



# Assessment of elemental background values and their relation with lifespan indicators: A comparative study of Jining in Shandong Province and Guanzhong area in Shaanxi Province, northern China



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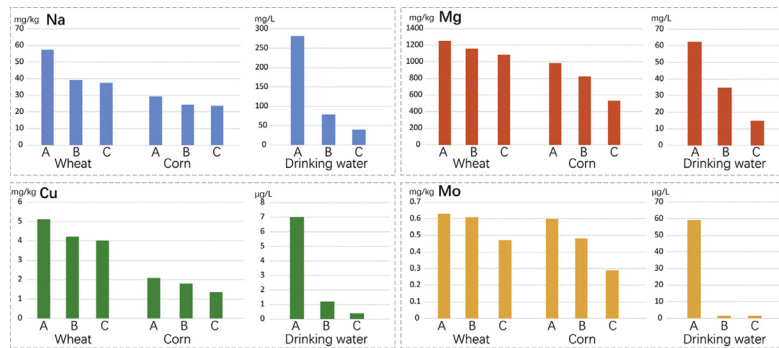
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## HIGHLIGHTS

- High level of centenarians is found in Jinxiang County in Jining, Shandong Province.
- Background values of Na, Mg, Mo, Cu show positive relation with lifespan indicators.
- Elemental difference in drinking water is more remarkable than in staple grains.
- Ion balance of Na, Ca and Mg shows a closed relation with longevity level.

## GRAPHICAL ABSTRACT



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## ABSTRACT

The remarkably high proportions of centenarians are found in the Jining Prefecture in southwestern Shandong province, demonstrating remarkable regional longevity differentiation. In this paper, census data at county-level, samples of drinking water and staple grains in Jining Prefecture were collected. Guanzhong area in Shaanxi Province, a non-longevity region in northern China was chosen as the contrast area. The major and trace elements in the samples were determined by using ICP-MS, ICP-OES and HG-AFS. The major results show that Jinxiang County in Jining Prefecture exhibit obviously higher longevity level than adjacent counties and Chinese average level based on temporal and spatial variation of lifespan indicators. Meanwhile, the contents of Na, Mg, Mo and Cu in wheat, corn and drinking water show a similar decline trend in the order of Jinxiang County, non-longevity counties of Jining Prefecture and Guanzhong area. In addition, Na/Ca and Mg/Ca show obvious difference both in staple grains and drinking ground water, and  $\text{Ca}^{2+}$  is the most abundance of major cations in drinking water samples from non-longevity counties which was different with the Jinxiang County showing  $\text{Na}^+$  as of major cations. The principal component analysis (PCA) shows that the difference of elemental concentrations in drinking water was more remarkable than in staple grains between Jining and Guanzhong areas. Na, Li, Ni, and Zn in staple grains and Mg, Co, Cu, Mn, and Sr in drinking ground water can explain most of the total variance as principal component between Jining and Guanzhong areas. These findings may help to provide further insight into the elemental background values and their relation with lifespan indicators especially in northern China.

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## 1. Introduction

The long human life span is a special phenomenon of human physiology. China is recognized with uneven-distributed pattern of longevity regions, which indicates that lifespan indicators show a great difference among provinces or even counties (Li et al., 2000; Wang et al., 2015a, 2015b). Long human lifespan or longevity phenomenon is generally considered relevant with the contributions of environment, lifestyle, health care, heredity and other psychological factors (e.g. Christensen and Vaupel, 1996; Ljungquist et al., 1998; Wang et al., 2015a, 2015b). Extensive studies have discussed the relationship between environment and longevity (e.g. Hamilton et al., 1973; Foster and Zhang, 1995; Christensen and Vaupel, 1996; Ljungquist et al., 1998; Borisenkov, 2011; Liu et al., 2014). Furthermore, the environmental background such as drinking water and staple grains are important to human health for they supply major and trace elements that are essential or harmful to human body (Buschmann et al., 2008; Sun et al., 2009; WHO, 2010; Liu et al., 2014).

Although the economy has experienced rapid growth, many Chinese residents in rural areas, still mainly consume plant-based food as the most important part in their diet. Their dietary structure includes a higher proportion of cereal, yam and vegetables than meat and milk, in which the proportion of calorific energy supplied from cereals accounted for 61.5% for residents in China's rural areas (He et al., 2004). In northern China, wheat-based cereals are the most important mineral sources for the local residents. Moreover, rural individuals lived most of their lives in their residences, which is a distinct characteristic compared with developed countries. Meanwhile, with fast socio-economic development, more detailed and accurate data on population size in every age category have been obtained in China. These provide valuable information and a potential basis for investigating the distribution and variation of longevity regions in China.

The North China Plain (also called Huang-Huai-Hai Plain) supplies >50% of Chinese wheat and 33% of its corn (Wu et al., 2006). Based on latest three national population censuses in China, it is remarkable that ratios of centenarians in the junction region of southwestern Shandong Province, eastern Henan Province and northern Anhui Province ("SHA region") are much higher than adjacent areas, and this junction area forms a distinct longevity region in Northern China (Wang et al., 2015b). Indeed, Jining Prefecture in southwestern Shandong Province is located in the core area of 3H-plain and "SHA" region. However, few studies have been conducted on the distribution of elemental

background values in staple grains and drinking water in this area and their relation with lifespan indicators.

Therefore, we selected Jining Prefecture in Shandong Province as our main study area. Then we chose three indexes as main lifespan indicators to describe temporal and spatial variation lifespan in this area at county level: 1) the number of centenarians per one hundred thousand inhabitants (CH) (Wang et al., 2015a, 2015b); 2) longevity index (LI), defined as the ratio of the population above 90 years old to the total population above 65 years old (Magnolfi et al., 2007); the percentage of the population aged at least 80 years old (ultra-octogenarian index, UOI) (Wang et al., 2015a, 2015b). We also selected Guanzhong area in Shaanxi Province as our comparative area, another grain production base in northern China, which share the similar temperature and climate regionalization with SHA region but with much lower lifespan indicators than "SHA" region.

In this study, we collected typical samples of drinking water and staple grains (wheat and corn) from Jining and Guanzhong areas. We aimed to discuss the chemical characteristics and difference especially the concentration of trace elements in drinking water and staple grains from longevity and non-longevity counties in Jining and Guanzhong areas. Furthermore, principal component analysis (PCA) is suitable for interpreting the complicated interrelationships between multiple factors, and it is considered as an effective analytical tool to reveal the internal structure with best explains of the variance in the data (Jolliffe, 2002). So, we conducted PCA, and in order to discuss the relationship between the spatial variation of chemical characteristics of drinking water, staple grains and lifespan indicators. Finally, this investigation may help to provide further insight into the elemental background values and their relation with lifespan indicators especially in northern China.

## 2. Materials and methods

### 2.1. Regional setting

Jining Prefecture (34°26'–35°57'N, 115°52'–117°36'E) locates in southwestern Shandong Province (Fig. 1). It is in the combined areas of the Shandong Peninsula and the Huang-Huai-Hai-Plain. The terrain is mainly lowland plain, and from east to west, the altitudes became lower. The eastern part of Jining is hilly topography, with altitude of 40–100 m. In the south-central part, there is the largest freshwater

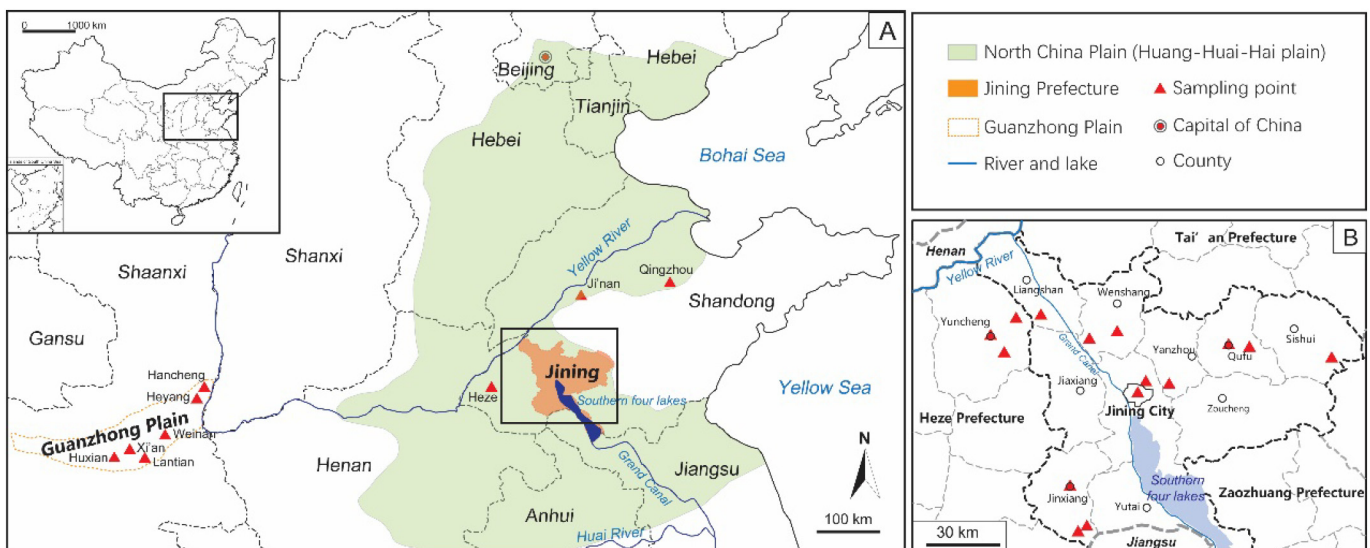


Fig. 1. Geographical distribution of sampling areas. Jining Prefecture in Shandong Province and Guanzhong Plain in Shaanxi Province (A); The locations of sampling points in Jining Prefecture in Shandong Province (B).

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