Chinese Geographical Science 2007 17(1) 092–098
DOI: 10.1007/s11769-007-0092-z
www.springerlink.com

Normal Reference Value of Red Blood Cell Count of Chinese Presenile Men and Geographical Factors

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Abstract: This paper aims at providing a scientific basis for unifying the normal reference value standards of red blood cell count of Chinese presenile men. The paper, using microscopical counting method, studies the relationship between the normal reference values of 38,061 samples of red blood cell count of presenile men and eight geographical factors in 297 units in China. It is found that the correlation of geographical factors and the normal reference value of red blood cell count of presenile men is quite significant (F=303.00, P=0.000). By using the method of stepwise regression analysis, one regression equation is inferred. It is concluded that if geographical data are obtained in a certain area, the normal reference value of red blood cell count of presenile men in this area can be reckoned by using the regression analysis. Furthermore, according to the geographical factors, China can be divided into eight regions: Northeast China Region, North China Region, Shanxi-Shaanxi-Inner Mongolia Region, Middle and Lower Reaches of the Changjiang River Region, Southeast China Region, Northwest China Region, Southwest China Region and Qinghai-Tibet Plateau Region.
Keywords: red blood cell count; normal reference value; geographical factors; regression analysis

1 Introduction

Red blood cell count is an important index of hematology, whose increase with pathology can lead to such symptoms as polycythemia vera and compensated polycythemia (including congenital cyanosis cardiopathy, chronic lung disease, dehydration). Otherwise, its decrease is caused by all kinds of losing blood, such as anemia, leucocythemia, after operation and postpartum, and its increase in a physiology way often seizes neonate or plateau inhabitant. At present, it is difficult to achieve the high exactness of clinical diagnosis because of the lacking of a unified standard of the normal reference value of presenile men's red blood cell count in China. In order to provide a scientific basis for unifying the normal reference value standard of red blood cell count of Chinese presenile men, many researchers have measured the normal reference value of the local presenile men's red blood cell count (Kou et al., 1999; Zhao et al., 1998; Wu et al., 2000; Ye et al., 1997a; 1997b; Zhang et al., 1997; Zhang et al., 1996; Ye, 1996; Zhu et al., 1998; Lu et al., 1997; Yang et al., 2000; Wu et al., 1998; Yang et al., 1998; Lu et al., 1996; Chen et al., 2001; Cai et al., 2001; Hu and Yang, 2001; Kong, 1998; Kong, 2002; Mei et al., 2001; Zhang et al., 2001; Jin et al., 2002; Zhang et al., 2003; Wu et al., 2002; Li et al., 2003; Peng et al., 2003; Xiong et al., 2004; Lin et al., 1995; Ma et al., 1993; Wang and Zhao, 1996; Shi et al., 2001; Zhu et al., 2001; Kuang and Wang, 1995; Chen et al., 2000; Sun et al., 2000; Zhou, 2000; Wang et al., 1998; Gong et al., 2001; Yang et al., 2003a; ATPAIBB, 1998; Li et al., 1997; Li, 1998; Du and Zhang, 2001; Sun et al., 2001; Chen et al., 2002; Yang et al., 2003b; Li et al., 2004; Chang, 2001; Zhang et al., 2003). But there is no report about the relationship between the normal reference value of presenile men's red blood cell count and geographical factors (Anthba and Louis, 1977; Ruiz-Arguelles and Llorente-Peters, 1981; Greendyke et al., 1962). By using the method of stepwise regression analysis, this paper indicates that there are certain regularities of the relationship between the normal reference value of presenile men's red blood cell count and geographical factors.

2 Materials

2.1 Normal reference value of presenile men's red blood cell count

The normal reference values of 38,061 healthy presenile

Received date: 2006-07-25; accepted date: 2006-11-01
Foundation item: Under the auspices of the National Natural Science Foundation of China (No. 40371004)
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men's red blood cell counts have been collected from 297 administrative units (hospitals, research institutes and universities) in China. The ages of the volunteers ranged from 46 to 59 years old. These units were distributed in 31 first-level administrative units (provinces, autonomous regions, and municipalities), but lack of Taiwan Province, Hong Kong Special Administrative Region, and Macao Special Administrative Region. The data from the eastern plain region are more than the western plateau region. And 50–210 random samples have been studied in every area. The determination of the normal reference value of presenile men's red blood cell count is performed according to the microscopical counting method (Ye et al., 1997a; 1997b). The experiment done by adopting this method includes the following steps: take one minor test tube, add 2.0mL of red blood cell diluents into it, get 10μm of blood with clean dry micro-straw, scrape the surplus blood off the tip of the micro-straw, inject the blood into the bottom of the blood cell diluents gently, and suck the upper clear liquid to rinse the micro-straw 2–3 times, then mix it immediately. After resting the mixture standing for 2–3 minutes, the visual counting of cell number was performed in turn with high power microscope, on the basis of the principle of counting the upper and left rather than the lower and right.

2.2 Geographical factors

The data of geographical factors affecting presenile men's red blood cell count come from relevant geographical works and dictionaries (Yan et al., 1991; Yan et al., 2002; Zhao et al., 1999). The selected geographical factors include altitude (X_1) (m), annual sunshine duration (X_2) (h), annual percentage of sunshine duration (X_3) (%), annual mean air temperature (X_4) (℃), annual range of air temperature (X_5) (℃), annual mean relative humidity (X_6) (%), annual precipitation (X_7) (mm), and annual mean wind speed (X_8) (m/s) .

3 Correlation Analysis and Regression Analysis

3.1 Correlation analysis

By using the method of mathematical correlation analysis (Zhang and Yang, 1991), simple correlation coefficients between the normal reference value of presenile men's red blood cell count and eight geographical factors were calculated respectively: r_1=0.898 (P_1=0.000), r_2=0.515 (P_2=0.000), r_3=0.498 (P_3=0.000), r_4=–0.816 (P_4=0.000), r_5=–0.160 (P_5=0.006), r_6=–0.687 (P_6=0.000), r_7=–0.596 (P_7=0.000), r_8=0.132 (P_8=0.023). If P value is higher than 0.05, it means the correlation is not significant. If P value is lower than 0.01, it means the correlation is quite significant. If it occurs between 0.05 and 0.01, the correlation is significant.

From simple correlation coefficients, it can be concluded that altitude is the main factor affecting the normal reference value of presenile men's red blood cell count. As altitude rises, the air becomes thinner, and the oxygen content gradually reduces. In response to the lack of oxygen, the amount of red blood cells in the human body gradually increases. It induces a rise of the normal reference value of presenile men's red blood cell count (Ge, 2001).

3.2 Regression analysis

According to the normal reference value of presenile men's red blood cell count and geographical factors, a regression equation is inferred by using the method of stepwise regression analysis:

$$\hat{Y}=2.543+0.0003623X_1+0.0002514X_2+0.01660X_5+0.01457X_6+0.0001608X_7\pm0.47 \quad (1)$$

In the above equation, $\hat{Y}$ is the normal reference value of presenile men's red blood cell count ($\times10^{12}$/L); X_1 is the altitude (m); X_2 is the annual sunshine duration (h); X_5 is the annual range of air temperature (℃); X_6 is the annual mean relative humidity (%); X_7 is the annual precipitation (mm); 0.47 is the value of the 1.96 residual standard deviations (Zhou et al., 1995).

By using F-test, F equals 303.00, P equals 0.000. Because P value is lower than 0.01, it indicates that the correlation between presenile men's red blood cell count and geographical factors is quite significant.

4 Regionalization

4.1 Main features of geographical factors in China

The People's Republic of China is situated in the eastern part of Asia and on the west coast of the Pacific Ocean. It has a vast territory, with a distance of 5000km from the east to the west and 5500km from the north to the south. When the sun rises over the Wusuli River in the northeast, the Pamirs in the west is still dark. When blizzards wrap the north in winter, spring sowing is under way on Hainan Island in the south. The Zengmu Shoal, the southernmost part of China, is close to the equator and stays hot all the year round.

4.1.1 Altitude

Chinese topography varies from high peaks to basins of different shapes and sizes, from wide and rolling plateaus to low and broad plains. There are great deserts and wilds in the northwest, while rivers, streams and lakes are on the plains of the middle and lower reaches of the Changjiang River. The topographical outline of China is a three-step west-east terrace. It is high in the western area and low in the eastern area. It begins from the Qinghai-Tibet Plateau, which is mostly 4000m. Crossing the Kunlun Mountains and Qilian Mountain on the plateau's northern edge and the Hengduan Mountains on its eastern edge, it descends northwards and eastwards and comes to highlands and basins, which are mostly 1000–2000m. Then it descends further eastward to hilly regions and plains mostly with an elevation below 500m.

4.1.2 Temperature

In China, some areas are warm all the year round while others have long winter and short summer. Most of the land lies in the temperate zone with four distinct seasons. A combination of high temperature and plentiful rainfall provides favorable conditions for farming there.

In the east, winter often brings a dry, cold northwest wind from the hinterland towards the sea; summer often brings a hot, moist southeast wind from the sea. The northwest, being far from the sea, has comparatively little precipitation and its temperature varies greatly even in the same day. On the other hand, the temperature on the Qinghai-Tibet Plateau in the southwest is relatively low because of its high altitude. Both Lhasa in the west and Hangzhou in the east are at the latitude of 30°N, but the average temperature of July is 15℃ for the former, while 28℃ for the latter.

Owing to the monsoon, the temperature in the north and south varies greatly in winter but little in summer. In January the difference of the average temperature between Harbin in the northeast and Guangzhou in the south is as much as 33℃. But in July the difference is only 5℃.

4.1.3 Precipitation

The distribution of annual precipitation in China generally decreases from southeast to northwest. Annual precipitation is abundant in southeast of the Qinling-Huaihe (Qinling Mountains-Huaihe River) line, which is roughly identical to the 750mm isohyet. Northwest of the 500mm isohyet (roughly coincident with the Great Wall), there are extensive areas of semi-arid and arid lands, occupying about 52.5% of China's total land area. In the transitional belt between the 500mm isohyet and the 750mm isohyet, precipitation is generally variable, often subject to both drought and flood hazards. In highly productive agricultural areas, annual precipitation is mostly concentrated in the summer half year, creating conditions favorable for crop growth, but these areas are often liable to flood and waterlogging.

4.1.4 Sunshine

The distribution of annual sunshine hours in China generally increases from the southeast to the northwest, inversely proportional to the distribution of annual precipitation. The Guizhou Plateau and the Sichuan Basin in Southwest China have the lowest sunshine hours, with an average of less than 1400h. Annual sunshine hours total about 2000h in South China and in the Changjiang (Yangtze) River valley, but range from 2400–3000h in the Huanghe (Yellow) River valley and Northeast China. Northwest China and Qinghai-Tibet Plateau have the greatest amount of annual sunshine hours, generally more than 3000h. The Lenghu area in the western Qaidam Basin has the highest annual sunshine hour recorded in China, with an average of 3600h. During recent years, the abundant sunshine has been gradually harnessed for home heating in Northwest China and Qinghai-Tibet Plateau.

4.1.5 Wind

As a rule, wind velocity is higher in North China than in South China, in coasts than in inland, in plains and plateaus than in mountainous areas. The southeastern coast and the northern Inner Mongolia have an annual mean wind velocity higher than 4–5m/s. Wind velocity is generally greatest in spring and winter and least in summer. Yet, in coastal areas south of 30°N, because of frequent typhoons, mean wind velocity is highest in autumn, but in Northwest China it is highest in summer.

4.2 Principles of regionalization

According to the dependent relations between the normal reference value of presenile men's red blood cell count and geographical factors, and taking altitude as the main differentiating factor, referring to distribution of population density and other geographical factors, China can be divided into eight regions: Northeast China, North China, Shanxi-Shaanxi-Inner Mongolia, Middle and Lower Reaches of the Changjiang River, Southeast China, Northwest China, Southwest China, Qinghai-Tibet Plateau (Fig. 1).

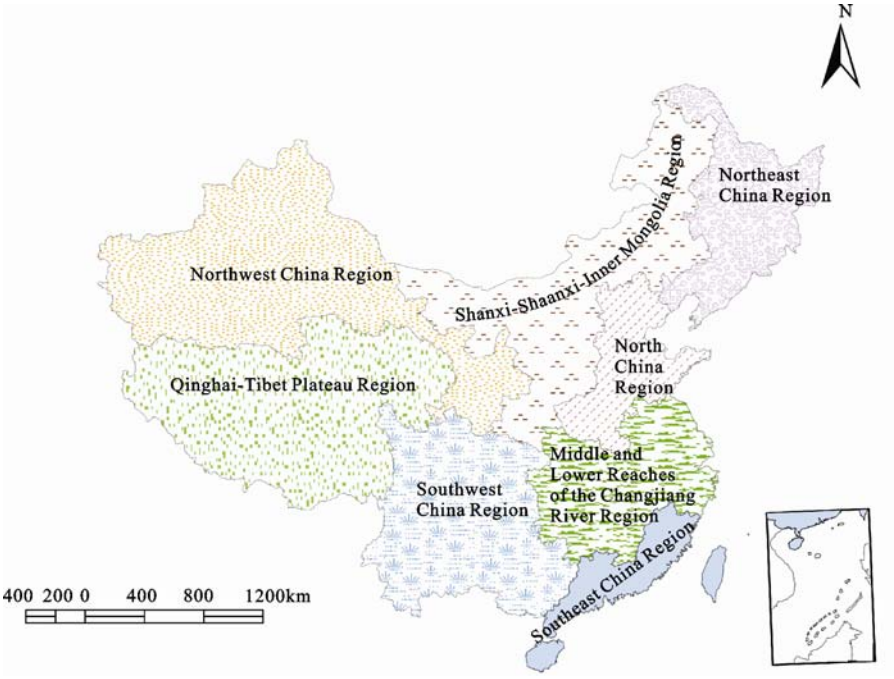

Fig. 1 Regionalization of normal reference value of presenile men's red blood cell count in China

4.3 Regionalization results

4.3.1 Northeast China Region

Northeast China Region includes Liaoning Province, Jilin Province and Heilongjiang Province. For example, in Harbin City, capital of Heilongjiang Province, the altitude (X_1) is 171.7m, the annual sunshine duration (X_2) is 2641.0h, the annual range of air temperature (X_5) is 42.2℃, the annual mean relative humidity (X_6) is 67.0%, and the annual precipitation (X_7) is 523.3mm. By Equation (1), it is calculated that normal reference value of presenile men's red blood cell count in Harbin is $(5.03\pm0.47)\times10^{12}$/L.

4.3.2 North China Region

North China Region includes Beijing City, Tianjin City, Hebei Province, Shandong Province and Henan Province. For example, in the Beijing area, the altitude (X_1) is 31.2m, the annual sunshine duration (X_2) is 2780.2h, the annual range of air temperature (X_5) is 30.4℃, the annual mean relative humidity (X_6) is 60.0%, the annual precipitation (X_7) is 644.2mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Beijing is $(4.74\pm0.47)\times10^{12}$/L.

4.3.3 Shanxi-Shaanxi-Inner Mongolia Region

Shanxi-Shaanxi-Inner Mongolia Region includes Shanxi Province, Shaanxi Province and Inner Mongolia Autonomous Region. For example, in Taiyuan City, capital of Shanxi Province, the altitude (X_1) is 777.9m, the annual sunshine duration (X_2) is 2675.8h, the annual range of air temperature (X_5) is 30.1℃, the annual mean relative humidity (X_6) is 60.0%, and the annual precipitation (X_7) is 459.5mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Taiyuan is $(4.95\pm0.47)\times10^{12}$/L.

4.3.4 Middle and Lower Reaches of the Changjiang River Region

Middle and Lower Reaches of the Changjiang River Region includes Hubei Province, Hunan Province, Anhui Province, Jiangxi Province, Zhejiang Province, Jiangsu Province and Shanghai City. For example, in Shanghai City, the altitude (X_1) is 4.6m, the annual sunshine duration (X_2) is 2014.0h, the annual range of air temperature (X_5) is 24.3℃, the annual mean relative humidity (X_6) is 79.0%, and the annual precipitation (X_7) is 1123.7mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Shanghai is $(4.79\pm0.47)\times10^{12}$/L.

4.3.5 Southeast China Region

Southeast China Region includes Fujian Province, Guangdong Province, Hainan Province, Taiwan Province, Hongkong Special Administrative Region and Macao Special Administrative Region. For example, in the Haikou City, capital of Hainan Province, the altitude (X_1) is 14.1m, the annual sunshine duration (X_2) is 2239.8h, the annual range of air temperature (X_5) is 11.0℃, the

annual mean relative humidity (X_6) is 83.0%, and the annual precipitation (X_7) is 1691.0mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Haikou is $(4.78\pm0.47)\times10^{12}$/L.

4.3.6 Northwest China Region

Northwest China Region includes Gansu Province, the Ningxia Hui Autonomous Region and the Xinjiang Uygur Autonomous Region. For example, in the Yinchuan City, capital of Ningxia Hui Autonomous Region, the altitude (X_1) is 1111.5m, the annual sunshine duration (X_2) is 3039.6h, the annual range of air temperature (X_5) is 32.4℃, the annual mean relative humidity (X_6) is 59.0%, and the annual precipitation (X_7) is 202.8mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Yinchuan is $(5.14\pm0.47)\times10^{12}$/L.

4.3.7 Southwest China Region

Southwest China Region includes Chongqing City, Sichuan Province, Yunnan Province, Guizhou Province, and the Guangxi Zhuang Autonomous Region. For example, in the Guiyang City, capital of Guizhou Province, the altitude (X_1) is 1071.2m, the annual sunshine duration (X_2) is 1371.0h, the annual range of air temperature (X_5) is 19.1℃, the annual mean relative humidity (X_6) is 77.0%, and the annual precipitation (X_7) is 1174.7mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Guiyang is $(4.90\pm0.47)\times10^{12}$/L.

4.3.8 Qinghai-Tibet Plateau Region

Qinghai-Tibet Plateau Region includes the Qinghai Province and Tibet Autonomous Region. For example, in the Lhasa City, capital of Tibet Autonomous Region, the altitude (X_1) is 3658.0m, the annual sunshine duration (X_2) is 3007.7h, the annual range of air temperature (X_5) is 17.7℃, the annual mean relative humidity (X_6) is 45.0%, and the annual precipitation (X_7) is 444.8mm. By Equation (1), it is calculated that the normal reference value of presenile men's red blood cell count in Lhasa is $(5.65\pm0.47)\times10^{12}$/L.

5 Conclusions

This paper, using microscopical counting method, studies the relationship between the normal reference values of 38,061 samples of red blood cell count of presenile men of China and eight geographical factors. It is found that the correlation of geographical factors and the normal reference value of red blood cell count of presenile men are quite significant. By using the method of stepwise regression analysis, a regression equation is given. So, if geographical data are obtained in a certain area, the normal reference value of red blood cell count of presenile men in this area can be reckoned by using the regression equation.

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