorphic map of China (scale 1:1,000,000). Mean annual temperature (TEM) data were corrected by a DEM (scale 1:1,000,000). Moisture index (MI) data were interpolated using the inverse distance weighting method (scale 1:1,000,000). All of the above data were obtained from the Data Centre for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn).

Tectonic division (TEC) data (scale 1:4,000,000) were drawn by the Lanzhou Institute of Glaciology and Cryopedology, Chinese Academy of Sciences. Stratum lithology (STR) data (scale 1:5,000,000) were drawn by the Ministry of Geology and Mineral Resources of the People’s Republic of China. All of the above data were obtained from the Digital Library of National Geological Archives of China (http://www.ngac.org.cn).

Data processing

The life expectancy for each county in Tibet was calculated according to the Tabulation on the 2010 Population Census of Tibet Autonomous Region (OSPCTAR et al. 2012). A life table represents, for each age, the death probability of people, which can be explained as a long-term mathematical way to measure a population’s longevity. In this paper, we use the abridged life table commanded by the World Health Organization (WHO) (Chiang 1968) to compile life tables using Excel software; life expectancy at birth was calculated.

Geodetector can effectively analyze the continuous factors by discretizing the data into discrete data (Cao et al. 2013), and the classification results of impact factors, which are continuous, are shown in Table 1. All data were extracted in grids (10 km × 10 km) with the intersect analysis tool in ArcGIS 10.2 and then input them into Excel-Geodetector.

Method

The Geodetector, which is composed of a factor detector, an ecological detector, a risk detector and an interaction detector, represents a spatial analysis method based on spatial stratified heterogeneity (Wang et al. 2016). If a factor has a significant impact on the spatial distribution of life expectancy, the factor will have a great consistency with the spatial distribution of life expectancy.

\[
q(Y|h) = 1 - \frac{1}{N\sigma^2} \sum_{h=1}^{L} \left( N_h \cdot \sigma_h^2 \right)
\]

where \(Y\) represents the life expectancy at birth, which is composed of \(L\) strata \((h = 1, \ldots, L)\); \(N\) represents the number of total samples; \(\sigma^2\) represents the variance in the study area. The range of \(q\) statistic value is between 0 and 1; if the life expectancy is completely associated with one impact factor, then \(q = 1\), whereas \(q = 0\) implies the lack of an association between the \(Y\) and a impact factor.

Excel-Geodetector can be downloaded from http://www.geodetector.org, the first column stores life expectancy at birth (\(Y\)) and the following columns store impact factors (\(X\)). After run the software, a worksheet “factor detector” will be created and \(q\) statistic values will be presented, as well as three other worksheets, namely risk detector, ecological detector and interaction detector.
<table>
<thead>
<tr>
<th>Impact factor</th>
<th>Classification interval</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP (million yuan)</td>
<td></td>
<td>103.15 to 158.22</td>
<td>158.23 to 233.15</td>
<td>233.16 to 293.00</td>
<td>293.01 to 333.22</td>
<td>333.23 to 398.26</td>
<td>398.27 to 467.68</td>
<td>467.69 to 745.74</td>
<td>745.75 to 2902.06</td>
<td></td>
</tr>
<tr>
<td>GRPPPC (yuan)</td>
<td></td>
<td>5241.00 to 7182.00</td>
<td>7182.01 to 8248.00</td>
<td>8248.01 to 8959.00</td>
<td>8959.01 to 9824.00</td>
<td>9824.01 to 11425.00</td>
<td>11425.01 to 14820.00</td>
<td>14820.01 to 19705.00</td>
<td>19705.01 to 49860.00</td>
<td></td>
</tr>
<tr>
<td>ELE (m)</td>
<td></td>
<td>−20.00 to 1410.12</td>
<td>1410.13 to 2635.94</td>
<td>2635.95 to 3657.45</td>
<td>3657.46 to 4338.46</td>
<td>4338.47 to 4781.11</td>
<td>4781.12 to 5121.62</td>
<td>5121.63 to 5496.17</td>
<td>5496.18 to 8662.87</td>
<td></td>
</tr>
<tr>
<td>RAD (MJ/m²)</td>
<td></td>
<td>4393.68 to 5135.87</td>
<td>5135.88 to 5604.71</td>
<td>5604.72 to 5982.36</td>
<td>5983.37 to 6307.92</td>
<td>6307.93 to 6633.48</td>
<td>6633.49 to 6919.92</td>
<td>6919.92 to 7193.41</td>
<td>7193.41 to 7714.20</td>
<td></td>
</tr>
<tr>
<td>PRE (mm)</td>
<td></td>
<td>&lt;100.00</td>
<td>100.00 to 200.00</td>
<td>200.01 to 400.00</td>
<td>400.01 to 600.00</td>
<td>600.01 to 800.00</td>
<td>800.01 to 1000.00</td>
<td>&gt;1000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEM (°C)</td>
<td></td>
<td>−15.00 to −10.00</td>
<td>−10.01 to −5.00</td>
<td>−5.01 to 0.00</td>
<td>0.01 to 5.00</td>
<td>5.01 to 10.00</td>
<td>10.01 to 15.00</td>
<td>15.01 to 20.00</td>
<td>&gt;20.00</td>
<td></td>
</tr>
<tr>
<td>MI (arid)</td>
<td></td>
<td>&lt;−60.00</td>
<td>−60.00 to −30.00 (semi-arid)</td>
<td>−30.01 to −15.00 (dry sub-humid)</td>
<td>−15.01 to 0.00 (humid sub-humid)</td>
<td>0.01 to 40.00 (humid)</td>
<td>40.01 to 80.00 (wet)</td>
<td>&gt;80.00 (over-wet)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESDC is the Data Centre for Resources and Environmental Sciences of Chinese Academy of Sciences (http://www.resdc.cn)
Results

Epidemiologic characteristics and spatial distribution of Tibet’s life expectancy at birth

The average life expectancy at birth in Tibet in 2010 was 70.32 years, and women were 72.55, who lived longer than men (68.17 years). The longest average value was located in Lhasa City’s Dagze County reaching 81.13 years, while the shortest one was located in Ali Prefecture’s Rutog County, namely 57.72 years. For the distribution of life expectancy at birth in Tibet, the longer were distributed like a strip, mainly located in Shigatse City, Lhasa City, Shannan City, northern Nyingchi City and Qamdo City; in contrast, the average life expectancy of Ali Prefecture and Naqu City were shorter (Fig. 3). Hotspot map is used to identify the high value and low value of space clustering distribution with statistical significance (Shafer et al. 2011), and we used Getis-Ord General G tool in ArcGIS 10.2 to explore the hot point and cold point’s distribution of life expectancy at birth (Fig. 4). We found that the clustering distribution of high values were located in Shannan City, Lhasa City, eastern Shigatse City and eastern Qamdo City, while the clustering distribution of low values were located in northwestern Naqu City and western Ali Prefecture.

Analysis of socioeconomic and environmental impact factors of life expectancy

The factor detector quantifies the potential impact factors, and on the basis of $q$ statistic values we selected 13 potential impact factors of socioeconomy, geographical environment, ecological environment and geological environment, to study their independent influences on the life expectancy in Tibet.

The $q$ statistic values of these factors are shown in Table 2. Generally, if the $q$ statistic value of a factor is greater than 0.2, it can explain the spatial pattern well, and thus, this factor can be regarded as an important potential impact factor (Li et al. 2013). Therefore,
Fig. 4 Clustering distribution map of the life expectancy at birth of 2010 in Tibet

Table 2 The $q$ statistic values, suitable types or ranges of all 13 impact factors and their corresponding average life expectancy in Tibet

<table>
<thead>
<tr>
<th>Impact factor</th>
<th>$q$ statistic value</th>
<th>Suitable range or type</th>
<th>Average life expectancy at birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP (million yuan)</td>
<td>0.365</td>
<td>745.75–2902.06</td>
<td>76.00</td>
</tr>
<tr>
<td>TEC</td>
<td>0.352</td>
<td>Hengduan mountains</td>
<td>71.03</td>
</tr>
<tr>
<td>VEGR</td>
<td>0.278</td>
<td>Temperate grassland region</td>
<td>70.93</td>
</tr>
<tr>
<td>RAD (MJ/m²)</td>
<td>0.244</td>
<td>5604.72–5982.36</td>
<td>73.50</td>
</tr>
<tr>
<td>VEG</td>
<td>0.202</td>
<td>Needle and broad leaved-mixed forest</td>
<td>72.15</td>
</tr>
<tr>
<td>GRPPC (yuan)</td>
<td>0.200</td>
<td>19,705.01–49,860.00</td>
<td>73.85</td>
</tr>
<tr>
<td>STR</td>
<td>0.194</td>
<td>$\delta o_1^1$, $\Sigma_1^1$</td>
<td>80.36</td>
</tr>
<tr>
<td>TEM (°C)</td>
<td>0.187</td>
<td>0.01–5.00</td>
<td>71.90</td>
</tr>
<tr>
<td>PRE (mm)</td>
<td>0.186</td>
<td>400.01–600.00</td>
<td>70.07</td>
</tr>
<tr>
<td>MI</td>
<td>0.138</td>
<td>0.01–40.00 (humid)</td>
<td>68.59</td>
</tr>
<tr>
<td>GEO</td>
<td>0.126</td>
<td>Large fluctuation mountains</td>
<td>69.86</td>
</tr>
<tr>
<td>ELE</td>
<td>0.088</td>
<td>3657.46–4338.46</td>
<td>71.63</td>
</tr>
<tr>
<td>SOI</td>
<td>0.046</td>
<td>Semi-luvisol</td>
<td>73.39</td>
</tr>
</tbody>
</table>

$\delta o_1^1$ (quartz diorite porphyry, belong to granitoid, Indo-Chinese epoch), $\Sigma_1^1$ (ultramafic rock, late Variscan)
GRP, TEC, VEGR, RAD, VEG and GRPPC were the most important impact factors, and they had larger impacts on the life expectancy in Tibet. Furthermore, the value of STR, TEM and PRE was close to 0.2, showing that they had some impacts on the life expectancy, and MI, GEO, ELE and SOI were all less than 0.15, meaning that they had little impacts.

Regional analysis of the leading impact ranges (types) of potential impact factors on the life expectancy

The risk detector reveals the statistically significant differences in the life expectancy at birth in Tibet between types or ranges, with a confidence of 95% by t test, and shows the average life expectancy at birth of each type or range of factors. The suitable types or ranges correspond to the maximum value of the life expectancy at birth, which means a high spatial distribution consistency (Table 2; Fig. 5).

Interactive influence of impact factors

The interaction detector reveals the interaction relationship between two factors and finds out whether they work independently. We found that the interaction between any two impact factors enhanced their impact on the life expectancy than their independent impact and that occurred even for those factors with the lowest q statistic values. The results of every pair of factors with interactive q statistic value, which are greater than 0.5, are tabulated in Table 3. The combination of socioeconomic factors had the largest impact on the life expectancy in Tibet, the interaction value was 0.861 of GRP and GRPPC pairs, and these two factors nonlinearly enhanced. Furthermore, the interactive effect of socioeconomic factors coupled with environmental factors is larger than the interactive effect within environmental factors; for instance, the interaction value of GRP and TEC pairs was bigger than that of TEC and RAD pairs. Consequently, the interactions of any two factors played a more important role on the life expectancy in Tibet.

Discussion

After quantitative analysis by using Geodetector, we found that GRP, TEC, VEGR, RAD, VEG and GRPPC are the most important impact factors on the life expectancy in Tibet (q ≥ 0.2), and STR, TEM and PRE showed some influences (0.15 ≤ q < 0.2), while MI, GEO, ELE and SOI have little impact on the life expectancy (q < 0.15). Moreover, we found that influences of all those factors on the life expectancy will increase when they interacted with each other, especially for STR, PRE and MI; although their independent effects are weak, these factors enhance their influence on the life expectancy in Tibet when interacting with main impact factors.

In general, socioeconomic has the greatest impact on the life expectancy in Tibet, including GRP (q = 0.365) and GRPPC (q = 0.200), and the impact of gross regional economic level is greater than the individual economy. Because of the region sparsely populated and with traffic inconvenience, Tibetan residents mainly rely on the local medical conditions and public health services (Mei 2008; Lai et al. 2012). People lived in areas with high gross regional product could enjoy better health care; furthermore, the improvement of educational facilities in public service could help local residents to form correct health consciousness, which have a beneficial impact on life expectancy.

The analysis of the factor TEC (q = 0.352) in the geological environment shows that the highest life expectancy at birth is located in the Hengduan Mountains area, reaching the age of 71.03. Hengduan Mountains are located in the Sanjiang fold system, where the tectonic area has undergone different stages of Tethys evolution and plate interactions in the Himalayan intracontinental collision orogenic stage (Zhong 1998); ultrabasic–basic-medium acid–alkaline magmatic rocks are widely exposed in the tectonic area (Wang 2006). Although the spatial correlation between STR and life expectancy is relatively small (q = 0.194), the average life expectancy at birth of
Fig. 5 Distribution of suitable ranges or types of main impact factors: a GRP; b GRPPC; c TEC; d VEGR; e RAD; f VEG; g TEM; h PRE.
these two igneous rock types ($d_{o 1}$ and $\Sigma_{d 1}$) is 80.36 years (Table 2). Scholars have also found that the longevity regions are mostly located in areas where igneous rocks are widely exposed, such as Hainan island (Ma et al. 1991), Bama County, Guangxi province (Yao et al. 2016), Southern Xinjiang (Liu et al. 2014; Xiao et al. 2006), Jining, Shandong (Gao and Tian 2018), Southern Qinling Mountains (Wu et al. 2006). A variety of trace elements needed by the human body are rich in magmatic rocks, such as Fe, Zn, Cu, Se, Li, V, Co, Ni, while Pb, Cd, Hg, As and other potentially toxic elements are less (Cox et al. 1979; C. Li 1992; Zhang et al. 1995). These trace elements can enter the human body through the environmental geochemical cycle and then affect the health and lifespan of human body. The water in most of magmatic rock outcrop areas often contain elements such as Li, Sr, Se and metasilicic acid (Luo et al. 2002; Liu et al. 2013; Gao and Tian 2018), and contents are superior to the Standard of National Mineral Water (GAQS et al. 2008), which has a beneficial impact on the human health, furthermore increasing the average life expectancy of the local population.

For factors of ecological environment, VEGR ($q = 0.278$), RAD ($q = 0.244$), VEG ($q = 0.202$), TEM ($q = 0.187$) and PRE ($q = 0.186$) have some impacts on the life expectancy. Vegetation regionalization and vegetation type are the comprehensive characterization of vegetation communities under the influence of climate and geographical environment to a certain degree (Maarel and Franklin 2013), which could comprehensively reflect the climate impact on the life expectancy. Vegetation regionalization and vegetation type are the comprehensive characterization of vegetation communities under the influence of climate and geographical environment to a certain degree (Maarel and Franklin 2013), which could comprehensively reflect the climate impact on the life expectancy. For radiation, we found that as the increasing of RAD, the trend of the average life expectancy at birth increased first and decreased afterward, and the suitable range is between 5604.72 and 5982.36 MJ/m² (Table 4), which is consistent with that high radiation has an adverse effect on the increase in life expectancy (Juckett and Rosenberg 1993). Temperature is also an important determinant.
of human health (Mills 1949). Huang et al. (2012) showed that the association between temperature and years of remaining life is U shape. According to the risk detector results, we found that the most suitable annual average temperature for the life expectancy in Tibet is between 0 and 10 °C, annual average precipitation is between 400 and 800 mm and the climate is the plateau subtemperate zone according to the People’s Republic of China climate Atlas (CMA 2002); furthermore, large or lower than these intervals leading to the average life expectancy at birth decreased (Table 4). In general, areas are located in the plateau subtemperate zone, with plenty of rainfall and suitable temperature, and the vegetation type is needle and broad leaved-mixed forest, as well as the lower radiation amount will have beneficial effects on the increase in life expectancy, while ecological factor MI \((q = 0.138)\) and geographical factor GEO \((q = 0.126)\), ELE \((q = 0.088)\) and SOI \((q = 0.046)\) have little impact on the life expectancy of Tibetans.

### Conclusions

We chose 13 potential impact factors of socioeconomic, ecological environment, geological environment and geographical environment to study multiple interrelated impact factors of the life expectancy in Tibet by using the Geodetector algorithm and furthermore to quantitatively analyze their impacts and figure out their suitable ranges or types. We can obtain that:

1. The average life expectancy at birth in Tibet in 2010 was 70.32 years, and women (72.55 years) lived longer than men (68.17 years). The higher values of life expectancy at birth in Tibet were distributed like a strip, mainly located in Shigatse City, Lhasa City, Shannan City, northern Nyingchi City and Qamdo City, while the distribution of lower values was located in Naqu City and Ali Prefecture.

2. The main control factors of the life expectancy spatial difference in Tibet are socioeconomic factors, followed by geological environmental factors; moreover, the highest range of GRP and GRPPC and the igneous rock exposed areas correspond to the maximum value of life expectancy at birth.
3. The ecological environmental factors have a certain impact on the life expectancy of Tibet residents, while the geographical environmental factors have little impact on the life expectancy. Lower radiation, moderate temperature and rainfall may have a favorable impact on the increase in the life expectancy.

4. The life expectancy of Tibet is mainly affected by socioeconomy, geological environment and ecological environment, and the interactions between these factors can enhance the impacts on the life expectancy of Tibet residents.

This study could contribute to better understand the impact factors of the life expectancy in Tibet and to figure out the suitable ranges or types and also could provide a basis for local governments to formulate relevant policies of relocation and population management. Because the concentrations of air pollutants have been regularly monitored covering the six cites and one prefecture in Tibet since 2015, we failed to obtain the monitoring data in 2010; therefore, air pollution did not be considered in this paper. In the future, we should explore and research more life expectancy potential impact factors and compare with other areas in China, which will help to further study the life expectancy impact mechanism.

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References


