1. Introduction

As a genetic marker, human blood group has certain differences among different ethnicities, nationalities, and different geographical groups, and is an important indicator reflecting the origin, migration, differentiation, and integration of ethnic groups, as well as the relationship between ethnic groups. Since the discovery of the ABO blood system in 1900, ongoing and in-depth research, confirmed by hypothesis verification, has been carried out in terms of geographic location in relation to micro-biological information such as genes and mitochondria. The first ABO blood group study of human genetic variation can be traced back to the first World War, taking about a century from geographical research to genetic exploration, while providing a basis for clinical treatment. In 1963, Kavar-Sforza [1] constructed the first human evolutionary tree by using blood group gene frequency data, opening the door of human genetics and gene research. After 30 years of DNA research, since 1994 when the map of human evolution “out of Africa” was drawn [2], the human blood group system has played an important role [3]. In the era of information revolution, the diversity of geographical pattern of ABO blood group genetic expression and the polymorphism of ABO gene loci ushered in the era of big data verification. Due to specific reasons, people are rarely able to understand the geographical and spatial characteristics of blood groups from the whole perspective of a region or country. In the past half century, there are numerous studies on ABO blood groups in China, but there is still a lack of confirmed big data to explain their characteristics. Data for ABO in China population are still limited. Based on this, it is very necessary to use big data to verify the ABO blood group distribution characteristics in China population.

The research to explore the distribution characteristics of ABO blood groups in China is first conducted by overseas scholars [4, 5]. However, Chinese researchers such as Shang Shusong et al. in 1963 [6], Chen Zhiyong et al. in 1982 [7] and Peng Deren et al. in 1991 [8] all analysed ABO blood group distribution and described the distribution of ABO blood groups in various provinces and regions of China, providing some meaningful references for the study of ethnic migration and regional characteristics of blood group distribution in China. Due to the division of administrative
regions, data from only 28 provinces are available in the study [7] in 1982, and there lacked data from 4 municipalities and 2 special administrative regions. The study [8] in 1991 still lacked data from Chongqing municipality, Tibet Autonomous Region, and two special administrative regions. Based on the availability of accurate and up-to-date data, we collected blood group data from 370 administrative municipalities, based on 2019 administrative region classifications in 34 provincial-level administrative regions in China. The 23 million ABO blood group population data is standardized by the municipal units of the seventh census to obtain ABO blood group data of the entire China population. The data will undoubtedly also be useful for anthropological research, blood group and disease correlation, forensic medicine, and other research.

2. Subjects and methods

2.1. Data sources

In order to investigate the distribution characteristics of ABO blood group in the china population, we assembled the phenotypic data from 34 Chinese administrative division. The blood group data covered areas in accordance with China administrative 2019 version which included 34 provincial-level administrative regions, a total of 370 municipal administrative units. Data sources included: (1) The latest data are collected from 642 papers published by CNKI (China National Knowledge Infrastructure) and 393 blood group related disease researches are collected, then 249 papers are remained which included 231 papers published from 1991 to 2021 and 18 papers published from 1981 to 1990; (2) The other latest blood type proportion data of 2019 and 2020 from blood centers in each city (139 blood centers); (3) Some important additions and explanatory notes from published monographs and books. Considering the change of blood group and population, all research subjects are non-renumerated blood donors and local residents.

The phenotypic and gene frequency data are planned to map according to the geography of china and 370 municipal administrative units from China map 2019 version includes: 4 municipalities directly under the Central Government, 2 special administrative regions, Taiwan Province (as a whole), 293 prefecture-level cities, 7 prefectures, 30 autonomous prefectures, 3 leagues and 30 counties directly under the jurisdiction of provinces, totally 370 cities.

2.2. Data correction

The 23,383 million ABO blood groups data is collected from published literature data and local blood stations provided data, which is not collected in accordance with the national each cities as the ratio of population proportion. In order to reduce sampling bias, we standardized the collected data by the seventh national population census data which is not in Table 1. The ranking of China phenotypic ABO blood group characteristics are as follows: O > A > B > AB, and the gene frequencies are r (0.583), p (0.211) and q (0.208), respectively.

2.3. Data quality control

To ensure data quality, blood group data from local residents or blood donors from the available literatures are used in blood group data collection based on prefecture-city units. Multiple paper's data from participants in the same locality are combined. Data from 231 cities and the other 139 cities are collected from 249 papers and local blood center respectively. The latest blood proportion data in 2019 and 2020 are obtained from 139 blood centers in the form of investigation letters, and the coverage rate of blood type data in 370 cities in China reached 100%.

Ethical approval for the study is obtained from the institutional review board of People's Hospital of Shangxi Province (No: 2020-R002), and a participants' consent waive is given.

2.4. Gene frequency estimation

The Bernstein method is used to estimate gene frequency and the Hardy-Weinberg equilibrium test are adopted by Zhao Tongmao [9, 10].

2.5. Statistical analysis

The samples are checked for conformity with HWE assumptions at the ABO genes. These analyses established that all of the samples of China populations are in conformity with HWE. Homogeneity is tested among the 34 regions china populations by employing the ABO gene frequencies (Mourant,A. E. 1976. For the ABO blood group classification of population from the different regions, cluster analysis is performed to elucidate gene frequencies in different regions by IBM SPSS(26.0) software. Through GIS10.2 software, the geographical boundaries of sub-district offices and administrative counties are taken as basic component units, and the administrative division codes are used as correlation fields to associate ABO group data with chinese vector maps, complete the establishment of spatial database, and to draw ABO blood group distribution maps.

3. Results

3.1. ABO blood group distribution in China

3.1.1. Distribution characteristics of ABO blood groups in 34 provincial level administrative regions in China

A total of 23 697 367 subjects are collected from 370 cities in China to demonstrate the ABO blood group proportion in each city and to complete an ABO blood group distribution survey for 34 regions in China (see Supplementary Table S1). The ABO blood group data of 1 441 497 378 people in China are obtained by population correction based on the Seventh national Census. The blood group proportion results are shown in Table 1. The ranking of China phenotypic ABO blood group characteristics are as follows: O > A > B > AB, and the gene frequencies are r (0.583), p (0.211) and q (0.208), respectively.

3.1.2. Ranking of ABO blood group proportion in 34 provincial level administrative regions in China

As can be seen from Figure 1-A, in terms of provincial-level region divisions, the first proportion of blood type in each region formed a clear north-south division with type O in the south and type B in the north. But the division isn't divided by the traditional north-south line, the north mapped by ABO group is much smaller than the geographical division.10 provincial-level regions' dominant blood group is type B consisting of Inner Mongolia, Hei longjiang, Liaoning, Jilin, Hebei, Beijing, Shandong, Shanxi, Henan and Tianjin, and the other 24 regions' first blood group is type O. Figure 1-B shows that the second ABO blood group proportion is varied by different areas. Type A blood is mainly distributed in 16 provinces south of the Yangtze River Basin. And type O is dominant in the 10 northern provinces including Inner Mongolia, the northeast provinces (Shanxi, Gansu, Ningxia, Qinghai, Xinjiang), Hebei, Beijing, Shandong, Shanxi, Henan and Tianjin. The left 8 provinces are type A with the five northwest provinces, Tibet Autonomous Region, Guangxi and Macao. In Figure 1-C, the third blood group proportion includes type A and type B,
| Province                  | Phenotypic frequency (n,%) | Gene frequency | T Distribution characteristics | Cluster |
|--------------------------|---------------------------|----------------|-------------------------------|---------|
|                          | A      | B      | O      | AB                 | p     | q     | r     |       |
| **Total**                | 414019735 | 406034740 | 492986063 | 128456841 | 0.211 | 0.208 | 0.583 | 1.81  | O > A > B > AB | i   |
| Anhui                    | 18349036 | 17496615 | 19083809 | 69471110 | 0.226 | 0.218 | 0.558 | 1.79  | O > A > B > AB | i   |
| Beijing                  | 5998715  | 6940169  | 6271177  | 2233094 | 0.211 | 0.238 | 0.553 | 1.75  | B > O>A-AB   | i   |
| Gansu                    | 6999172  | 7656235  | 8022157  | 2342267 | 0.208 | 0.225 | 0.566 | 1.77  | O > B > A-B   | i   |
| Hebei                    | 18896822 | 25578932 | 22385726 | 7248755 | 0.199 | 0.257 | 0.546 | 1.71  | B > O>A-AB   | i   |
| Henan                    | 28056450 | 30262906 | 30015539 | 11010624 | 0.223 | 0.238 | 0.545 | 1.76  | B > O-A>AB   | i   |
| Heilongjiang             | 8606754  | 10380477 | 9625010  | 3227847 | 0.208 | 0.244 | 0.549 | 1.73  | O > A > B > AB | i   |
| Jilin                    | 6228874  | 7982861  | 7500910  | 2360868 | 0.198 | 0.245 | 0.557 | 1.73  | B > O>A-AB   | i   |
| Jiangsu                  | 2567126  | 24219624 | 26420629 | 8436537 | 0.228 | 0.217 | 0.557 | 1.80  | O > A > B > AB | i   |
| Liaoning                 | 11639498 | 13669455 | 13013411 | 4269043 | 0.209 | 0.239 | 0.552 | 1.74  | B > O>A-AB   | i   |
| Net Mongolia Autonomous Region | 6198011 | 7825430  | 7737646  | 2288068 | 0.196 | 0.236 | 0.566 | 1.74  | B > O>A-AB   | i   |
| Ningxia Hui Autonomous Region | 2025328 | 2186323  | 2262741  | 728262  | 0.215 | 0.230 | 0.557 | 1.78  | O > B-A>AB   | i   |
| Qinghai                  | 1538538  | 1758041  | 2160280  | 467096  | 0.198 | 0.212 | 0.592 | 1.79  | O > B > A > AB | i   |
| Shandong                 | 28037997 | 32931594 | 29845561 | 10712301 | 0.214 | 0.245 | 0.542 | 1.73  | B > O>A-AB   | i   |
| Shanxi                   | 8816628  | 11716087 | 11234227 | 3148674 | 0.189 | 0.242 | 0.568 | 1.77  | B > O>A-AB   | i   |
| Shaanxi                  | 11237045 | 12065226 | 12350589 | 3881543 | 0.215 | 0.228 | 0.558 | 1.77  | B > O>A-AB   | i   |
| Shanghai                 | 7501062  | 6991209  | 7981070  | 2397555 | 0.225 | 0.212 | 0.565 | 1.80  | O > A > B > AB | i   |
| Tianjin                  | 3768781  | 4455149  | 4196628  | 1443452 | 0.211 | 0.243 | 0.549 | 1.74  | B > O > A > B | i   |
| Xinjiang Uygur Autonomous Region | 7700147 | 7687048  | 7863668  | 2601482 | 0.224 | 0.224 | 0.551 | 1.78  | O > A > B > AB | i   |
| Guizhou                  | 11531935 | 9959373  | 13974773 | 3096067 | 0.213 | 0.187 | 0.601 | 1.85  | O > A > B > AB | ii  |
| Hubei                    | 18590264 | 14265611 | 19661038 | 5236544 | 0.235 | 0.187 | 0.581 | 1.86  | O > A > B > AB | ii  |
| Hunan                    | 21970583 | 15105178 | 24035249 | 5333854 | 0.233 | 0.169 | 0.600 | 1.89  | O > A > B > AB | ii  |
| Jiangxi                  | 14124277 | 10821121 | 16794353 | 3448884 | 0.219 | 0.173 | 0.609 | 1.88  | O > A > B > AB | ii  |
| Sichuan                  | 26308093 | 21161795 | 29336959 | 6808019 | 0.223 | 0.184 | 0.592 | 1.85  | O > A > B > AB | ii  |
| Yunnan                   | 14817728 | 12108695 | 16192328 | 4091126 | 0.226 | 0.190 | 0.585 | 1.85  | O > A > B > AB | ii  |
| Zhejiang                 | 19863961 | 16555430 | 22810206 | 5337991 | 0.219 | 0.187 | 0.594 | 1.85  | O > A > B > AB | ii  |
| Chongqing                | 10351303 | 7627276  | 11475504 | 2600077 | 0.228 | 0.175 | 0.597 | 1.88  | O > A > B > AB | ii  |
| Fujian                   | 11787800 | 10057490 | 17050381 | 2644415 | 0.192 | 0.167 | 0.641 | 1.88  | O > A > B > AB | iii |
| Guangdong                | 33794549 | 32013524 | 51513947 | 8690490 | 0.187 | 0.178 | 0.637 | 1.86  | O > A > B > AB | iii |
| Guangxi Zhuang Autonomous Region | 11924226 | 13184362 | 22122711 | 2895505 | 0.161 | 0.176 | 0.664 | 1.85  | O > B > A >-AB | iii |
| Hainan                   | 2526578  | 2475684  | 4448595  | 630375  | 0.173 | 0.170 | 0.661 | 1.88  | O > A > B > AB | iii |
| Taiwan                   | 6264197  | 5573778  | 10324258 | 1399003 | 0.179 | 0.162 | 0.661 | 1.89  | O > A > B > AB | iii |
| Hong Kong Special Administrative Region | 1965715 | 1904426  | 3125710  | 478349  | 0.180 | 0.175 | 0.646 | 1.86  | O > A > B > AB | iii |

(continued on next page)
with type A including most parts of north China and type B embraced the rest regions.

3.1.3. Distribution of the four ABO blood groups in 34 provincial-level administrative regions in China

As can be seen from Figure 2, ABO blood groups in 34 provincial-level administrative regions in China shows an unbalanced distribution. Figure 2-A shows that type A frequency distribution's highest proportion of 33.07% is in Hunan Province, and lowest proportion of 20.62% in Tibet Autonomous Region, with 23.79%-32.29% in other provinces. North by northwest region and South by southwest regions appeared the higher type A expression. Figure 2-B shows that type B frequency distribution's highest proportion of 34.28% in Hebei Province, and lowest proportion of 22.66% in Taiwan Province, with 23.73%-33.64% in other provinces. Northeast by northeast regions and Tibet Autonomous Region appeared the higher type B expression. Figure 2-C shows that the proportion of type O in Guangxi Zhuang Autonomous Region and Hainan Province is the highest at 44.14%, that in Shandong Province is the lowest at 29.40%, and that in other provinces is between 30.00% and 43.86%. The southernmost part of China appeared the highest type O expression Figure 2-D shows that the proportion of AB type is 5.78% in Guangxi, 10.56% in Henan Province, and 6.25%-10.55% in other provinces.

3.1.4. Distribution of ABO blood group proportion in 370 prefecture-level administrative regions in China

In terms of prefecture-level administrative region divisions, the first proportion of blood type among the 370 prefecture-level administrative regions in China involved three types, successively accounted for type O (245,66.21%), type B (106,28.65%) and type A (19,5.14%) (Supplementary Figure S1-A). The second proportion constituted by type A (183,49.46%), type B (106,28.65%) and type A (19,5.14%) (Supplementary Figure S1-B). The third proportion had type B (183,49.46%), type A (169, 45.48%) and type O (18,4.86%) (Supplementary Figure S1-C).

Distribution of the four ABO blood groups in 370 prefecture-level regions in China (Supplementary Figure S2). The ratio of A, B and O is tend to be the same, and AB accounted for about 37%. The proportion of type A in cities along the Yangtze River, such as Hunan and Hubei provinces, is about 32%, and the proportion of type A blood is the lowest in the Tibet Autonomous Region, which is 20% (Supplementary Figure S2-A). The proportion of type B in different China regions also varies greatly, ranging from 20% to 38%. The proportion of type B was relatively high in northern cities in China, such as Shandong, Hebei and Shanxi provinces. The proportion of type B in the Tibet Autonomous Region was relatively high, at about 35%. Hunan and Guangdong accounted for the lowest proportion, while Fujian and Sichuan accounted for about 24% (Supplementary Figure S2-B). The proportion of type O blood varied greatly in different China regions, ranging from 27% to 49%. The proportion of type O blood is as high as 45% in the cities and towns of Guangdong, Guangxi and Taiwan in southern China, while the proportion of type O blood is as low as 27%-30% in northern China (Supplementary Figure S2-C). AB blood type ranged from 5 to 12%, with a higher proportion in northern China and cities in the central plains, and a lower proportion in Guangxi, Fujian and other cities (Supplementary Figure S2-D).

3.2. Difference analysis of ABO blood group distribution in China

3.2.1. Blood group cluster analysis of 34 provincial-level administrative regions in China

According to the gene frequency and cluster analysis of blood type, the blood type distribution of Chinese can be divided into 4 groups, which is basically consistent with the research results of Chen Zhiyong. As shown in Table 2 and Figure 3. There are 18 provincial-level administrative regions distributed in Area i, with a ranking of B > O:A>AB; The ratio of A, B and O is to tend to be the same, and AB accounted for about 10%. There are 8 provincial-level administrative regions distributed in Area ii, with a frequency ranking of O > A > B > AB,, consisting of 34%-37% for type O, 30%-32% for type A, 23%-26% for B, and 8%–9% for type AB. Area iii: In these 7 provinces, the ranking of blood type is O > A > B > AB, consisting of 40%-44% for type O, 23%-28% for type A, 23%-26% for B, and 5%-7% for type AB. The Distribution of blood groups in Tibet Autonomous Region appeared unique by cluster analysis, as Area iv. The ranking of the blood group there is O > B > A>AB, and accounting...
for 38.74% of type O, accounting for 33.64% of type B, accounting for 20.62% of type A, and 7.00% for type AB.

3.2.2. ABO blood group cluster analysis of 370 cities in China

Cluster analysis is conducted on blood group distribution in 370 cities in China, excluding the interference of administrative provinces. Below the cluster features for all four areas are reported (see Supplementary Table S2 and Supplementary Figure S3), including 178 cities in area i, 114 cities in area ii, 73 cities in area iii, and 5 cities in Area iv. In Area i, most cities of Anhui, entire prefecture-level cities (Gansu, Henan Province, Jiangsu, Qinghai, Shaanxi, Xinjiang Uygur Autonomous Region) are in Area i, while others are in Area ii. Shanxi Province is mainly located in Area i, and 1 city is located in Area iii. Ten provinces, including Beijing, Hebei, Heilongjiang, Jilin, Liaoning, Inner Mongolia autonomous Region, Ningxia Hui Autonomous Region, Shandong, Shanghai and Tianjin, are all in Area i. There are 8 cities in Area ii and 1 city in Area iii in Guizhou. In Hubei, 15 cities are located in Area ii, 1 city is located in Area iii, and 1 city is located in Area i. Thirteen cities in Hunan are located in Area ii, and one city is located in Area iii. Ten cities in Jiangxi are in Area ii, and one city is in Area iii. Twenty cities in Sichuan are located in Area ii, and one city is located in Area i. In Yunnan, 12 cities are located in Area ii, 3 in Area iii and 1 in Area i. Ten cities in Zhejiang are located in Area ii, and one city is located in Area i. Chongqing is in Area ii. Area iii: Macao Special Administrative Region, Guangxi Zhuang Autonomous Region, Hainan and Taiwan are all in Area iii. In Fujian, 7 cities are in Area iii, and 2 cities are in Area ii. Fifteen cities in Guangdong are in Area iii, four are in Area ii and two are in Area i. Area iv: Ngari Prefecture, Lhasa, Nagqu, Xigaze and Shannan are all in Area iv.

4. Discussion

The ranking of ABO blood phenotype distribution characteristics of China population are O > A > B > AB. In China’s 1.442 billion population, type O population occupies 492,986,063, accounting for 34.20%, followed by type A is 414,019,735, accounting for 28.72%, and type B population is 406,034,740, accounting for 28.17%, which the proportion of type A and O is close. ABO blood phenotype distribution appeared an equilibrium tendency. Type AB is 128,456,841, accounting for 8.91%. In terms of provincial-level administrative region divisions, the first proportion of blood type in each region formed a clear north-south division with type O in the south and type B in the north. But the division isn’t divided by the traditional north-south line, the north defined by ABO group is much smaller than the geographical division. 10 administrative regions’ dominant blood group is type B consisting of Inner Mongolia,
Heilongjiang, Liaoning, Jilin, Hebei, Beijing, Shandong, Shanxi, Henan and Tianjin, and the other 24 regions' first blood type is type O. The second ABO blood type proportion is varied by different areas. Type A dominated in 16 provinces and type O in 10 provinces including Inner Mongolia, the northeastern provinces (Shanxi, Gansu, Ningxia, Qinghai, Xinjiang), Hebei, Beijing, Shandong, Shanxi, Henan and Tianjin, the left 8 provinces are type A with the five northwest provinces, Tibet Autonomous Region, Guangxi and Macao. The third blood group is type A and type B, with type A including most parts of north China and type B embraced the rest regions. After cluster analysis, ABO blood phenotype distribution characteristics divisioned by 370 prefecture-level administrative regions are basically consistent with the characteristics of provincial-level administrative regions.

China population’s blood phenotype is dominated by type O, but the O gene frequency (r [O]) is obviously lower than other countries [11, 12]. In terms of type O phenotype prevalence, Caucasoid Americans, African Americans, Brazilians and Africans stand at between 45%-67%, while Southern Asian Indians are measured at 37% [13, 14, 15, 16, 17, 18], and 34% among the Chinese. The results of this study are basically consistent with those of Zhao Tengmao [7] and Peng Deren et al. [8] in 1981 and 1992, respectively. Long Youguo's study [19] on China's 56 ethnic groups, to explore the distribution characteristics of the ABO blood group, found that except for a part of the Yunnan minority, ethnic minorities have higher frequencies of type A, while most of the southern minorities have higher frequencies of type O. And in the northern ethnic groups, B type frequency is high, while O type frequency is low. It is also mentioned that the distribution characteristics of ABO blood group in 56 ethnic groups are related to their geographical distribution. Zhe Xuelan [20] conducted a sampling survey on human ABO blood group genetics and found that the overall distribution characteristic of ABO blood groups in both the south and the north of China is O > A > B → AB.

The second proportion group of the ABO phenotypic distribution of China population is type A. While O genes almost always exhibit higher frequencies globally. A and genes frequencies can vary among populations, in particular, A genes almost always exhibit higher frequencies than B genes [21, 22, 23]. In China, it is generally believed that type B occupies the dominant or second position in northern China. In many genetic and ABO blood group studies, it is believed that the frequency of type B is higher in northern China. But it's actually only 10 provinces in north or northeast China have a slightly higher proportion of type B blood than type O blood. According to the Yangtze River as the dividing line between the north and the South, the geographical or genetic north still has the highest proportion of O blood type, followed by A blood type secondly.

Through the further study of 370 cities in China, the ABO distribution characteristics in prefecture-level are generally consistent with those in provincial level and the prefecture-level ABO distribution characteristics express the uniqueness of geography and demography, especially with regard to ethnic minorities, which present unique distribution patterns, including multi-ethnic migration in northwest and southwest China. By clustering prefecture-level phenotype data, we can summarize an interesting correlation, in the areas of southern and eastern Qinghai, Guangxi, Hainan, Taiwan, and Yushu of Tibetan autonomous prefecture, the phenotypes distribution characteristics appear a similar tendency. These results are confirmed by genetic and anthropological studies of Yang Jinjin et al. [24] and Chen Xue et al. [25] Yang Jinjin et al. believed that there is a close relationship between the Li minority in Hainan and indigenous residents of Guangxi Zhuang Autonomous Region, while Chen Xue et al. [25] obtained the evidence of homology in two regional populations by studying the population heritability of mitochondrial DNA in the Zhuang people in Guangxi and the Li minority in Hainan.

China has a vast territory and diverse terrain, and the ABO blood group characteristics in China have a certain correlation with geographical characteristics. In China, ABO blood group can be divided into four areas from north to south according to provincial level clustering. Area i has 18 provincial-level administrative regions with a slightly difference between B and O blood groups, and the proportion of B and A blood groups is generally close to that of O, indicating that ethnic fusion has taken place for longer and blood group genetic distribution is sufficient. In Area ii included 8 provincial-level cities, O type dominates and type A has more obvious advantage over type B. In Area iii included 7 provincial-level regions, the proportion of type O appears absolute advantage than A and B accounting for 40%-44%, and the proportion of type A and type B is 23-28%. The Tibet Autonomous region (Area iv) shows an unique proportion pattern of O, B, A and AB phenotypes increased gradually, accounting for 38.74%, 33.64%, 22.26% and 7%, respectively. The research results are different from Chen Chiyong's findings in 1982 [7] in that Anhui Province changed from Area ii to Area i; Hainan province changed from Area i to Area iii. Compared with Peng Deren’s Chinese blood type results in 1992 [8], the Tibet Autonomous Region data are added and updated the distribution characteristics of blood groups in China.

Under the prefecture-level phenotypes characteristics clustering, almost all cities in Guangdong, Guangxi Zhuang Autonomous Region,
Hainan Province and Taiwan Province show the same phenotypes characteristics with Haidong of Qinghai, Yushu of Tibetan Autonomous Prefecture, Qamdo Autonomous Prefecture in Tibet and Lijiang of Yunnan. In the genetic distribution characteristics of Tibeto-Burman population, blood type heredity shows great similarity with other human genetics. The Tibeto-Burman population is an important ethnic group with a large population in East Asia and Asia has a whole, who mainly live in Qinghai in the north of China in regions such as Tibet, Sichuan, Yunnan and Hunan in the southwest of China, as nomadic people on the Plateau. Their main blood type in Tibet is type O. When classifying ethnic groups, it is found that Tibetan type B is the dominant blood type, but it is still not supported that Tibetan type B is the dominant blood type, and the phenotypic characteristics of type A blood in Tibet are significantly different from those in other regions of China, indicating that most of the fusion is possibly conducted by northern ethnic groups [26].

The phenotypic frequency distribution of ABO blood groups can show significant changes in a short period of time, especially after a relatively stable migration period. The reasons why the frequency of Type B phenotype is slightly higher than that of Type O in some regions of northern China are as follows: First, the degree of integration is more sufficient than other regions, and it has been the main region of population aggregation and ethnic integration for a long time. Second, type B blood was mainly found in the nationalities that fused with north and northwest China. With the development of politics, economy and culture as the main line, type B in north China is the early influx of blood except type O. Southern type A is an early influx except for type O. There are obvious regional differences at the distribution of blood phenotype in China, which is due to the combined effects of natural selection and genetic drift. In this study, the data of various ethnic groups in the literature were combined to reflect the ABO blood group distribution characteristics of the whole Chinese population. In general, there is no further elaboration of the research on ethnic blood type in this paper, but it suggests that we need more studies on blood type distribution among ethnic groups with big data. We will explore this further. The relationship between blood group genetics and human health is very important and many questions need to be further discussed.

Characteristics

1. Based on the corrected data of the entire Chinese population, this study obtained the ABO blood group distribution characteristics of Chinese people as O > A > B > AB, with O type accounting for 34.20%, A type for 28.72%, B type for 28.17%, and AB type for 8.91%.

2. This study’s data are collected from 370 municipal administrative units in China. The ABO blood group data covers all cities of China,
which truly reflects the distribution characteristics of ABO blood group in China.

**Insufficient**

In this study, data from the whole local population are combined to reflect the ABO blood group distribution characteristics of the whole Chinese population, without a separate statistical analysis of ABO blood group characteristics among ethnic groups.

**Declarations**

**Author contribution statement**

Jiangcun Yang, Yang Sun: Conceived and designed the experiments; Wrote the paper.
Yang Sun, Yuan Shen: Analyzed and interpreted the data.
Yuan Shen, Liqin Wang: Performed the experiments.
Jiameng Niu, Ting Ma, Lili Xing, Aowei Song, Wenhua Wang: Contributed reagents, materials, analysis tools or data.

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**Data availability statement**

Data included in article/supp. material/referenced in article.

**Declaration of interests statement**

The authors declare no conflict of interest.

**Additional information**

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**References**

[1] E. Cavalli-Sforza, L. L., Analysis of human evolution under random genetic drift, Cold Spring Harbor Symp. Quant. Biol. 29 (1964) 9–20.
[2] A.M. Bowcock, A. Ruiz-Linares, J. Tomfohrde, E. Minch, J.R. Kidd, L.J.N. Cavalli-Sforza, High resolution of human evolutionary trees with polymorphic microsatellites, Nature 368 (6470) (1994) 455–457.
[3] W. Bodmer, et al., Genetic characterization of human populations: from ABO to a genetic map of the British people, Genetics, 2015.
[4] H.S. Liu, J.H., Iso-Agglutination Tests on One Thousand Chinese Bloods, 1918.
[5] Mourgant, A., Domaniowska-Sobczak K: The Distribution of the Human Blood Groups and Other Polymorphisms 1976.
[6] Shu Song Shang, Yintong Guo, Distribution of ABO blood groups in Different provinces and ethnic groups in China, Tianjin Medical Journal and Hematology Supplement 1 (2) (1963) 57.
[7] Zhiyong Chen, Tongmao Zhao, Gongliang Zhang, The distribution of ABO blood groups in China, Gene (2) (1982) 6–9.
[8] Deren Peng, Distribution of ABO blood groups in Han Chinese, Chinese Journal of Blood Transfusion 4 (1) (1991) 4.
[9] Tongmao Zhao, Human Blood Group Genetics, Science Press, Beijing, 1987.
[10] Tongmao Zhao, A method for estimating ABO gene frequency, Chin. J. Hematol. 1 (2) (1980) 121–124.
[11] T. Tills, P. Trendall, A.E. Mourgant, et al., Blood groups of the Irish, Ann Hum Biol, 1977.
[12] Morgan L.H., Watkin, ABO blood groups, human history and language in Herefordshire with special reference to the low B frequency in Europe, Heredity 20 (1) (1965) 83–9.
[13] M.L. Ridi Mo, C. Lamassfrancis, The Blood Group Antigen FactsBook, The Blood Group Antigen FactsBook, 2012.
[14] A.G. Falusi, O.G. Ademowo, C.A. Latunji, et al., Distribution of ABO and RH genes in Nigeria, Afr. J. Med. Med. Sci. 29 (1) (2000) 23–26.
[15] B.B. Hawkins, M.J.J.H. Simons, Blood Group Genetic Studies in an Urban Chinese Population, Human heredity 26 (6) (1976) 441–453.
[16] L. Yan, F. Zhu, Q. Fu, J.J.I. He, Rh Abo, Duffy Mns, Yt Kidd, Sclanzia, and Colton blood group systems in indigenous Chinese, Immunohematology 21 (1) (2005) 10.
[17] D. Geoff, Human Blood Groups, third ed., 2012.
[18] J.P. Gonzalez, P. Vidal, E. Johnson, M.C. Georges-Courbot, Georges AJJRfdtei-h, Geographic distribution of hematologic elements in Central African countries: distribution of the ABO blood group system, Rev. Fr. Transfus. Immuno-Hematol. 30 (2) (1987) 135.

[19] Youguo Long, Wengiang Huang, Yuesheng Yu, Sifang Long, ABO blood group distribution in 56 ethnic groups in China, Foreign Medicine (Medical Geography) 1(2020) 22–25.

[20] Xuelan Zhu, Shucheng Xu, Li Zhang, Xiu Cuicui, Wanlu Yang, Population genetics of HUMAN ABO blood group, J. Fujian Normal Univ. (Philos. Soc. Sci. Ed.) 28 (3) (2011) 4.

[21] S. Adalsteinsson, Possible changes in the frequency of the human ABO blood groups in Iceland due to smallpox epidemics selection, Ann. Hum. Genet. 49 (4) (1985) 275–281.

[22] R.I.H.J. Glass, C.E. Haley, M.R. Khan, A. Svennerholm, B.J. Stoll, Predisposition for cholera of individuals with O blood group. Possible evolutionary significance, Am. J. Epidemiol. 121 (1985) 791–796.

[23] F.A. Villanea, K.N. Safi, J.W. Busch, A general model of negative frequency dependent selection explains global patterns of human ABO polymorphism, PLoS One 10 (5) (2015), e0125003.

[24] Jinjin Yang, Using Monte Carlo Simulation to Analyze the Evolutionary History of Li People in Hainan and Zhuang People in Guangxi, Yunnan University, 2012.

[25] Chen Xue, Genetic Relationship of Mitochondrial DNA Populations between Zhuang and Li Populations in Guangxi and Hainan, Yunnan University, 2011.

[26] Long Kang, Yang Li, Tianji Deng, Chuncheng Yan, Guijin Wang, Li Gong, L.I. Shengbin, Genetic polymorphism analysis of ABO blood group system in Lhoba nationality, J. Xi'an Jiaot. Univ. (Med. Sci.) 25 (4) (2004) 336–338.