BMJ Open

Effect of High-Altitude on Health-Related Quality of Life: Based on the 2013 and 2018 National Health Services Survey of Tibet, China

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-072854
Article Type:	Original research
Date Submitted by the Author:	17-Feb-2023

Complete List of Authors:	Dou, Lei; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Shi, Zhao; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Cuomu; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Cidan, Zhuoga; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Chaofan; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Dawa; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Shun-Ping; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University)

Keywords:	PUBLIC HEALTH, Quality of Life, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

Title page

Title: Effect of High-Altitude on Health-Related Quality of Life: Based on the 2013 and 2018 National Health Services Survey of Tibet, China

Authors:

Lei Dou[1,2,3], Zhao Shi[1,2,3], Zhaxi Cuomu[4,5], Cidan Zhuoga[4,5], Chaofan Li[1,2,3], Zhaxi Dawa[4,5*], Shunping Li[1,2,3*]

Affiliations:

[1] Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China

[2] NHC Key Lab of Health Economics and Policy Research (Shandong University), Jinan, China

[3] Center for Health Preference Research, Shandong University, Jinan, China

[4] Medical College of Tibet University, Lhasa, China

[5] Center of Tibetan Studies (Everest Research Institute), Tibet University, Lhasa, China

***Corresponding author:**

Shunping Li and Zhaxi Dawa are co- corresponding author.

Shunping Li: lishunping@sdu.edu.cn;

Zhaxi Dawa: 904397981@qq.com

Effect of High-Altitude on Health-Related Quality of Life: Based on the 2013 and 2018 National Health Services Survey of Tibet, China

Abstract

Objective: The Tibet Autonomous Region (TAR), on the Qinghai-Tibet plateau has an average altitude of 4000 m above sea level. It has been undergoing unprecedented economic growth and development, which may greatly affect the resident's health. Therefore, this study aimed to assess the impact of different altitudes on health-related quality of life (HRQoL) and explore changes in the HRQoL of the residents over time.

Design: Two cross-sectional population-based surveys were conducted in 2013 and 2018. A four-stage stratified cluster probability sampling framework was used for sampling.

Setting: China.

Participants: This study recruited 14752 participants in 2013 and 13106 participants in 2018

Primary and secondary outcome measures: The EQ-5D-3L was used to measure participants' HRQoL.

Results: The mean utility scores of the participants were 0.969 ± 0.078 and 0.966 ± 0.077 in 2013 and 2018, respectively. Pain/discomfort was the most frequently prevalent issue reported in 18.09 and 17.91% of the participants in 2013 and 2018, respectively. Tibetans living 3500–4000 m above sea level had the best HRQoL. Age, sex, employment status, educational attainment, chronic disease, and weekly physical activities were influencing factors associated with HRQoL.

Conclusions: The changes in HRQoL in the Tibetan population between 2013 and 2018 were minimal. Moreover, an association was observed between different altitudes and HRQoL in TAR. Based on the findings of this study, HRQoL changes should be characterized more extensively in Tibetans who are older, female, unemployed, and without formal education. Furthermore, targeted strategies need to be developed based on HRQoL and altitude-related influencing factors for residents at different altitudes.

Strengths and limitations of this study

- We used Tibetan resident data from two National Health Service Surveys conducted in 2013 and 2018.
- We divided the residents into three different altitude groups based on the international altitude standard and analysed the changes in health-related quality of life of the Tibetan population.
- This is the first study to assess the relationship between altitude and residents' health-related quality of life.
- The same pool of participants was not characterized in the two surveys; however, some overlap may exist.

Introduction

Majority of the world's population lives close to the sea or at low altitudes above sea level. While, approximately 400 million people live in plateau areas worldwide; most people live in valleys at lower altitudes[1]. The complex terrain and diverse topography of high-altitudes provide a unique climate with rarefied air and low atmospheric pressure, with only two-third oxygen levels as that at sea level[2]. High-altitude areas present a complex ecology in physical environment and population characteristics including genetics, lifestyle, socioeconomic factors, and access to medical care[3], directly or indirectly impact health[4]. Previous studies have reported that high-altitude is strongly associated with the many health issues including psychiatric disorders [5, 6], hypertension[7, 8], and cardiovascular diseases[4].

The Tibet Autonomous Region (TAR), located on the Qinghai-Tibet plateau in southwest China with an average altitude of 4000 m above sea level, is commonly referred to as the "Roof of the World"[8]. The TAR has an area of > 1.2 million km^2, accounting for one-eighth of China's geographic area. In 2021, the population in TAR was 3.65 million with 90% of the population being Tibetan[9]. Its social and economic development levels are relatively low among China's provinces. Most of the TAR population comprises of farmers and herders, scattered in remote rural areas with limited income source mainly depending on agriculture[10]. The geographical environment of the plateau, relatively poor economic conditions, poor transportation and communication, and low access to medical services increased the health risks of residents compared to those in low-altitude areas[11]. China has been undergoing a period of unprecedented rates of economic growth, development, and poverty reduction in recent decades, including the TAR[12]. Various economic, educational, and health policies have been implemented for the development of society, which may have greatly affected the health of residents living in TAR[13].

Health-related quality of life (HRQoL) is considered an important health outcome measure in recent years to inform patient-centred care, clinical decision-making, health policy and reimbursement decisions[14].

HRQoL refers to the impact of health on the quality of life of individuals focusing on individuals' health influencing their goals, expectations, standards, and concerns. It is a multidimensional concept referring to people's capacity to perform daily activities (i.e., functioning) in addition to their perspective and subjective management of their health[15]. Thus, HRQoL attempts to represent quality of life in the context of one's health and illness[16]. The EuroQol5-Dimensions (EQ-5D) is the most widely used preference-based instrument to measure and evaluate HRQoL in population surveys, clinical studies, and economic evaluations[17]. The EQ-5D-3L was included in the 2008 National Health Services Surveys (NHSS) for the first time to assess the population health status in China[18].

Previous studies have assessed the population HRQoL using EQ-5D-3L in mainland China including Heilongjiang [18], Gansu [19], Shanxi [20], and Hunan[21]. However, these studies focused on low-altitude areas. Thus, the health consequences of living at high-altitudes are underexplored. Moreover, all previous studies are cross-sectional, and no studies have compared data between two rounds of surveys. Additionally, previous studies on the health status of Tibetan population are limited due to the geographical environment, lack of basic resources and facilities, and low population density. Therefore, evaluation of HRQoL and its changes in the Tibetan population is important to explore the effects of high-altitude to identify potential altitude-health risks. Therefore, the aim of this study was to assess the HRQoL of Tibetan people and its changes over time, and the impact of different high-altitudes on HRQoL based on the Health Service Survey of Tibet in 2013 and 2018.

Methods

Study design and population

In this study, data were extracted from the 2013 and 2018 NHSS of the TAR in China. A four-stage stratified cluster probability sampling strategy was used to select representative participants. Each stage had a systematic random sampling approach. In the first stage, 22 counties (both in 2013 and 2018) were selected from the seven cities in Tibet in proportion to their population size. In the second stage, 44 and 50 townships/sub-districts were identified in 2013 and 2018, respectively, in the selected counties. Then, three residential villages or communities were randomly selected from each township or sub-district. Finally, 20 households from each residential community or village were randomly selected for participation.

Questionnaires were administered to the participants through face-to-face interviews. The students majoring in Preventive Medicine at Medical College of Tibet University were uniformly recruited and trained to be interviewers by supervisors who had participated in national training. Pre-survey training workshops were offered to all interviewers following a standardised protocol. Eligible interviewers had to demonstrate proper understanding of the purpose of the NHSS and their ability to meet data collection standards developed by the Centre for Health Statistics and Information. The interviewers visited the selected households, and all family members in a sampled household were eligible to participate in the survey. Before the survey commenced, participants were informed of the survey's purposes and procedure and then provided informed consent.

In total, 14752 participants in 2013 and 13106 participants in 2018 completed the survey. The exclusion criteria in this study were as follows: (1) participants aged < 15 years (n = 3412 and 2677 in 2013 and 2018, respectively), based on the eligibility for EQ-5D-3L; (2) participants who did not answer the questions by themselves (n = 1001 and 3798 in 2013 and 2018, respectively); (3) participants with missing values for key variables (n = 4 and 1 in 2013 and 2018, respectively); and (4) participants with ethnicities other than Tibetan (n = 88 and 194 in 2013 and 2018, respectively). Overall, final sample size of 10247 in 2013 and 6436 in 2018 were included in this study.

Measurement of HRQoL

The EQ-5D-3L is one of the most widely used HRQoL measurement instruments classified into five dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD). Each dimension contains three functioning response levels (no problems, moderate problems, and extreme problems), generating 243 (3^5) possible health states, with the best state indicated by the response "11111" and the worst health state indicated by the response "33333"[22]. A single utility index score can be assigned to each health state using a value set, developed in a valuation study based on the general population's health preferences.

Four value sets exist for the EQ-5D-3L in China with the first value set developed in 2014 ($3L_{2014}$ value set) using a sample comprising residents mainly from urban areas[23], the second value set developed in 2018 ($3L_{2018}$ value set) adopted a more representative sample of residents from both rural and urban areas[24], the other two value set developed in 2022 ($3L_{2022}$ value set) recruited participants from rural areas of five cities[25]. In this study, we chose to adopt the $3L_{2018}$ value set, although the $3L_{2014}$ value set has been used more frequently than the $3L_{2018}$ value set. The main reason for the choice was based on the participants in the 3L2014 value set being selected conveniently from big cities in urban areas through quota sampling. While the 3L2018 value set, a more representative sample of respondents was obtained from both rural and urban areas using a random sampling method[26]. The rural population accounts for half of the Chinese population, and large disparities exist in socioeconomic status, lifestyle, and health status between urban and rural areas in China[27]. In the two NHSS in the TAR, more than 75% of participants were from farming and pastoral areas. The theoretical utility index score of the $3L_{2018}$ value set ranges from 0.170–1, with 1 representing full health[24]. To evaluate the robustness and sensitivity of the $3L_{2018}$ value set, we also used the $3L_{2022}$ value set to analyse the main results revealing that the main results of the two value sets had the same trends (Supplementary Table 1).

Independent variables

In this study, the independent variables were altitude-related, sociodemographic, and clinical disease variables, and health-related behaviours. The altitude-related variables included location and altitude. The participants were divided into rural and urban groups based on their geographical location. The NHSS did not collect data on the altitude of their residence; therefore, we used Google Maps to obtain the precise altitude. Altitudes were defined as high (1500–3500 m), very high (3500–5500 m), and extreme altitude (>5500 m), as suggested by the International Society for Mountain Medicine[28]. In this study, based on the China's policy of subsidising plateau areas[29], we divided the plateau areas into three altitude groups, high (< 3500 m), very high (3500–4000 m), and extreme altitude (> 4000 m).

Sociodemographic variables were sex, age, employment status, educational attainment, and marital status. We divided age into three groups: 15–44, 45–65, and ≥ 65 years old. Employment status was divided into employed, retired, and unemployed. Educational attainment was divided into three groups: illiterate, primary school, junior high school, and above. Marital status was divided into single, married, divorced, and other.

The clinical disease variables included diagnosis of the participant with any illness within two weeks before survey and the number of chronic diseases during the past six months. A chronic condition was defined as a condition diagnosed by a doctor with symptoms persisting or relevant medical treatment continuing over the past six months.

Health-related behavioural variables were current smoking status, divided into three groups: smoking all the time, has ever smoked, and never smoked. Participants were asked to perform weekly physical activities during the past six months, and the frequency of physical activities included three groups: exercised never, 1–5 times, and > 6 times.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Statistical analysis

Descriptive statistics were used for participants' characteristics and the reported problems on the five dimensions of the EQ-5D-3L. Continuous variable were described as mean and standard deviation (SD), whereas categorised variable was described as frequency and percentages. Student's *t* test or analysis of variance (ANOVA) was used when variables conformed to an approximately normal distribution; otherwise, the Mann-Whitney *U* test or Kruskal-Wallis H test was used. Categorical variables were compared between the groups using the chi-square test. As the EQ-5D-3L utility index was left-skewed with a large proportion of respondents in full health, a Tobit regression model was used to assess the association between influencing factors and the EQ-5D-3L health utility index. Data were entered into Epidata3.1 and analysed using SPSS 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Participant characteristics

The baseline characteristics of the participants are listed in Table 1. In 2013, more than half of the participants were in the 16–44 years age group (56.15%), and older participants accounted for < 15% of the participants (11.03%) and less than half of the participants were male (46.51%). Moreover, 57% of participants had never received education and 14.98% of the participants were unemployed. More than four out of five participants resided in rural areas (84.89%) with an average altitude of 3838 ± 526 m. Overall, 11.35% of participants reported having a disease during 2 weeks before data collection, while, more than half of participants (65.64%) had no chronic diseases during the past 6 months.

In 2018, the sociodemographic characteristics of the participants were basically the same as those in 2013. The average age was 45.22 ± 14.71 years, and more than half of the participants were female (56.62%). Of the participants, 52.02% never had education, 81.23% were employed, 78.26% were married, and 77.50% lived in rural areas with an average altitude of 3903 ± 495 m. Most of the participants (85.05%) were non-smokers, and 62.99% had never engaged in weekly physical activities during the past 6 months. Characteristics of the participants in different altitudes were shown in supplementary Table 2.

Health problems reported

In two rounds of surveys, pain/discomfort was the most frequently reported problem in 18.09% of the participants in 2013 and 17.91% of the participants in 2018. Problems with self-care were least prevalent, reported in 7.75 and 8.47% of the participants in 2013 and 2018, respectively. As compared to the reported health problems in 2013, reported problems increased in mobility (by 1.26%), self-care (by 0.72%), usual activities (by 0.72%), and anxiety/depression (by 3.78%) in 2018. While, reported problems in pain/discomfort decreased by 0.18% (Table 2).

Figure 1 summarises the percentage of participants with self-reported problems on the EQ-5D-5L based on altitude groups. Among the three altitude groups, the 3500–4000 m group had the least reported problems in all five dimensions. However, the < 3500 m and the > 4000 m groups were more likely to report problems in mobility, self-care, and usual activities. Meanwhile, as compared to other altitude groups, participants living below 3500 m reported the most problems in the pain/discomfort and anxiety/depression dimensions.

EQ-5D-3L health utility scores based on participant's characteristics

Figure 2 presents the utility scores of the EQ-5D-3L and their distribution among the participants. It revealed a left-skewed distribution with skewness of -4.189 in 2013 and -4.642 in 2018, ranging from 0.170 to 1.000. The states of 11111 (no problems in any dimension) were reported in 74.05% and 70.09% of the participants in 2013 and 2018, respectively. The EQ-5D-3L utility scores stratified by characteristics in different years and altitudes are listed in Table 3. The mean utility score of the participants was 0.966 ± 0.077 in 2018, slightly lower than that in 2013 (0.969 ± 0.078). The mean utility scores of the participants at < 3500, 3500–4000 and >4000 m altitudes were 0.965 ± 0.078, 0.973 ± 0.073, and 0.963 ± 0.083, respectively. Furthermore, several variables had statistically significant differences at different levels.

Factors associated with HRQoL in different altitudes

The results of the multivariate analyses of the factors associated with HRQoL at different altitudes are presented in Table 4. In all altitude groups, the EQ-5D-3L utility scores of females were lower than those of males ($p < 0.001$) and decreased with age. Participants with junior high school education and above had significantly higher utility scores than the participants without junior high school education. Moreover, unemployed participants had lower scores than employed participants. Additionally, participants without any diseases during the past two weeks and chronic diseases during the past six months had higher scores than those with diseases. Furthermore, weekly physical activities > six times had a positive effect on HRQoL. Moreover, retired Tibetans had lower utility scores than employed Tibetans (p =0.019) in the < 3500 m group. Tibetans who were married, lived in urban areas, and performed weekly physical activities between 1–5 times had higher utility scores in 3500–4000 m group. In the > 4000 m group, ex-smokers had lower utility scores than smokers ($p < 0.001$).

Discussion

To the best of our knowledge, this is the first study to evaluate the impact of different high-altitudes on HRQoL of Tibetan people and its changes over time, based on a representative sample from the NHSS of Tibet in China. HRQoL changes over time in the Tibetan population in five years (2013–2018) are minimal, and health utility scores in 2018 were slightly lower than those in 2013. Moreover, we explored the effect of different altitudes on HRQoL, and Tibetans living at 3500–4000 m had the best HRQoL. Our study also identified factors influencing HRQoL including females, elders, unemployed, and more chronic diseases with a negative impact. While, higher education levels, no disease during the past two weeks, and frequent weekly physical activities had a positive impact on HRQoL of the Tibetan population. Moreover, the focus should be on retired residents at < 3500 m, unmarried and rural residents living in at 3500–4000 m, and ex-smokers living at > 4000 m.

The average health utility score of the population was 0.969 (SD ± 0.078) in 2013 and 0.966 (SD ± 0.077) in 2018, higher than that reported in Heilongjiang, Hunan, and Shanxi in China[18, 19, 21]. This may be due to the use of two different 3 L value sets used to calculate the utility index score. Compared to the $3L_{2018}$ algorithm, the $3L_{2014}$ algorithm includes a constant term and N3, resulting in a utility value gap between full health and the second-best health state, reducing the values of other health states[30]. Therefore, the $3L_{2018}$ index score was systematically higher than the $3L_{2014}$ index score at absolute levels[26]. The result also indicated that health utility scores of two rounds of surveys were significantly lower than the that of the general Chinese population, confirming regional and residential disparities in HRQoL of the Chinese populations[31]. The eastern–middle–western disparities in development have existed historically. Although in recent years China's development strategy has focused more on western areas including implementing poverty alleviation policies, promoting the construction of infrastructure, low taxation, and national level fiscal transfer to the middle and western areas, a huge gap still exists between regions[27] with lower HRQoL in residents of western regions than that of those in the eastern region.

Based on the HRQoL changes between the two rounds of surveys, health utility scores in 2018 were slightly lower than those in 2013, and statistical differences existed in the total population and at different demographic characteristics levels. However, the changes between 2013 and 2018 were minimal and failed to reach the threshold minimal clinically important difference (MCID) of ~0.074 based on EQ-5D-3L[32]. This is consistent with a previous study on the changes in HRQoL in the Chinese population between 2008 and 2013, and the combination of changing health problems resulted in a small decline in health utility score[34]. This could be due to proportion of extreme problems reported by EQ-5D-3L, with 0.42 to 0.45% reporting extreme problems in anxiety/depression and pain/discomfort compared to 2013. According to the $3L_{2014}$ algorithm, the value in level-3 (L3) parameters is larger than level-2 (L2) or level-1 (L1) with increasing health state severity. Hence, for a health transition involving both improvement and deterioration, the magnitude of health gain from improvement in a certain dimension may be offset to a large extent by deterioration in another dimension[26]. Another possible reason may be related to the changing demographic and socioeconomic status in China. Between 2013 and 2018, the government implemented a series of policies, especially the targeting poverty alleviation strategy, driving continuous rapid growth of residents' income and further improving the consumption level and length of life. Life expectancy increased from 76.3–77.0 years during this time[35]. However, the aging of the population, unhealthy lifestyles, and environmental exposure have led to the rising prevalence of chronic diseases and functional limitations, related to lower HRQoL among the Tibetan population.

Pain/discomfort was the most frequently reported problem in this study similar to previous studies in China, however, the absolute proportion of each dimension reported was higher than the general population trends based on the NHSS data[31] and other provincial studies in China[18, 20, 21]. This may be due to the plateau disease[33]. Residents living on the plateau for a long time evolve a unique physiological mechanism to adapt to the environment. However, some residents gradually lose their adaptability and suffer from various acute or chronic diseases related to the plateau environment under the stimulation of continuous hypoxia and low pressure[34]. The two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in 2018, and hypertension has been reported as the most common chronic disease[35]. A previous study reported that the prevalence of hypertension in Tibet is higher than the Chinese national level and is the highest among all provinces, as well as higher than other residents living at high altitudes[36, 37]. Other studies higher prevalence of oxygen-related cardiovascular diseases, chronic respiratory diseases, digestive diseases, and respiratory infections (e.g., high-altitude pulmonary oedema) with high-altitude[38]. Moreover, Tibetans living at > 5500 m altitudes with long-term residence and heavy exertion, may be at increased risk of developing chronic mountain sickness[39]. As altitude increases, progressive reductions in barometric pressure, air temperature, and air humidity are observed. Headache, shortness of breath, chest tightness, anorexia, dizziness, limb fatigue, and sleep disturbances were common symptoms of Tibetan.[35]

Those living in low-altitude areas (< 3500 m) reported the most problems in anxiety/depression consistent with previous studies. A large sample survey of the prevalence of depression among Tibetans of the Qinghai-Tibet Plateau was 28.6%, higher than that in the general Chinese population and higher than that reported in a western study with high-altitude samples[40]. The prevalence of depression is significantly correlated with climatic pressure, particularly altitude[41]. Generally, the combined effects of harsh natural environment on the plateau, high-altitude hypoxia, low atmospheric pressure, intense ultraviolet radiation, relatively weak community support caused by low population density, and lack of access to mental health resources increases the severity of depression among those living in high-altitude areas[42-44]. In this study, the area with an altitude of < 3500 m was located southeast of the TAR. Nyingchi City, with an average altitude of 3100 m, has the lowest altitude and wettest climate in TAR. With convenient transportation and multiple splendid sceneries, tourism is the main source of income in this area, attracting millions of people traveling for sightseeing, mountaineering, and trekking every year[38]. Previous studies have reported a significant association between tourism impact and residents' quality of life[45, 46]. Tourism provides employment opportunities and tax revenues, supports economic diversity, and services and products enjoyed by residents[47, 48]. However, negative impacts of tourisms on residents' QOL have been reported including crowding, traffic and parking issues, criminality, and cost of living, changes in hosts' way of life, and friction between tourists and residents[49]. The perceived negative impacts, negative emotions, pressure, and relative deprivation of the residents will affect their subjective well-being, leading to psychological problems including anxiety and depression. Therefore, the impact of tourism development on residents' subjective well-being and happiness, should be considered.

In this study, we report that Tibetans living at 3500–4000 m had the best HRQoL. Moreover, participants who were married, lived in urban areas, and engaged in physical activities 1–5 times/week had better HRQoL compared with other high-altitudes. This could be attributed to Tibet's topography, population distribution, and socioeconomic status. The TAR is a vast territory with a sparse population with high-altitude in the northwest and low in the southeast. The region can be divided into three regions based on altitude. The Qiangtang Plateau in the north (> 5000 m), and the central basin region and Himalayan mountains (4000–5000 m on average). The valleys of the middle and lower reaches of the Yarlung Zangbo River and the three rivers in eastern Tibet have an altitude of 3000–4000 m, and 60% of the population is concentrated there. Of the seven cities surveyed, Lhasa, Shannan, Qamdo, and Shigaze have an average altitude of 3500–4000 m with their GDP ranking among the top four in Tibet according to the Seventh National Census in 2020. Similar results have been reported previously with socioeconomic status significantly associated with higher HRQoL[50]. Socioeconomic status is detrimental to health as it affects people's living and working conditions and restricts accessibility to medical care[51]. Moreover, socioeconomic status affects people's psychological state and cognition of the world around them[52]. During the few last decades, China has implemented strong policies to facilitate economic development in the Qinghai-Tibet plateau (e.g., the Strategy of the Development of China's West). The implementation of supportive strategies should help improve socioeconomic status in the future, including improving public infrastructure, medical service capacity, and disease prevention improving HRQoL.

This study had several limitations. First, this study did not recruit the same pool of participants in two rounds of surveys, making it difficult to identify causal associations. However, the same cities were selected, and the participants may partly overlap. Second, many studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys because of its small cognitive burden. Moreover, the comparison of the two rounds of surveys indicated the overall changing trends of HRQoL derived from EQ-5D-3L.

Conclusion

This study had several limitations. First, this study did not recruit the same pool of participants in two rounds of surveys, making it difficult to identify causal associations. However, the same cities were selected, and the participants may partly overlap. Second, many studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys because of its small cognitive burden. Moreover, the comparison of the two rounds of surveys indicated the overall changing trends of HRQoL derived from EQ-5D-3L.

Acknowledgements

We gratefully acknowledge the contribution of the investigators from Preventive Medicine at Medical College of Tibet University, and we also thank all the participants who participated in the study.

Funding statement

This work was supported by the Sixth National Health Service Survey Project in Tibet (grant number 18080027); and China Medical Board (grant number 11-086).

Competing interest statement

All authors declare no competing interests.

Author Contributions

SPL and ZXDW have substantial contributions to conception and design, acquisition of funding, data and interpretation of data. CDZG and ZXCM were involved in the acquisition of data. LD, ZS and CFL were responsible for the data analysis and interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM and CFL revised it critically for important intellectual content, LD and SPL was responsible for the decision to submit the manuscript, and all authors contributed to final approval of the manuscript.

Ethics statements

Patient consent for publication

Not applicable.

Ethics approval

This study involves human participants and was approved. This study was conducted with the approval of the National Health Commission of the People's Republic of China and the Health Commission of Tibet autonomous region.

Data availability statement

Data are available upon reasonable request. We have included all the data produced in the present work in the manuscript. Note that the raw data used in the study were obtained from National Health Service Surveys of China. We are unable to attach all the raw data for each participant in this paper due to the ethical restrictions.

References

1. Cohen JE, Small C. Hypsographic demography: the distribution of human population by altitude, Proc Natl Acad Sci U S A 1998;95:14009-14014.
2. Hou R, Mi Y, Xu Q et al. Oral health survey and oral health questionnaire for high school students in Tibet, China, Head & Face Medicine 2014;10:17.
3. Beall, CM. An ecology of high-altitude infancy., AMER J PHYS ANTHROPOL 2006.
4. Mallet RT, Burtscher J, Richalet JP et al. Impact of High Altitude on Cardiovascular Health: Current Perspectives, Vasc Health Risk Manag 2021;17:317-335.
5. Kious BM, Bakian A, Zhao J et al. Altitude and risk of depression and anxiety: findings from the intern health study, Int Rev Psychiatry 2019;31:637-645.
6. Wang F, Liu S, Zhang Q et al. Prevalence of Depression in Older Nursing Home Residents in High and Low Altitude Regions: A Comparative Study, Frontiers in Psychiatry 2021;12:669234.
7. Song C, Chongsuvivatwong V, Wangdui S et al. Coverage and effectiveness of hypertension screening in different altitudes of Tibet autonomous region, BMC PUBLIC HEALTH 2021;21:33.
8. Mingji C, Onakpoya IJ, Perera R et al. Relationship between altitude and the prevalence of hypertension in Tibet: a systematic review, HEART 2015;101:1054-1060.
9. Tibet Autonomous Region Statistics Bureau (2021), 'Communiqué on Main Data of the Seventh National Population Census of Tibet Autonomous Region'.
10. Zheng Z. Research on the village public service system innovation of agricultural and pastoral areas in tibet--from the perspective of integrated anti-poverty development, Ethnology Journal 2012:34-43.

11. JieAnNaMu, Xu X, You H et al. Inequalities in health-related quality of life and the contribution from socioeconomic status: evidence from Tibet, China, BMC PUBLIC HEALTH 2020;20:630.
12. Graham C, Zhou S, Zhang J. Happiness and Health in China: The Paradox of Progress, WORLD DEVELOPMENT 2017: S305750X-S15308056X.
13. Huang L, Wang Z, Wang H et al. Nutrition transition and related health challenges over decades in China, EUROPEAN JOURNAL OF CLINICAL NUTRITION 2021;75:247-252.
14. Calvert M, Blazeby J, Altman DG et al. Reporting of Patient-Reported Outcomes in Randomized Trials, Jama 2013;309:814.
15. Karimi M, Brazier J. Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? PHARMACOECONOMICS 2016; 34:645-649.
16. Ware JE. Health Status and Outcomes Assessment Tools, MEDICAL CARE 1992;30: S205-S209.
17. Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: Past, Present and Future, Appl Health Econ Health Policy 2017;15:127-137.
18. Huang W, Yu H, Liu C et al. Assessing Health-Related Quality of Life of Chinese Adults in Heilongjiang Using EQ-5D-3L, Int J Environ Res Public Health 2017;14.
19. Si L, Shi L, Chen M et al. Establishing benchmark EQ-5D-3L population health state utilities and identifying their correlates in Gansu Province, China, QUALITY OF LIFE RESEARCH 2017;26:3049-3058.
20. Tan Z, Liang Y, Liu S et al. Health-related quality of life as measured with EQ-5D among populations with and without specific chronic conditions: a population-based survey in Shaanxi Province, China, PLoS One 2013;8: e65958.
21. Deng X, Dong P, Zhang L et al. Health-related quality of life in residents aged 18 years and older with and without disease: findings from the First Provincial Health Services Survey of Hunan, China, BMJ Open 2017;7: e15880.
22. Brooks R. EuroQol: the current state of play, HEALTH POLICY 1996;37:53-72.
23. Liu GG, Wu H, Li M et al. Chinese time trade-off values for EQ-5D health states, VALUE IN HEALTH 2014;17:597-604.
24. Zhuo L, Xu L, Ye J et al. Time Trade-Off Value Set for EQ-5D-3L Based on a Nationally Representative Chinese Population Survey, VALUE IN HEALTH 2018;21:1330-1337.
25. Liu GG, Guan H, Jin X et al. Rural population's preferences matter: a value set for the EQ-5D-3L health states for China's rural population, Health Qual Life Outcomes 2022;20:14.
26. Zhang RY, Wang W, Zhou HJ et al. A head-to-head comparison of the EQ-5D-3L index scores derived from the two EQ-5D-3L value sets for China, Health Qual Life Outcomes 2022;20:80.
27. Sun S, Chen J, Johannesson M et al. Regional differences in health status in China: population health-related quality of life results from the National Health Services Survey 2008, HEALTH & PLACE 2011;17:671-680.
28. Woolcott OO, Ader M, Bergman RN. Glucose homeostasis during short-term and prolonged exposure to high altitudes, ENDOCRINE REVIEWS 2015;36:149-173.
29. The Ministry of Labor and Personnel and the Ministry of Finance (1984), 'The Ministry of Labor and Personnel and the Ministry of Finance responded to the People's Government of Tibet Autonomous Region on issues concerning the implementation of temporary subsidies for workers in plateau areas'.
30. Pan CW, Zhang RY, Luo N et al. How the EQ-5D utilities are derived matters in Chinese diabetes patients: a comparison based on different EQ-5D scoring functions for China, QUALITY OF LIFE RESEARCH 2020;29:3087-3094.
31. Yao Q, Liu C, Zhang Y et al. Population norms for the EQ-5D-3L in China derived from the 2013 National Health Services Survey, Journal of Global Health 2021;11:8001.
32. Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D, QUALITY OF LIFE RESEARCH 2005;14:1523-1532.
33. Netzer N, Strohl K, Faulhaber M et al. Hypoxia-related altitude illnesses, JOURNAL OF TRAVEL MEDICINE 2013;20:247-255.
34. Crawford JE, Amaru R, Song J et al. Natural Selection on Genes Related to Cardiovascular Health in High-Altitude Adapted Andeans, AMERICAN JOURNAL OF HUMAN GENETICS 2017;101:752-767.
35. Deng R, Labasangzhu, Zhaxideji et al. Illness prevalence rate in Tibet, China: data from the 2018 National Health Service

Survey, BMC PUBLIC HEALTH 2020;20:955.

36. Li K, Liang Y, Sun Y et al. The relationship between polymorphisms at 17 gene sites and hypertension among the Aboriginal Tibetan people, BIOMEDICAL AND ENVIRONMENTAL SCIENCES 2012;25:526-532.

37. Wang J, Zhang L, Wang F et al. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey, AMERICAN JOURNAL OF HYPERTENSION 2014;27:1355-1361.

38. Chen Y, Zhang G, Chen Z et al. A warming climate may reduce health risks of hypoxia on the Qinghai-Tibet Plateau, Science Bulletin 2022;67:341-344.

39. Tian-Yi WU. Chronic mountain sickness on the Qinghai-Tibetan plateau, Chinese Medical Journal: English Edition 2005;118:8.

40. Golicki D, Niewada M, Jakubczyk M et al. Self-assessed health status in Poland: EQ-5D findings from the Polish valuation study, Pol Arch Med Wewn 2010;120:276-281.

41. Gamboa JL, Caceda R, Arregui A. Is depression the link between suicide and high altitude? HIGH ALTITUDE MEDICINE & BIOLOGY 2011; 12:403-404, 405.

42. Wang J, Zhou Y, Liang Y et al. A Large Sample Survey of Tibetan People on the Qinghai-Tibet Plateau: Current Situation of Depression and Risk Factors, Int J Environ Res Public Health 2019;17.

43. Ding Y, Shi B, Su G et al. Assessing Suitability of Human Settlements in High-Altitude Area Using a Comprehensive Index Method: A Case Study of Tibet, China, Sustainability 2021;13.

44. Li XY, Wu XY, Fu C et al. Effects of acute mild and moderate hypoxia on human mood state, Space Med Us Eng (Beijing) 2000;13:1-5.

45. Kim, Hyelin, Uysal et al. Life satisfaction and support for tourism development, Annals of tourism research: A social sciences journal 2015;50:84-97.

46. Vargas-Sanchez A, Plaza-Mejia MDLA, Porras-Bueno N. Understanding Residents' Attitudes toward the Development of Industrial Tourism in a Former Mining Community, Journal of Travel Research 2009;47:373-387.

47. Aref F. The Effects of Tourism on Quality of Life: A Case Study of Shiraz, Iran, Life ence Journal 2011;8:26-30.

48. Andereck, Kathleen L, Nyaupane et al. Exploring the Nature of Tourism and Quality of Life Perceptions among Residents., Journal of Travel Research 2011;11:25-34.

49. Andereck KL, Valentine KM, Knopf RC et al. Residents' perceptions of community tourism impacts, ANNALS OF TOURISM RESEARCH 2005;32:1056-1076.

50. Yao Q, Liu C, Zhang Y et al. Changes in health-related quality of life of Chinese populations measured by the EQ-5D-3 L: a comparison of the 2008 and 2013 National Health Services Surveys, Health Qual Life Outcomes 2019;17:43.

51. Jiang Y, Hesser JE. Associations between health-related quality of life and demographics and health risks. Results from Rhode Island's 2002 behavioral risk factor survey, Health Qual Life Outcomes 2006;4:14.

52. Matthews KA, Gallo LC. Psychological perspectives on pathways linking socioeconomic status and physical health, Annual Review of Psychology 2011;62:501-530.

Table 1 Characteristics of the participants

Characteristics	2013		2018	
	N	%	N	%
Age				
15-44 years	5754	56.15	3159	49.08
45-64 years	3363	32.82	2568	39.90
≥65 years	1130	11.03	709	11.02
Gender				
Male	4766	46.51	2792	43.38
Female	5481	53.49	3644	56.62
Educational attainment				
Illiterate	5841	57.00	3348	52.02
Primary school	3080	30.06	2143	33.30
Junior high school and above	1326	12.94	945	14.68
Employment				
Employed	8514	83.09	5228	81.23
Retired	198	1.93	131	2.04
Unemployed	1535	14.98	1077	16.73
Marital status				
Single	1563	15.25	748	11.62
Married	7718	75.32	5037	78.26
Separated/divorced/windowed	966	9.43	651	10.11
Location				
Rural	8699	84.89	4988	77.50
Urban	1548	15.11	1448	22.50
Altitude, m (Mean±SD)	3838±526	-	3903 ± 495	-
Diseased during the past 2 weeks				
Yes	1152	11.35	701	10.89
No	9002	88.65	5735	89.11
Number of chronic diseases				
0	6726	65.64	3684	57.24
1	2634	25.71	1743	27.08
≥2	887	8.66	1009	15.68
Smoking				
Smoker	1424	13.90	724	11.25
Ex-smoker	487	4.75	238	3.70
Non-smoker	8336	81.35	5474	85.05
Weekly physical activities				
Never exercised	9437	92.28	4054	62.99
1–5 times	511	5.00	1247	19.38
≥6 times	279	2.73	1135	17.64

Table 2 Reported health problems of participants

EQ-5D-3L	2013		2018		Total		χ2	*P*-value
	N	%	N	%	N	%		
Mobility							12.794	0.002
No problem	8956	87.40	5544	86.14	14500	86.91		
Moderate problem	1221	11.92	865	13.44	2086	12.50		
Extreme problem	70	0.68	27	0.42	97	0.58		
Self-care							2.791	0.248
No problem	9453	92.25	5891	91.53	15344	91.97		
Moderate problem	733	7.15	502	7.80	1235	7.40		
Extreme problem	61	0.60	43	0.67	104	0.62		
Usual activities							1.407	0.495
No problem	9014	87.97	5624	87.38	14638	87.74		
Moderate problem	1077	10.51	714	11.09	1791	10.74		
Extreme problem	156	1.52	98	1.52	254	1.52		
Pain/discomfort							7.543	0.023
No problem	8393	81.91	5283	82.09	13676	81.98		
Moderate problem	1750	17.08	1059	16.45	2809	16.84		
Extreme problem	104	1.01	94	1.46	198	1.19		
Anxiety/depression							52.078	<0.001
No problem	9111	88.91	5479	85.13	14590	87.45		
Moderate problem	1047	10.22	874	13.58	1921	11.51		
Extreme problem	89	0.87	83	1.29	172	1.03		

Table 3 Health utility score stratified by different years and altitudes

Characteristics	Different Years (SD)			Different altitudes (SD)			
	2013	2018	*P*-value	< 3500m	3500-4000m	>4000m	*P* -value
Age							
15-44 years	0.987(0.049)	0.987(0.041)	0.003	0.985(0.050)	0.98(0.044)	0.985(0.047)	<0.001
45-64 years	0.962(0.078)	0.959(0.076)	0.013	0.954(0.082)	0.968(0.072)	0.954(0.081)	<0.001
≥65 years	0.900(0.133)	0.899(0.139)	0.973	0.900(0.126)	0.915(0.129)	0.878(0.146)	<0.001
Gender							
Male	0.975(0.071)	0.973(0.070)	0.002	0.971(0.072)	0.978(0.071)	0.972(0.070)	<0.001
Female	0.964(0.083)	0.961(0.082)	<0.001	0.959(0.083)	0.970(0.074)	0.955(0.092)	<0.001
Employment							
Employed	0.977(0.064)	0.976(0.058)	<0.001	0.974(0.065)	0.980(0.059)	0.975(0.063)	<0.001
Retired	0.945(0.116)	0.965(0.057)	0.493	0.937(0.118)	0.977(0.051)	0.918(0.131)	<0.001
Unemployed	0.926(0.117)	0.918(0.128)	0.011	0.903(0.118)	0.944(0.113)	0.899(0.131)	<0.001
Educational attainment							
Illiterate	0.959(0.088)	0.956(0.088)	<0.001	0.956(0.087)	0.962(0.086)	0.956(0.090)	<0.001
Primary school	0.979(0.064)	0.971(0.069)	<0.001	0.969(0.074)	0.979(0.062)	0.973(0.068)	<0.001
Junior high school and above	0.990(0.046)	0.991(0.038)	0.180	0.985(0.045)	0.993(0.039)	0.988(0.050)	<0.001
Marital status							
Single	0.975(0.086)	0.979(0.068)	0.182	0.973(0.090)	0.978(0.076)	0.976(0.083)	0.579
Married	0.973(0.069)	0.969(0.069)	<0.001	0.966(0.075)	0.977(0.065)	0.968(0.070)	<0.001
Separated/divorced/windowed	0.928(0.111)	0.925(0.124)	0.832	0.936(0.090)	0.940(0.107)	0.904(0.135)	<0.001
Location							
Rural	0.967(0.080)	0.966(0.077)	0.001	0.966(0.076)	0.970(0.077)	0.963(0.081)	<0.001

Urban	0.980(0.065)	0.967(0.080)	<0.001	0.951(0.094)	0.985(0.053)	0.960(0.092)	<0.001
Altitude								
< 3500m	0.966(0.078)	0.961(0.079)	<0.001	-	-	-	-
3500-4000m	0.975(0.072)	0.970(0.073)	<0.001	-	-	-	-
>4000m	0.963(0.084)	0.963(0.081)	0.411	-	-	-	-
Diseased during the past 2 weeks								
Yes	0.933(0.111)	0.934(0.100)	0.303	0.943(0.094)	0.943(0.101)	0.938(0.102)	0.659
No	0.974(0.072)	0.970(0.073)	<0.001	0.980(0.060)	0.987(0.048)	0.981(0.059)	<0.001
Number of chronic diseases								
0	0.983(0.057)	0.986(0.049)	0.331	0.980(0.060)	0.987(0.048)	0.981(0.059)	<0.001
1	0.950(0.097)	0.951(0.091)	0.663	0.950(0.088)	0.952(0.096)	0.949(0.096)	0.041
≥2	0.920(0.113)	0.919(0.106)	0.223	0.926(0.104)	0.920(0.110)	0.915(0.111)	0.115
Smoking								
Smoker	0.985(0.056)	0.984(0.048)	0.094	0.979(0.071)	0.986(0.050)	0.985(0.046)	0.060
Ex-smoker	0.965(0.073)	0.954(0.089)	0.146	0.972(0.056)	0.970(0.064)	0.953(0.091)	0.004
Non-smoker	0.967(0.081)	0.964(0.080)	<0.001	0.962(0.080)	0.971(0.076)	0.961(0.085)	<0.001
Weekly physical activities								
Never exercised	0.969(0.079)	0.961(0.086)	<0.001	0.965(0.080)	0.971(0.078)	0.962(0.085)	<0.001
1–5 times	0.967(0.071)	0.973(0.066)	0.004	0.956(0.075)	0.980(0.058)	0.964(0.077)	<0.001
≥6 times	0.985(0.044)	0.977(0.051)	<0.001	0.970(0.056)	0.984(0.042)	0.972(0.060)	<0.001
Total	0.969(0.078)	0.966(0.077)	<0.001	0.965(0.078)	0.973(0.073)	0.963(0.083)	<0.001

Table 4 Tobit regression analysis on the EQ-5D-3L HSU scores in different altitudes

Characteristics	Total		<3500m		3500-4000m		>4000m	
	Coe(SE)	*P*-value	Coe(SE)	*P*-value	Coe(SE)	*P*-value	Coe(SE)	*P*-value
Age years (ref.:15-44 years)								
45-64 years	-0.071(0.004)	<0.001	-0.071(0.008)	<0.001	-0.064(0.007)	<0.001	-0.079(0.007)	<0.001
≥65 years	-0.142(0.006)	<0.001	-0.131(0.012)	<0.001	-0.131(0.010)	<0.001	-0.154(0.010)	<0.001
Gender (ref.: male)								
Female	-0.025(0.004)	<0.001	-0.020(0.008)	0.009	-0.022(0.006)	0.001	-0.035(0.006)	<0.001
Educational attainment (ref.: illiterate)								
Primary school	0.016(0.004)	<0.001	0.002(0.008)	0.774	0.021(0.006)	0.001	0.014(0.007)	0.044
Junior high school and above	0.054(0.007)	<0.001	0.043(0.012)	0.001	0.061(0.011)	<0.001	0.049(0.013)	<0.001
Employment (ref.: employed)								
Retired	-0.033(0.012)	0.007	-0.048(0.020)	0.019	-0.013(0.021)	0.549	-0.030(0.027)	0.263
Unemployed	-0.073(0.005)	<0.001	-0.094(0.002)	<0.001	-0.073(0.008)	<0.001	-0.075(0.008)	<0.001
Marital status (ref.: single)								
Married	0.017(0.006)	0.003	0.005(0.013)	0.714	0.021(0.009)	0.018	0.017(0.010)	0.092
Separated/divorced/windowed	-0.008(0.008)	0.311	-0.002(0.016)	0.905	-0.004(0.012)	0.755	-0.019(0.013)	0.142
Location (ref.: rural)								
Urban	0.038(0.005)	<0.001	0.008(0.014)	0.592	0.078(0.008)	<0.001	-0.004(0.008)	0.583
Diseased during the past 2 weeks (ref.: Yes)								
No	0.041(0.005)	<0.001	0.030(0.009)	0.001	0.062(0.009)	<0.001	0.033(0.008)	<0.001
Number of chronic diseases (ref.: 0)								
1	-0.084(0.004)	<0.001	-0.065(0.008)	<0.001	-0.098(0.006)	<0.001	-0.072(0.007)	<0.001
≥2	-0.128(0.005)	<0.001	-0.096(0.010)	<0.001	-0.146(0.009)	<0.001	-0.118(0.008)	<0.001

Smoking (ref.: smoker)								
Ex-smoker	-0.036(0.010)	<0.001	0.013(0.021)	0.536	-0.022(0.007)	0.197	-0.058(0.015)	<0.001
Non-smoker	-0.012(0.006)	0.065	-0.024(0.012)	0.052	-0.009(0.010)	0.375	-0.008(0.011)	0.505
Weekly physical activities (ref.: never exercised)								
1–5 times	0.026(0.006)	<0.001	0.018(0.012)	0.121	0.036(0.009)	<0.001	0.006(0.011)	0.595

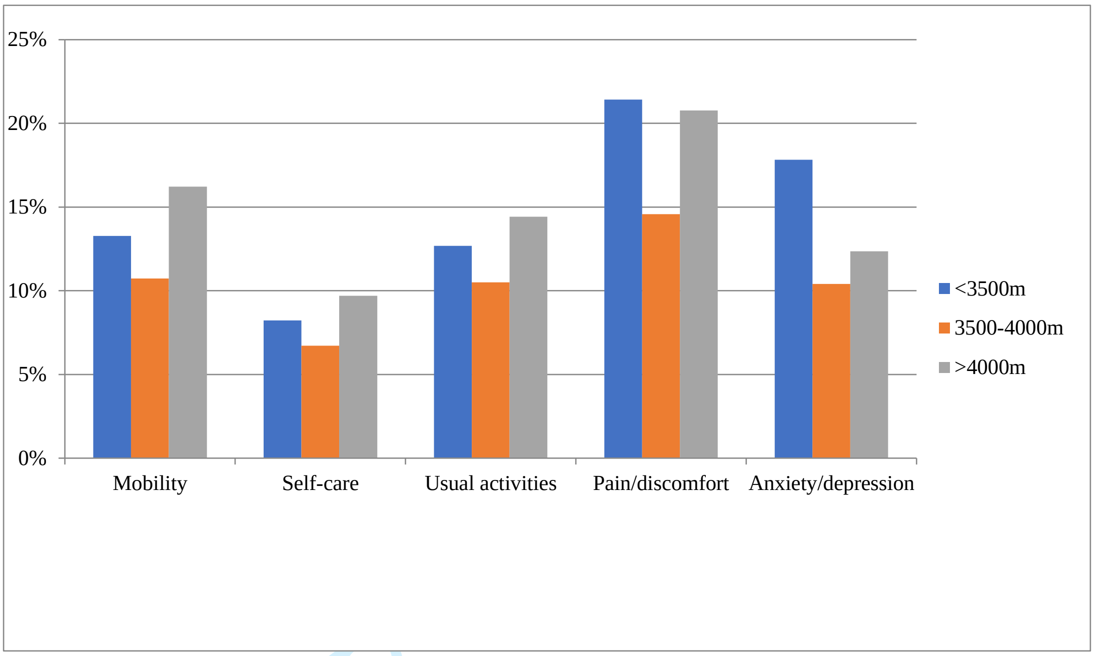

Figure 1 Proportions of problems reported on each EQ-5D-3L dimension by altitude

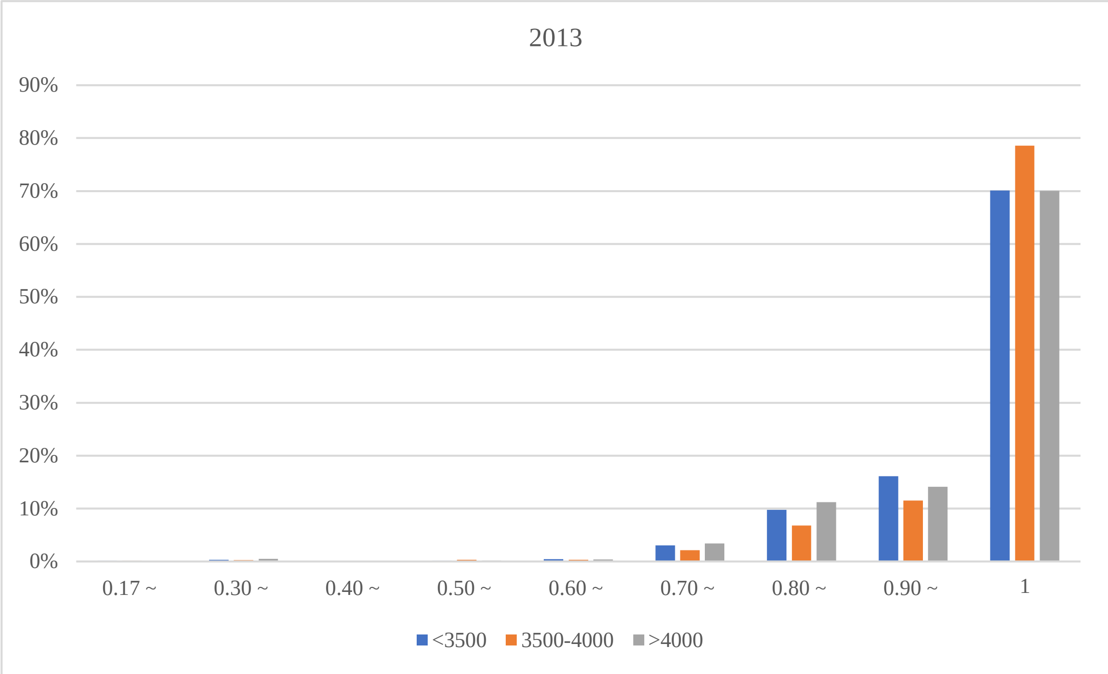

Figure 2a Distribution of health utility scores based on the EQ-5D-3L values set for China in 2013

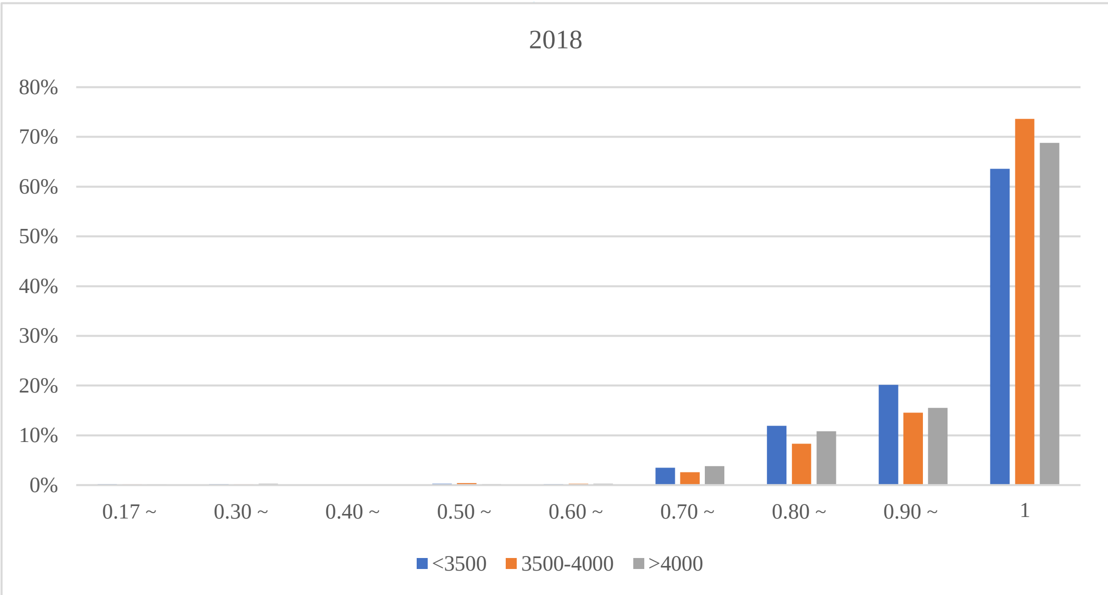

Figure 2b Distribution of health utility scores based on the EQ-5D-3L values set for China in 2018

Supplementary Table 1 Tobit regression analysis on the EQ-5D-3L HSU scores in different altitudes using 3L2022 value set

Characteristics	Total			<3500m			3500-4000m			>4000m		
	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value
Age years (ref.:15-44 years)												
45-64 years	-0.032	0.002	<0.001	-0.040	0.005	<0.001	-0.027	0.003	<0.001	-0.039	0.004	<0.001
≥65 years	-0.113	0.004	<0.001	-0.111	0.009	<0.001	-0.096	0.005	<0.001	-0.136	0.007	<0.001
Gender (ref.: male)												
Female	-0.011	0.002	<0.001	-0.012	0.005	0.017	-0.006	0.003	0.071	-0.021	0.004	<0.001
Educational attainment (ref.: illiterate)												
Primary school	0.011	0.002	<0.001	0.002	0.005	0.687	0.012	0.003	<0.001	0.007	0.004	0.115
Junior high school and above	0.014	0.003	<0.001	0.022	0.007	0.003	0.010	0.004	0.025	0.012	0.007	0.083
Employment (ref.: employed)												
Retired	-0.008	0.007	0.301	-0.025	0.015	0.086	0.011	0.010	0.282	-0.030	0.020	0.133
Unemployed	-0.060	0.003	<0.001	-0.094	0.008	<0.001	-0.049	0.004	<0.001	-0.072	0.005	<0.001
Marital status (ref.: single)												
Married	0.017	0.003	<0.001	0.017	0.008	0.027	0.018	0.004	<0.001	0.016	0.006	0.005
Separated/divorced/windowed	-0.004	0.004	0.342	0.011	0.011	0.327	0.001	0.006	0.931	-0.020	0.008	0.016
Location (ref.: rural)												
Urban	0.020	0.003	<0.001	0.004	0.010	0.651	0.029	0.004	<0.001	-0.003	0.005	0.475
Diseased during the past 2 weeks (ref.: Yes)												
No	0.036	0.003	<0.001	0.028	0.007	<0.001	0.048	0.005	<0.001	0.027	0.005	<0.001
Number of chronic diseases (ref.: 0)												
1	-0.039	0.002	<0.001	-0.030	0.006	<0.001	-0.045	0.003	<0.001	-0.030	0.004	<0.001
≥2	-0.083	0.003	<0.001	-0.063	0.008	<0.001	-0.093	0.005	<0.001	-0.072	0.006	<0.001
Smoking (ref.: smoker)												

Ex-smoker	-0.012	0.005	0.029	0.015	0.014	0.274	0.001	0.008	0.935	-0.028	0.009	0.002
Non-smoker	-0.003	0.003	0.314	-0.009	0.007	0.214	-0.002	0.004	0.669	-0.002	0.006	0.800
Weekly physical activities (ref.: never exercised)												
1–5 times	0.019	0.003	<0.001	0.009	0.008	0.241	0.024	0.004	<0.001	0.003	0.006	0.664
≥6 times	0.028	0.004	<0.001	0.026	0.009	0.007	0.026	0.005	<0.001	0.022	0.007	0.002

Note: Coe, coefficient; SE, standard error.

Supplementary Table 2 Characteristics of the participants in different altitudes

Characteristics	2013									2018								
	Total		<3500m		3500-4000m		>4000m		*P*-value	Total		<3500m		3500-4000m		>4000m		*P*-value
	N	%	N	%	N	%	N	%		N	%	N	%	N	%	N	%	
Age																		
15-44 years	5754	56.15	1249	56.29	2674	55.50	1831	57.00	0.150	3159	49.08	527	46.93	1361	46.40	1271	53.40	<0.001
45-64 years	3363	32.82	740	33.30	1619	33.60	1004	31.30		2568	39.90	469	41.76	1240	42.30	859	36.10	
≥65 years	1130	11.03	230	10.37	523	10.90	377	11.74		709	11.02	127	11.31	332	11.32	250	10.50	
Gender									0.571									0.068
Male	4766	46.51	1047	47.18	2214	45.97	1505	46.86		2792	43.38	513	45.70	1230	41.90	1049	44.10	
Female	5481	53.49	1172	52.82	2602	54.03	1707	53.14		3644	56.62	610	54.30	1703	58.10	1331	55.92	
Educational attainment									<0.001									<0.001
Illiterate	5841	57.00	1217	54.84	2392	49.70	2232	69.49		3348	52.02	550	48.98	1238	42.20	1560	65.50	
Primary school	3080	30.06	674	30.40	1663	34.50	743	23.13		2143	33.30	421	37.50	1164	39.70	558	23.45	
Junior high school and above	1326	12.94	328	14.80	761	15.80	237	7.40		945	14.68	152	13.50	531	18.10	262	11.00	
Employment									<0.001									<0.001
Employed	8514	83.09	1911	86.12	3975	82.54	2628	81.80		5228	81.23	932	83.00	2240	76.40	2056	86.39	
Retired	198	1.93	89	4.01	83	1.72	26	0.81		131	2.04	39	3.47	71	2.40	21	0.88	
Unemployed	1535	14.98	219	9.87	758	15.74	558	17.37		1077	16.73	152	13.54	622	21.21	303	12.70	
Marital status									<0.001									<0.001
Single	1563	15.25	291	13.10	810	16.82	462	14.38		748	11.62	101	8.99	366	12.50	281	11.80	
Married	7718	75.32	1754	79.00	3553	73.80	2411	75.06		5037	78.26	929	82.70	2240	76.40	1868	78.50	
Separated/divorced/windowed	966	9.43	174	7.84	453	9.41	339	10.60		651	10.11	93	8.30	327	11.15	231	9.70	
Location									<0.001									<0.001
Rural	8699	84.89	1988	89.59	3733	77.51	2978	92.71		4988	77.50	1036	92.30	2250	76.70	1702	71.50	

Urban	1548	15.11	231	10.41	1083	22.49	234	7.29		1448	22.50	87	7.75	683	23.30	678	28.50	
Diseased during the past 2 weeks									<0.001									0.659
Yes	1152	11.35	380	17.19	321	6.78	451	14.07		701	10.89	121	10.77	310	10.57	270	11.30	
No	9002	88.65	1830	82.81	4417	93.22	2755	85.90		5735	89.11	1002	89.20	2623	89.40	2110	88.70	
Number of chronic diseases									<0.001									<0.001
0	6726	65.64	1334	60.12	3415	70.91	1977	61.60		3684	57.24	614	54.70	1834	62.50	1236	51.90	
1	2634	25.71	631	28.40	1100	22.80	903	28.10		1743	27.08	319	28.40	712	24.30	712	29.92	
≥2	887	8.66	254	11.40	301	6.30	332	10.30		1009	15.68	190	16.90	387	13.20	432	18.20	
Smoking									<0.001									<0.001
Smoker	1424	13.90	298	13.43	786	16.30	340	10.60		724	11.25	142	12.60	361	12.30	221	9.30	
Ex-smoker	487	4.75	84	3.80	163	3.40	240	7.50		238	3.70	36	3.20	74	2.50	128	5.40	
Non-smoker	8336	81.35	1837	82.80	3867	80.29	2632	81.90		5474	85.05	945	84.10	2498	85.20	2031	85.30	
Weekly physical activities									<0.001									<0.001
Never exercised	9437	92.28	2046	92.29	4302	89.64	3089	96.20		4054	62.99	755	67.20	1648	56.19	1651	69.37	
1–5 times	511	5.00	127	5.73	303	6.31	81	2.50		1247	19.38	185	16.50	687	23.40	375	15.80	
≥6 times	279	2.73	44	2.00	194	4.04	41	1.30		1135	17.64	183	16.30	598	20.40	354	14.87	

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study’s design with a commonly used term in the title or the abstract	P1,2
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	P3-4
Objectives	#3	State specific objectives, including any prespecified hypotheses	P4
Methods			
Study design	#4	Present key elements of study design early in the paper	P4-5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	p4

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	p5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p5
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	p5
Bias	#9	Describe any efforts to address potential sources of bias	P5
Study size	#10	Explain how the study size was arrived at	P5
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	P6-7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	P7-8
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	P7-8
Statistical methods	#12c	Explain how missing data were addressed	P8
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	P8
Statistical methods	#12e	Describe any sensitivity analyses	P8
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	P8
Participants	#13b	Give reasons for non-participation at each stage	P8
Participants	#13c	Consider use of a flow diagram	P8

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	P8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	P8
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	P8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	p8-10
Discussion			
Key results	#18	Summarise key results with reference to study objectives	P10
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	P14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	P14-15
Generalisability	#21	Discuss the generalisability (external validity) of the study results	P14-15
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P15

This checklist was completed on 14. February 2023 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-072854.R1
Article Type:	Original research
Date Submitted by the Author:	11-Jul-2023
Complete List of Authors:	Dou, Lei; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Shi, Zhao; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Cuomu; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Cidan, Zhuoga; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Chaofan; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Dawa; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Shun-Ping; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University)
Primary Subject Heading:	Global health
Secondary Subject Heading:	Public health, Health policy, Global health
Keywords:	PUBLIC HEALTH, Quality of Life, China

Title page

Title: Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Authors:

Lei Dou[1,2,3], Zhao Shi[1,2,3], Zhaxi Cuomu[4,5], Cidan Zhuoga[4,5], Chaofan Li[1,2,3], Zhaxi Dawa[4,5*], Shunping Li[1,2,3*]

Affiliations:

[1] Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China

[2] NHC Key Lab of Health Economics and Policy Research (Shandong University), Jinan, China

[3] Center for Health Preference Research, Shandong University, Jinan, China

[4] Medical College of Tibet University, Lhasa, China

[5] Center of Tibetan Studies (Everest Research Institute), Tibet University, Lhasa, China

***Corresponding author:**

Shunping Li and Zhaxi Dawa are co- corresponding author.

Shunping Li: lishunping@sdu.edu.cn;

Zhaxi Dawa: 904397981@qq.com

Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Abstract

Objective: Health-related quality of life (HRQoL) was an important health outcome measure for evaluating individual's overall health status. However, there was limited in the literature on HRQoL and its long-term changes of Tibetan population. This study aimed to assess HRQoL of Tibetan and its changes over time, and explore the differences in HRQoL for residents at different altitudes.

Design: Data for the cross-sectional study were extracted from the fifth and sixth waves of the National Health Services Surveys (NHSS) which conducted in 2013 and 2018. A multi-stage stratified cluster random sampling strategy was used to select representative participants.

Setting: Tibet Autonomous Region in China.

Participants: This study recruited 14752 participants in 2013 and 13106 participants in 2018, and after excluding observations with missing values for key variables, 10247 in 2013 and 6436 in 2018 were included in the study analysis.

Primary and secondary outcome measures: The EQ-5D-3L was used to measure participants' HRQoL.

Results: The mean health state utility (HSU) scores of the participants were 0.969 ± 0.078 and 0.966 ± 0.077 in 2013 and 2018, respectively. Pain/discomfort was the most frequently prevalent issue reported in 18.1% and 17.9% of the participants in 2013 and 2018, respectively. Tibetans living 3500–4000 m altitude had the best HRQoL. Age, sex, employment status, educational attainment, chronic disease, and weekly physical exercise were influencing factors associated with HRQoL.

Conclusions: The HRQoL of Tibetan population was lower than general Chinese population, and decreased over time between 5 years. There were differences in HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m having the best quality of life. More attention should be paid to those Tibetans who are older, female, unemployed and without formal education.

Strengths and limitations of this study

- We used Tibetan resident data from two National Health Service Surveys conducted in 2013 and 2018.
- This is the first study to assess the health-related quality of life and its changes of Tibetan over time.
- We divided the residents into three different altitude groups based on the international altitude standard and analysed the differences in HRQoL for residents at different altitudes.

- The same pool of participants was not characterized in the two surveys; however, some overlap may exist.

Introduction

Health-related quality of life (HRQoL) is considered an important health outcome measure in recent years to inform patient-centred care, clinical decision-making, health policy and reimbursement decisions[1]. HRQoL refers to the impact of health on the quality of life of individuals focusing on individuals' health influencing their goals, expectations, standards, and concerns. It is a multidimensional concept referring to people's physical, mental, and social domains of well-being, as well as personal beliefs, level of independence, and their relationships with the environment[2]. The HRQoL of the residents in a region could be measured through the health surveys for the resident population[3]. The HRQoL can be evaluated by generic preference-based measures (GPBMs), which provide a standardized health state classification system and a tariff of quality weights for all health states described by the classification system[4]. The EuroQol5-Dimensions (EQ-5D) is the most widely used GPBMs to measure and evaluate HRQoL in population surveys, clinical studies, and economic evaluations[5]. The EQ-5D-3L was included in the 2008 National Health Services Surveys (NHSS) for the first time to assess the population health status in China.

The Tibet Autonomous Region (TAR), located on the Qinghai-Tibet plateau in southwest China with an average altitude of 4000 m above sea level, is commonly referred to as the "Roof of the World"[6]. The TAR has an area of > 1.2 million km^2, accounting for one-eighth of China's geographic area. In 2021, the population in TAR was 3.65 million with 90% of the population being Tibetan[7]. Its social and economic development levels are relatively low among China's provinces. Most of the TAR population comprises of farmers and herders, scattered in remote rural areas with limited income source mainly depending on agriculture[8]. The geographical environment of the plateau, relatively poor economic conditions, poor transportation and communication, and low access to medical services increased the health risks of residents compared to those in low-altitude areas[9]. China has been undergoing a period of unprecedented rates of economic growth, development, and poverty reduction in recent decades, including the TAR[10]. Various economic, educational, and health policies have been implemented for the development of society, which may have greatly affected the health of residents living in TAR[11].

Previous studies have assessed the population HRQoL in various provinces of China, such as Heilongjiang [12], Gansu [13], Shanxi [14], and Hunan[15]. However, these studies focused on low-altitude areas and used data only from a cross-sectional survey. Moreover, there are only two studies have assessed the change in HRQoL over time in the general population of mainland China[16, 17]. One study used the data from two waves of NHSS from 2008 to 2013[16], while another study used three waves of Health Services Surveys from 2008 to 2020 in Tianjin[17]. Both studies reported a slightly decreasing in HRQoL of the population and disparities in HRQoL across different demographic and socioeconomic subgroups in China. Additionally, previous studies on the health status of Tibetan population are limited due to the geographical environment, lack of basic resources and facilities, and low population density. Therefore, this study aimed to assess the HRQoL of Tibetan population and its changes over time, and explore the differences in HRQoL for residents at different altitudes.

Methods

Study design and population

Data for the cross-sectional study were extracted from the fifth and sixth waves of the NHSS in Tibet, which were conducted in 2013 and 2018. A multi-stage stratified cluster random sampling strategy was used to select representative participants. Each stage had a systematic random sampling approach. In the first stage, 24 counties were selected in 2013 and 25 counties were selected in 2018 from the seven cities in Tibet in proportion to their population size. In the second stage, 60 towns/sub-districts selected in 2013 and 59 towns/sub-districts were selected in 2018 using the random cluster method according to population size. In the third stage, three villages/communities were randomly selected from each town or sub-district, and 155 villages/communities were selected in 2013 and 159 villages/communities were selected in 2018. The majority of the counties, towns/ sub-districts, villages/communities sampled in 2018 were the same as those sampled in 2013. In the fourth stage, 20 households from each village of community were randomly selected for participation, and 4140 households were selected in 2013 and 4232 households were selected in 2018.

Questionnaires were administered to the participants through face-to-face interviews. The students majoring in Preventive Medicine at Medical College of Tibet University were uniformly recruited and trained to be interviewers by supervisors who had participated in national training. Pre-survey training workshops were offered to all interviewers following a standardised protocol. Eligible interviewers had to demonstrate proper understanding of the purpose of the NHSS and their ability to meet data collection standards developed by the Centre for Health Statistics and Information. The interviewers visited the selected households, and all family members in a sampled household were eligible to participate in the survey. Before the survey commenced, participants were informed of the survey's purposes and procedure and then provided informed consent.

In total, 14752 participants in 2013 and 13106 participants in 2018 completed the survey. The exclusion criteria in this study were as follows: (1) participants aged < 15 years were excluded since the EQ-5D-3L is recommended to be used among ⩾15 years by the user guide (n=3412 in 2013 and n=2677 in 2018); (2) participants who did not answer the questionnaires by themselves were excluded since the EQ-5D-3L need to be self-complete (n=1001 in 2013 and n=3798 in 2018); (3) participants with missing values for key variables including socio-demographic characteristics were excluded (n=4 in 2013 and n=1 in 2018); (4) participants with ethnicities other than Tibetan were excluded (n=88 in 2013 and n=194 in 2018). Overall, final sample size of 10247 in 2013 and 6436 in 2018 were included in this study for analysis.

Measurement of HRQoL

The EQ-5D-3L is one of the most widely used HRQoL measurement instruments classified into five dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD). Each dimension contains three functioning response levels (no problems, moderate problems, and extreme problems), generating 243 (3^5) possible health states, with the best state indicated by the response "11111" and the worst health state indicated by the response "33333"[18]. A single health state utility (HSU) score can be assigned to each health state using a value set, developed in a valuation study based on the general population's health preferences.

Four value sets exist for the EQ-5D-3L in China with the first value set developed in 2014 ($3L_{2014}$ value set) using a sample comprising residents mainly from urban areas[19], the second value set developed in 2018 ($3L_{2018}$ value set) adopted a more representative sample of residents from both rural and urban areas[20], the other two value set developed in 2022 ($3L_{2022}$ value set) recruited participants from rural areas of five cities[21]. In this study, we chose to adopt the $3L_{2018}$ value set. The main reason for the choice was based on the participants in the 3L2014 value set being selected conveniently from big cities in urban areas through quota sampling. While the 3L2018 value set, a more representative sample of respondents was obtained from both rural and urban areas using a random sampling method[22]. The rural population accounts for half of the Chinese population, and large disparities exist in socioeconomic status, lifestyle, and health status between urban and rural areas in China[23]. In the two waves of NHSS in the TAR, more than 75% of participants were from farming and pastoral areas. Therefore, the $3L_{2018}$ value set, which more closely matches the distribution of the Tibetan population, was used in this study. To evaluate the robustness and sensitivity of the $3L_{2018}$ value set, we also used the $3L_{2022}$ value set to analyse the main results revealing that the main results of the two value sets had the same trends (Supplementary Table 1).

Independent variables

In this study, the independent variables were sociodemographic, altitude-related, and clinical disease variables, and health-related behaviours. Sociodemographic variables were sex, age, employment status, educational attainment, and marital status. We divided age into three groups: 15–44, 45–65, and ≥ 65 years old. Employment status was divided into employed, retired, and unemployed. Educational attainment was divided into three groups: illiterate, primary school, junior high school, and above. Marital status was divided into single, married, divorced, and other.

The altitude-related variables included location and altitude. The participants were divided into rural and urban groups based on their geographical location. The NHSS did not collect data on the altitude of their residence; therefore, we used Google Maps to obtain the precise altitude. Altitudes were defined as high (1500–3500 m), very high (3500–5500 m), and extreme altitude (>5500 m), as suggested by the International Society for Mountain Medicine[24]. In this study, based on the China's policy of subsidising plateau areas[25], we divided the plateau areas into three altitude groups, high (1500–3500 m), very high (3500–4000 m), and extreme altitude (4000-5000 m). The altitude classification criterion was consistent in two waves of surveys.

The clinical disease variables included diagnosis of the participant with any illness within two weeks before survey and the number of chronic diseases during the past six months. A chronic condition was defined as a condition diagnosed by a doctor with symptoms persisting or relevant medical treatment continuing over the past six months.

Health-related behavioural variables were current smoking status, divided into three groups: smoking all the time, has ever smoked, and never smoked. Participants were asked to perform weekly physical exercise during the past six months, such as climbing, ball games, equipment exercise, swimming, jogging, etc. The frequency of physical exercise was divided into three groups: never exercised, 1–5 times, and > 6 times.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Statistical analysis

Descriptive statistics were used for participants' characteristics and the reported problems on the five dimensions of the EQ-5D-3L. Continuous variable were described as mean and standard deviation (SD), whereas categorised variable was described as frequency and percentages. Student's *t* test or analysis of variance (ANOVA) was used when variables conformed to an approximately normal distribution; otherwise, the Mann-Whitney *U* test or Kruskal-Wallis H test was used. Categorical variables were compared between the groups using the chi-square test.

The importance of changes in the HSU scores was estimated using effect sizes (ES), which were calculated as the difference between the highest and the lowest HSU scores among the two surveys divided by the pooled standard deviation. The Effect sizes was defined ≤0.5, 0.5 to 0.8 and ≥0.8 were small, moderate and large[26]. In this study, the moderate effect size (0.5) was considered as a threshold for minimal importance of changes in the HSU scores. As the HSU score was left-skewed with a large proportion of respondents in full health, the Tobit regression model was used to assess the influencing factors associated with EQ-5D-3L HSU scores. Data were entered into

Epidata3.1 and analysed using SPSS 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Participant characteristics

The characteristics of the participants are listed in Table 1. In 2013, more than half of the participants were in the 15–44 years age group (56.2%), and older participants accounted for < 15% of the participants (11.0%) and less than half of the participants were male (46.5%). Moreover, 57% of participants had never received education and 14.98% of the participants were unemployed. More than four out of five participants resided in rural areas (84.9%) with an average altitude of 3838 ± 526 m. Overall, 11.35% of participants reported having a disease during 2 weeks before data collection, while, more than half of participants (65.6%) had no chronic diseases during the past 6 months.

In 2018, the sociodemographic characteristics of the participants were basically the same as those in 2013. The average age was 45.22 ± 14.71 years, and more than half of the participants were female (56.6%). Of the participants, 52.0% never had education, 81.2% were employed, 78.3% were married, and 77.5% lived in rural areas with an average altitude of 3903 ± 495 m. Most of the participants (85.1%) were non-smokers, and 62.3% had never engaged in weekly physical exercise during the past 6 months. Compared two waves of surveys, participants in the 2018 were more female (P<0.001), reported a higher level of education (P<0.001), had a lower employed proportion (P=0.008), more lived in urban with more high altitude (P<0.001).

Participant's HRQoL and its changes

The HSU scores stratified by characteristics of participants in two surveys were listed in Table 2. The mean HSU scores of the participants were 0.969 ± 0.078 in 2013 and 0.966 ± 0.077 in 2018, which showed a significantly decreasing trend (P<0.001, ES=0.136). Figure 1 presents the distribution of participant's HSU scores in two surveys. It revealed a left-skewed distribution with skewness of -4.189 in 2013 and -4.642 in 2018, ranging from 0.170 to 1.000. The states of 11111 (no problems in any dimension) were reported in 74% and 70% of the participants in 2013 and 2018, respectively. The trend in HSU scores was observed decreased in most subgroups.

The highest proportion of reporting health problems was the pain/discomfort dimension (2013:18.1%, 2018: 17.9%). Problems with self-care dimension was least prevalent, 7.7% and 8.5% participants reported in 2013 and 2018, respectively. As compared to the 2013, reported problems increased in mobility (by 1.2%), self-care (by 0.8%), usual activities (by 0.6%), and anxiety/depression (by 3.8%) in 2018. While, reported problems in pain/discomfort decreased by 0.2% (Table 3).

HRQoL of participants at different altitudes

Two survey's findings showed that participants lived in the 3500-4000m group had the highest HSU scores. Similar to the general trend, health state scores in 2018 were slightly lower than those in 2013 at different altitude groups (Table 2). Figure 2 describes the percentage of participants with self-reported health problems by different altitude groups. The distribution trend was generally consistent in two surveys.

Participants lived in 3500–4000m had the least reported problems in all five dimensions, while participants lived in 1500–3500m and 4000–5000m reported more problems in pain/discomfort, anxiety/depression and mobility dimensions.

Factors associated with HSU scores

The Tobit regression analyses of the factors associated with HSU scores were presented in Table 4. The result confirmed the decreased trend in HSU scores over time (β = -0.014, P<0.001), after adjustment for variations in the other independent variables. However, the effect sizes of this change did not reach the threshold of minimal clinical importance (ES=0.04). The elderly, the unemployed, the separated/divorced/widowed, and the healthy participants were significant predictors of the HSU score, with generally larger values of ES and reached the threshold of minimal clinical importance.

Discussion

To the best of our knowledge, this is the first study to evaluate the HRQoL of Tibetan population and its changes over time, based on a representative sample from the NHSS of Tibet in China. The HRQoL of Tibetan was lower than general Chinese population, and decreased over time in five years (2013–2018). Moreover, we found Tibetans living at 3500–4000m altitude had the best HRQoL. Our study also identified factors influencing HRQoL including females, elders, unemployed, and more chronic diseases with a negative impact. While, higher education levels, no disease during the past two weeks, and frequent weekly physical exercise had a positive impact on HRQoL of the Tibetan population.

The mean HSU scores of the Tibetan population were 0.969 (SD = 0.078) in 2013 and 0.966 (SD = 0.077) in 2018, higher than that reported in Heilongjiang, Hunan, and Shanxi in China[12, 13, 15]. This may be due to the use of two different 3L value sets used to calculate the HSU score. Compared to the $3L_{2018}$ algorithm, the $3L_{2014}$ algorithm includes a constant term and N3, resulting in a utility value gap between full health and the second-best health state, reducing the values of other health states[27]. Therefore, the $3L_{2018}$ index score was systematically higher than the $3L_{2014}$ index score at absolute levels[22]. The result also indicated that HSU scores of two waves of surveys were significantly lower than the that of the general Chinese population, confirming regional and residential disparities in HRQoL of the Chinese populations[28]. The eastern–middle–western disparities in development have existed historically. Although in recent years China's development strategy has focused more on western areas including implementing poverty alleviation policies, promoting the construction of infrastructure, low taxation, and national level fiscal transfer to the middle and western areas, a huge gap still exists between regions[23] with lower HRQoL in residents of western regions than that of those in the eastern region.

Based on the HRQoL changes between the two waves of surveys, HSU scores in 2018 were slightly lower than those in 2013, and statistical differences existed in the total population and at different demographic characteristics levels. However, the changes between 2013 and 2018 were minimal and failed to reach the threshold minimal clinically important difference of ~0.074 based on EQ-5D-3L[29]. This is consistent with previous studies on the changes in HRQoL in the Chinese population[16, 17]. This could be due to proportion of extreme problems reported by EQ-5D-3L, with 0.42 to 0.45% reporting extreme problems in anxiety/depression and pain/discomfort compared to 2013. According to the $3L_{2014}$ algorithm, the value in level-3 (L3) parameters is larger than level-2 (L2) or level-1 (L1) with increasing health state severity. Hence, for a health transition involving both improvement and deterioration, the magnitude of health gain from improvement in a certain dimension may be offset to a large extent by deterioration in another dimension[22]. Another possible reason may be related to the changing demographic and socioeconomic status in China. Between 2013 and 2018, the government implemented a series of policies, especially the targeting poverty alleviation strategy, driving continuous rapid growth of residents' income and further improving the consumption level and length of life. Life expectancy increased from 76.3–77.0 years during this time[35]. However, the aging of the population, unhealthy lifestyles, and environmental exposure have led to the rising prevalence of chronic diseases and functional limitations, related to lower HRQoL among the Tibetan population.

Pain/discomfort was the most frequently reported problem in this study similar to previous studies in China, however, the absolute proportion of each dimension reported was higher than the general population trends based on the NHSS data[28] and other provincial studies in China[12, 14, 15]. This may be due to the plateau disease[30]. Residents living on the plateau for a long time evolve a unique physiological mechanism to adapt to the environment. However, some residents gradually lose their adaptability and suffer from various acute or chronic diseases related to the plateau environment under the stimulation of continuous hypoxia and low pressure[31]. The two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in 2018, and hypertension has been reported as the most common chronic disease[32]. A previous study reported that the prevalence of hypertension in Tibet is higher than the Chinese national level and is the highest among all provinces, as well as higher than other residents living at high altitudes[33, 34]. As altitude increases, progressive reductions in barometric pressure, air temperature, and air humidity are observed. Headache, shortness of breath, chest tightness, anorexia, dizziness, limb fatigue, and sleep disturbances were common symptoms of Tibetan[32].

Compared with other high-altitudes, we found that Tibetans living at 3500–4000 m had the best HRQoL. This could be attributed to Tibet's topography, population distribution, and socioeconomic status. The TAR is a vast territory with a sparse population with high-altitude in the northwest and low in the southeast. The region can be divided into three regions based on altitude. The Qiangtang Plateau in the north (> 5000 m), and the central basin region and Himalayan mountains (4000–5000 m on average). The valleys of the middle and lower reaches of the Yarlung Zangbo River and the three rivers in eastern Tibet have an altitude of 3000–4000 m, and 60% of the population is concentrated there. Of the seven cities surveyed, Lhasa, Shannan, Qamdo, and Shigaze have an average altitude of 3500–4000 m with their GDP ranking among the top four in Tibet according to the Seventh National Census in 2020. Similar results have been reported previously with socioeconomic status significantly associated with higher HRQoL[16]. Socioeconomic status is detrimental to health as it affects people's living and working conditions and restricts accessibility to medical care[35]. Moreover, socioeconomic status affects people's psychological state and cognition of the world around them[36]. During the few last decades, China has implemented strong policies to facilitate economic development in the Qinghai-Tibet plateau (e.g., the Strategy of the Development of China's West). The implementation of supportive strategies should help improve socioeconomic status in the future, including improving public infrastructure, medical service capacity, and disease prevention improving HRQoL.

Those living in low-altitude areas (1500–3500m) reported the most problems in anxiety/depression consistent with previous studies. A large sample survey of the prevalence of depression among Tibetans of the Qinghai-Tibet Plateau was 28.6%, higher than that in the general Chinese population and higher than that reported in a western study with high-altitude samples[37]. The prevalence of depression is significantly correlated with climatic pressure, particularly altitude[38]. Generally, the combined effects of harsh natural environment on the plateau, high-altitude hypoxia, low atmospheric pressure, intense ultraviolet radiation, relatively weak community support caused by low population density, and lack of access to mental health resources increases the severity of depression among those living in high-altitude areas[39-41]. In this study, the area with an altitude of 1500–3500 m was located southeast of the TAR. Nyingchi City, with an average altitude of 3100 m, has the lowest altitude and wettest climate in TAR. With convenient transportation and multiple splendid sceneries, tourism is the main source of income in this area, attracting millions of people traveling for sightseeing, mountaineering, and trekking every year[42]. Previous studies have reported a significant association between tourism impact and residents' quality of life[43, 44]. Tourism provides employment opportunities and tax revenues, supports economic diversity, and services and products enjoyed by residents[45, 46]. However, negative impacts of tourisms on residents' HRQoL have been reported including crowding, traffic and parking issues, criminality, and cost of living, changes in hosts' way of life, and friction between tourists and residents[47]. The perceived negative impacts, negative emotions, pressure, and relative deprivation of the residents will affect their subjective well-being, leading to psychological problems including anxiety and depression.

This study had several limitations. First, this study did not recruit the same pool of participants in two waves of surveys, making it difficult to identify causal associations. However, the same cities were selected, and the participants may partly overlap. Second, the participants recruited in the surveys were those had lived in Tibet for more than six months; however, we could not determine if they were born in Tibet or came to work from other low-altitude areas. A small-scale survey could be conducted to refine the participant inclusion criteria to validate the study findings in the future. Third, many studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys because of its small cognitive burden. Moreover, the comparison of the two waves of surveys indicated the overall changing trends in HRQoL of participants were able to be derived from EQ-5D-3L.

Conclusion

This study revealed the HRQoL of Tibetan population was lower than general Chinese population, and decreased over time between 5 years. There were differences in HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m having the best quality of life. More attention should be paid to those Tibetans who are older, female, unemployed and without formal education. Targeted policies and strategies need to be strengthened, including plateau subsidies, poverty alleviation, primary health service capacity, standardized management of chronic diseases, and health education.

Acknowledgements

We gratefully acknowledge the contribution of the investigators from Preventive Medicine at Medical College of Tibet University, and we also thank all the participants who participated in the study.

Funding statement

This work was supported by the Sixth National Health Service Survey Project in Tibet (grant number 18080027); and China Medical Board (grant number 11-086).

Competing interest statement

All authors declare no competing interests.

Author Contributions

SPL and ZXDW have substantial contributions to conception and design, acquisition of funding, data and interpretation of data. CDZG and ZXCM were involved in the acquisition of data. LD, ZS and CFL were responsible for the data analysis and interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM and CFL revised it critically for important intellectual content, LD and SPL was responsible for the decision to submit the manuscript, and all authors contributed to final approval of the manuscript.

Ethics statements

Patient consent for publication

Not applicable.

Ethics approval

This study involves human participants and was approved. This study was conducted with the approval of the National Health Commission of the People's Republic of China and the Health Commission of Tibet autonomous region.

Data availability statement

Data are available upon reasonable request. We have included all the data produced in the present work in the manuscript. Note that the raw data used in the study were obtained from National Health Service Surveys of China. We are unable to attach all the raw data for each participant in this paper due to the ethical restrictions.

References

1. Calvert M, Blazeby J, Altman DG, et al. Reporting of Patient-Reported Outcomes in Randomized Trials. JAMA 2013; 309:814

2.Karimi M, Brazier J. Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? Pharmacoeconomics 2016; 34:645-9

3.Macran S, Weatherly H, Kind P. Measuring population health: a comparison of three generic health status measures. Med Care 2003; 41:218-31

4.Goodwin E, Green C. A Systematic Review of the Literature on the Development of Condition-Specific Preference-Based Measures of Health. Appl Health Econ Health Policy 2016; 14:161-83

5.Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: Past, Present and Future. Appl Health Econ Health Policy 2017; 15:127-37

6.Mingji C, Onakpoya IJ, Perera R, Ward AM, Heneghan CJ. Relationship between altitude and the prevalence of hypertension in Tibet: a systematic review. Heart 2015; 101:1054-60

7.Tibet Autonomous Region Statistics Bureau. Communiqué on Main Data of the Seventh National Population Census of Tibet Autonomous Region., 2021

8.Zheng Z. Research on the village public service system innovation of agricultural and pastoral areas in tibet--from the perspective of integrated anti-poverty development. Ethnology Journal 2012:34-43

9.Jieannamu, Xu X, You H, et al. Inequalities in health-related quality of life and the contribution from socioeconomic status: evidence from Tibet, China. BMC Public Health 2020; 20:630

10.Graham C, Zhou S, Zhang J. Happiness and Health in China: The Paradox of Progress. World Dev 2017:S305750X-S15308056X

11.Huang L, Wang Z, Wang H, et al. Nutrition transition and related health challenges over decades in China. Eur J Clin Nutr 2021; 75:247-52

12.Huang W, Yu H, Liu C, et al. Assessing Health-Related Quality of Life of Chinese Adults in Heilongjiang Using EQ-5D-3L. Int J Environ Res Public Health 2017; 14

13.Si L, Shi L, Chen M, Palmer AJ. Establishing benchmark EQ-5D-3L population health state utilities and identifying their correlates in Gansu Province, China. Qual Life Res 2017; 26:3049-58

14.Tan Z, Liang Y, Liu S, et al. Health-related quality of life as measured with EQ-5D among populations with and without specific chronic conditions: a population-based survey in Shaanxi Province, China. PLoS One 2013; 8:e65958

15.Deng X, Dong P, Zhang L, et al. Health-related quality of life in residents aged 18 years and older with and without disease: findings from the First Provincial Health Services Survey of Hunan, China. BMJ Open 2017; 7:e15880

16.Yao Q, Liu C, Zhang Y, Xu L. Changes in health-related quality of life of Chinese populations measured by the EQ-5D-3 L: a comparison of the 2008 and 2013 National Health Services Surveys. Health Qual Life Outcomes 2019; 17:43

17.Wang D, Xie S, Wu J, Sun B. The trend in quality of life of Chinese population: analysis based on population health surveys from 2008 to 2020. BMC Public Health 2023; 23:167

18.Brooks R. EuroQol: the current state of play. Health Policy 1996; 37:53-72

19.Liu GG, Wu H, Li M, Gao C, Luo N. Chinese time trade-off values for EQ-5D health states. Value Health 2014; 17:597-604

20.Zhuo L, Xu L, Ye J, et al. Time Trade-Off Value Set for EQ-5D-3L Based on a Nationally Representative Chinese Population Survey. Value Health 2018; 21:1330-7

21.Liu GG, Guan H, Jin X, Zhang H, Vortherms SA, Wu H. Rural population's preferences matter: a value set for the EQ-5D-3L health states for China's rural population. Health Qual Life Outcomes 2022; 20:14

22.Zhang RY, Wang W, Zhou HJ, Xuan JW, Luo N, Wang P. A head-to-head comparison of the EQ-5D-3L index scores derived from the two EQ-5D-3L value sets for China. Health Qual Life Outcomes 2022; 20:80

23.Sun S, Chen J, Johannesson M, et al. Regional differences in health status in China: population health-related quality of life results from the National Health Services Survey 2008. Health Place 2011; 17:671-80

24.Woolcott OO, Ader M, Bergman RN. Glucose homeostasis during short-term and prolonged exposure to high altitudes. Endocr Rev 2015; 36:149-73

25.The Ministry of Labor and Personnel and the Ministry of Finance. The Ministry of Labor and Personnel and the Ministry of Finance responded to the People's Government of Tibet Autonomous Region on issues concerning the implementation of temporary subsidies for workers in plateau areas., 1984

26.Cohen J. A power primer. Psychol Bull 1992; 112:155-9

27.Pan CW, Zhang RY, Luo N, et al. How the EQ-5D utilities are derived matters in Chinese diabetes patients: a comparison based on different EQ-5D scoring functions for China. Qual Life Res 2020; 29:3087-94

28.Yao Q, Liu C, Zhang Y, Xu L. Population norms for the EQ-5D-3L in China derived from the 2013 National Health Services Survey. J Glob Health 2021; 11:8001

29.Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. Qual Life Res 2005; 14:1523-32

30.Netzer N, Strohl K, Faulhaber M, Gatterer H, Burtscher M. Hypoxia-related altitude illnesses. J Travel Med 2013; 20:247-55

31.Crawford JE, Amaru R, Song J, et al. Natural Selection on Genes Related to Cardiovascular Health in High-Altitude Adapted Andeans. Am J Hum Genet 2017; 101:752-67

32.Deng R, Labasangzhu, Zhaxideji, et al. Illness prevalence rate in Tibet, China: data from the 2018 National Health Service Survey. BMC Public Health 2020; 20:955

33.Li K, Liang Y, Sun Y, et al. The relationship between polymorphisms at 17 gene sites and hypertension among the Aboriginal Tibetan people. Biomed Environ Sci 2012; 25:526-32

34.Wang J, Zhang L, Wang F, Liu L, Wang H. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. Am J Hypertens 2014; 27:1355-61

35.Jiang Y, Hesser JE. Associations between health-related quality of life and demographics and health risks. Results from Rhode Island's 2002 behavioral risk factor survey. Health Qual Life Outcomes 2006; 4:14

36.Matthews KA, Gallo LC. Psychological perspectives on pathways linking socioeconomic status and physical health. Annu Rev Psychol 2011; 62:501-30

37.Golicki D, Niewada M, Jakubczyk M, Wrona W, Hermanowski T. Self-assessed health status in Poland: EQ-5D findings from the Polish valuation study. Pol Arch Med Wewn 2010; 120:276-81

38.Gamboa JL, Caceda R, Arregui A. Is depression the link between suicide and high altitude? High Alt Med Biol 2011; 12:403-4, 405

39.Wang J, Zhou Y, Liang Y, Liu Z. A Large Sample Survey of Tibetan People on the Qinghai-Tibet Plateau: Current Situation of Depression and Risk Factors. Int J Environ Res Public Health 2019; 17

40.Ding Y, Shi B, Su G, et al. Assessing Suitability of Human Settlements in High-Altitude Area Using a Comprehensive Index Method: A Case Study of Tibet, China. Sustainability 2021; 13

41.Li XY, Wu XY, Fu C, Shen XF, Wu YH, Wang T. Effects of acute mild and moderate hypoxia on human mood state. Space Med Eng (Beijing) 2000; 13:1-5

42.Chen Y, Zhang G, Chen Z, et al. A warming climate may reduce health risks of hypoxia on the Qinghai-Tibet Plateau. Sci Bull (Beijing) 2022; 67:341-4

43.Kim, Hyelin, Uysal, Muzaffer, Woo, Eunju. Life satisfaction and support for tourism development. Annals of tourism research: A social sciences journal 2015; 50:84-97

44.Vargas-Sanchez A, Plaza-Mejia MDLA, Porras-Bueno N. Understanding Residents' Attitudes toward the Development of Industrial Tourism in a Former Mining Community. J Travel Res 2009; 47:373-87

45.Aref F. The Effects of Tourism on Quality of Life: A Case Study of Shiraz, Iran. Life ence Journal 2011; 8:26-30

46.Andereck, Kathleen L, Nyaupane, Gyan P. Exploring the Nature of Tourism and Quality of Life Perceptions among Residents. J Travel Res 2011; 11:25-34

47.Andereck KL, Valentine KM, Knopf RC, Vogt CA. Residents' perceptions of community tourism impacts. Ann Tour Res 2005; 32:1056-76

Table 1 Characteristics of the participants

Characteristics	2013 (N=10247)		2018 (N=6436)		Total (N=16683)		*P*-value
	N	%	N	%	N	%	
Age groups							<0.001
15-44 years	5754	56.2	3159	49.1	8913	53.4	
45-64 years	3363	32.8	2568	39.9	5931	35.6	
≥65 years	1130	11.0	709	11.0	1839	11.0	
Gender							<0.001
Male	4766	46.5	2792	43.4	7558	45.3	
Female	5481	53.5	3644	56.6	9125	54.7	
Educational attainment							<0.001
Illiterate	5841	57.0	3348	52.0	9189	55.1	
Primary school	3080	30.1	2143	33.3	5223	31.3	
Junior high school and above	1326	12.9	945	14.7	2271	13.6	
Employment							0.008
Employed	8514	83.1	5228	81.3	13742	82.4	
Retired	198	1.9	131	2.0	329	2.0	
Unemployed	1535	15.0	1077	16.7	2612	15.7	
Marital status							<0.001
Single	1563	15.3	748	11.6	2311	13.9	
Married	7718	75.3	5037	78.3	12755	76.5	
Separated/divorced/widowed	966	9.4	651	10.1	1617	9.7	
Location							<0.001
Rural	8699	84.9	4988	77.5	13687	82.0	
Urban	1548	15.1	1448	22.5	2996	18.0	
Altitude, m (Mean±SD)	3838± 526	-	3903 ± 495	-	3863±515	-	
Altitude groups							<0.001
1500-3500 m	2219	21.7	1123	17.5	3342	20.0	
3500-4000 m	4816	47.0	2933	45.6	7749	46.4	
4000-5000 m	3212	31.3	2380	36.9	5592	33.5	
Diseased during the past 2 weeks							0.366
Yes	1152	11.4	701	10.9	1853	11.1	
No	9002	88.6	5735	89.1	14737	88.3	
Number of chronic diseases							<0.001
0	6726	65.6	3684	57.2	10410	62.4	
1	2634	25.7	1743	27.1	4377	26.2	
≥2	887	8.7	1009	15.7	1896	11.4	
Smoking							<0.001
Smoker	1424	13.9	724	11.2	2148	12.9	
Ex-smoker	487	4.7	238	3.7	725	4.3	
Non-smoker	8336	81.4	5474	85.1	13810	82.8	

Weekly physical exercise during the past 6 months							<0.001
Never exercised	9437	92.3	4054	63.0	13491	80.9	
1–5 times	511	5.0	1247	19.4	1758	10.5	
≥6 times	279	2.7	1135	17.6	1414	8.5	

Table 2 Health state utility score stratified by characteristics of participants in two surveys

Characteristics	2013 (N=10247)	2018 (N=6436)	Effect Size (ES)	*P*-value
Age				
15-44 years	0.987(0.049)	0.987(0.041)	0.000	0.003
45-64 years	0.962(0.078)	0.959(0.076)	0.039	0.013
≥65 years	0.900(0.133)	0.899(0.139)	0.007	0.973
Gender				
Male	0.975(0.071)	0.973(0.070)	0.030	0.002
Female	0.964(0.083)	0.961(0.082)	0.036	<0.001
Employment				
Employed	0.977(0.064)	0.976(0.058)	0.016	<0.001
Retired	0.945(0.116)	0.965(0.057)	0.205	0.493
Unemployed	0.926(0.117)	0.918(0.128)	0.066	0.011
Educational attainment				
Illiterate	0.959(0.088)	0.956(0.088)	0.034	<0.001
Primary school	0.979(0.064)	0.971(0.069)	0.121	<0.001
Junior high school and above	0.990(0.046)	0.991(0.038)	0.023	0.180
Marital status				
Single	0.975(0.086)	0.979(0.068)	0.050	0.182
Married	0.973(0.069)	0.969(0.069)	0.058	<0.001
Separated/divorced/widowed	0.928(0.111)	0.925(0.124)	0.026	0.832
Location				
Rural	0.967(0.080)	0.966(0.077)	0.013	0.001
Urban	0.980(0.065)	0.967(0.080)	0.183	<0.001
Altitude groups				
1500-3500m	0.966(0.078)	0.961(0.079)	0.064	<0.001
3500-4000m	0.975(0.072)	0.970(0.073)	0.069	<0.001
4000-5000m	0.963(0.084)	0.963(0.081)	0.000	0.411
Diseased during the past 2 weeks				
Yes	0.933(0.111)	0.934(0.100)	0.009	0.303
No	0.974(0.072)	0.970(0.073)	0.055	<0.001
Number of chronic diseases				
0	0.983(0.057)	0.986(0.049)	0.055	0.331
1	0.950(0.097)	0.951(0.091)	0.010	0.663
≥2	0.920(0.113)	0.919(0.106)	0.009	0.223
Smoking				
Smoker	0.985(0.056)	0.984(0.048)	0.019	0.094
Ex-smoker	0.965(0.073)	0.954(0.089)	0.138	0.146
Non-smoker	0.967(0.081)	0.964(0.080)	0.037	<0.001
Weekly physical exercise during the past 6 months				
Never exercised	0.969(0.079)	0.961(0.086)	0.098	<0.001
1–5 times	0.967(0.071)	0.973(0.066)	0.087	0.004

≥6 times	0.985(0.044)	0.977(0.051)	0.171	<0.001
Total	0.969(0.078)	0.966(0.077)	0.136	<0.001

Table 3 health problems reported by participants based on EQ-5D-3L

EQ-5D-3L	2013		2018		χ2	*P*-value
	N	%	N	%		
Mobility					12.794	0.002
No problem	8956	87.4	5544	86.2		
Moderate problem	1221	11.9	865	13.4		
Extreme problem	70	0.7	27	0.4		
Self-care					2.791	0.248
No problem	9453	92.3	5891	91.5		
Moderate problem	733	7.1	502	7.8		
Extreme problem	61	0.6	43	0.7		
Usual activities					1.407	0.495
No problem	9014	88.0	5624	87.4		
Moderate problem	1077	10.5	714	11.1		
Extreme problem	156	1.5	98	1.5		
Pain/discomfort					7.543	0.023
No problem	8393	81.9	5283	82.1		
Moderate problem	1750	17.1	1059	16.4		
Extreme problem	104	1.0	94	1.5		
Anxiety/depression					52.078	<0.001
No problem	9111	88.9	5479	85.1		
Moderate problem	1047	10.2	874	13.6		
Extreme problem	89	0.9	83	1.3		

Table 4 Tobit regression analysis on the EQ-5D-3L HSU scores

Independent variable	β	SE	*P*-value	95%CI	Effect Size
Age years (ref.:15-44 years)					
45-64 years	-0.071	0.004	<0.001	-0.079, -0.063	0.43
≥65 years	-0.142	0.006	<0.001	-0.153, -0.130	1.26
Gender (ref.: male)					
Female	-0.025	0.004	<0.001	-0.033, -0.017	0.14
Educational attainment (ref.: illiterate)					
Primary school	0.016	0.004	<0.001	0.009,0.024	-0.22
Junior high school and above	0.055	0.007	<0.001	0.041, 0.069	-0.40
Employment (ref.: employed)					
Retired	-0.036	0.012	0.003	-0.060, -0.012	0.38
Unemployed	-0.073	0.005	<0.001	-0.082, -0.064	0.72
Marital status (ref.: single)					
Married	0.018	0.006	0.002	0.007,0.029	0.07
Separated/divorced/widowed	-0.007	0.008	0.335	-0.022 0.008	0.52
Location (ref.: rural)					
Urban	0.039	0.005	<0.001	0.029, 0.049	0.00
Altitude groups (ref.: 1500-3500m)					
3500-4000m	0.028	0.005	<0.001	0.019, 0.037	-0.11
4000-5000m	0.011	0.004	0.017	0.002, 0.021	0.03
Diseased during the past 2 weeks (ref.: Yes)					
No	0.042	0.005	<0.001	0.033, 0.052	-0.50
Number of chronic diseases (ref.: 0)					
1	-0.083	0.004	<0.001	-0.091, -0.075	0.34

≥2	-0.125	0.005	<0.001	-0.136, -0.115	0.13
Smoking (ref.: smoker)					
Ex-smoker	-0.036	0.010	<0.001	-0.055, -0.018	0.34
Non-smoker	-0.011	0.006	0.086	-.0233,0.002	0.13
Weekly physical exercise (ref.: never exercised)					
1–5 times	0.032	0.006	<0.001	0.020, 0.043	0.00
≥6 times	0.050	0.007	<0.001	0.036, 0.064	-0.13
Year (ref.: 2013)					
2018	-0.014	0.004	<0.001	-0.022, -0.007	0.04

Figure legends

Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

Figure 2a Proportions of health problems reported by participants at different altitude in 2013

Figure 2b Proportions of health problems reported by participants at different altitude in 2018

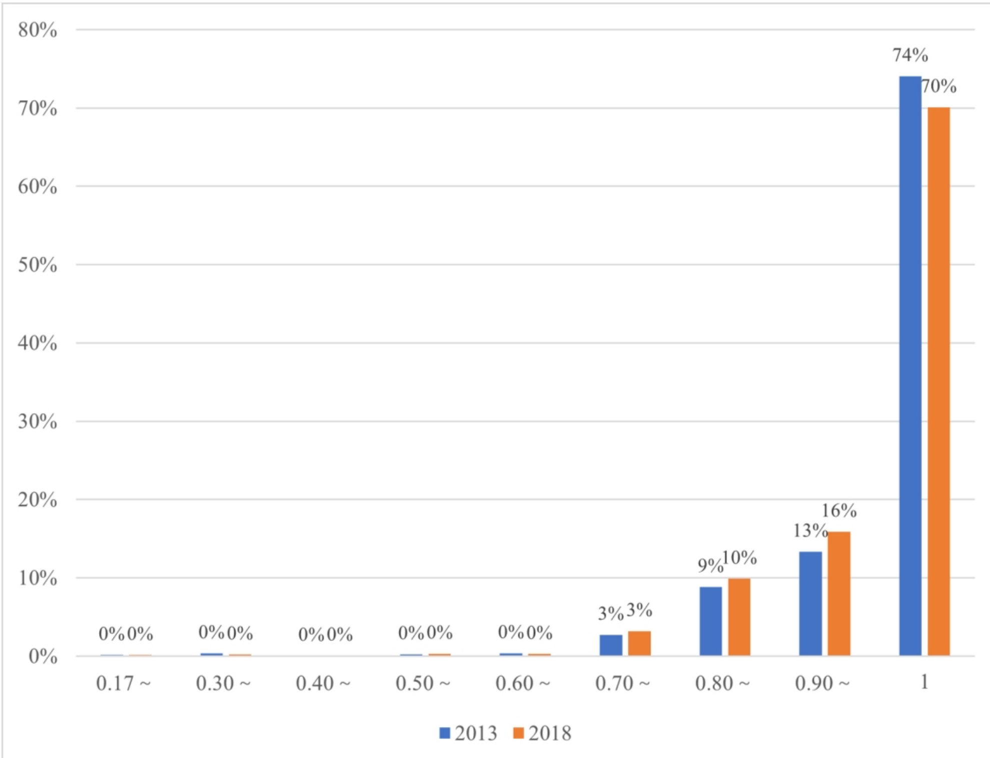

Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

146x111mm (300 x 300 DPI)

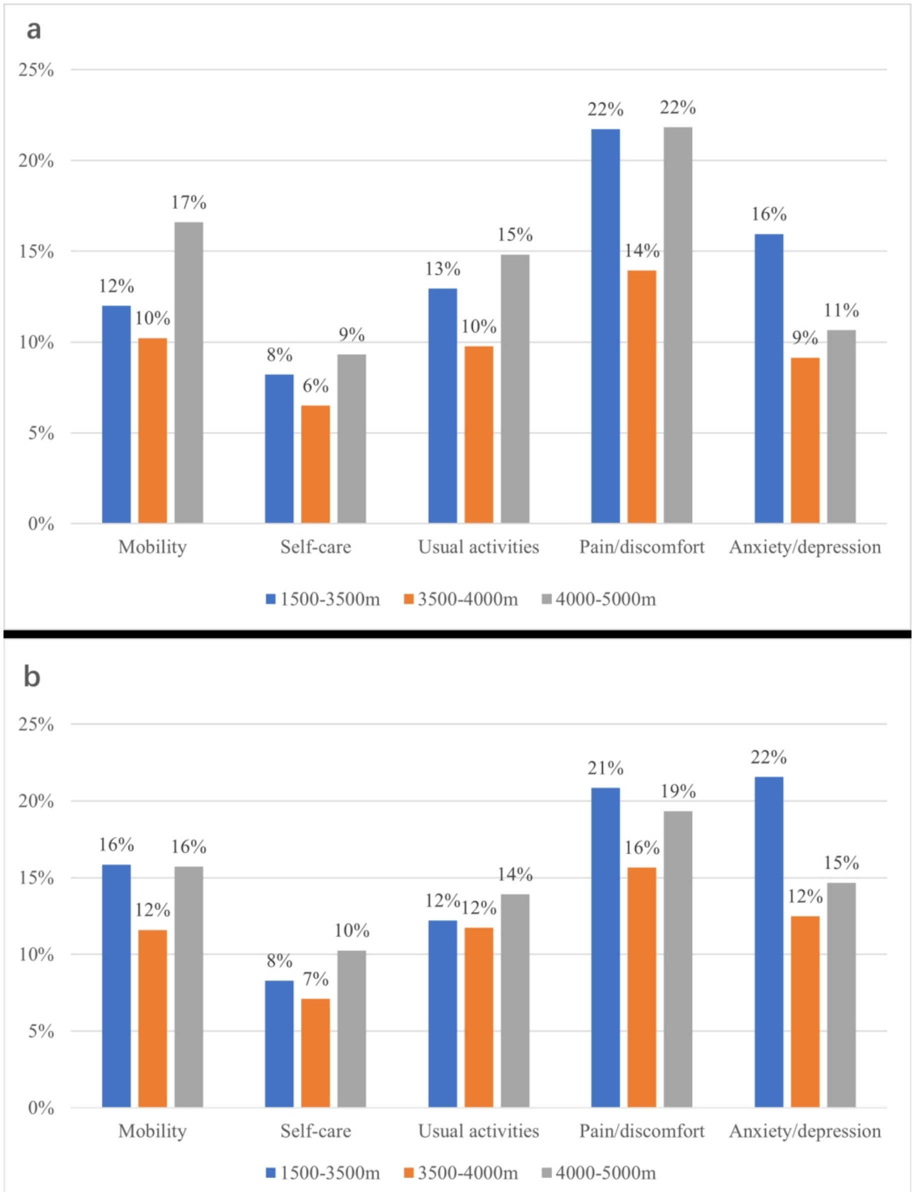

Figure 2a Proportions of health problems reported by participants at different altitude in 2013
Figure 2b Proportions of health problems reported by participants at different altitude in 2018

146x193mm (300 x 300 DPI)

Supplementary Table 1 Tobit regression analysis on the EQ-5D-3L HSU scores in different altitudes using 3L2022 value set

Characteristics	Total			<3500m			3500-4000m			>4000m		
	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value
Age years (ref.:15-44 years)												
45-64 years	-0.032	0.002	<0.001	-0.040	0.005	<0.001	-0.027	0.003	<0.001	-0.039	0.004	<0.001
≥65 years	-0.113	0.004	<0.001	-0.111	0.009	<0.001	-0.096	0.005	<0.001	-0.136	0.007	<0.001
Gender (ref.: male)												
Female	-0.011	0.002	<0.001	-0.012	0.005	0.017	-0.006	0.003	0.071	-0.021	0.004	<0.001
Educational attainment (ref.: illiterate)												
Primary school	0.011	0.002	<0.001	0.002	0.005	0.687	0.012	0.003	<0.001	0.007	0.004	0.115
Junior high school and above	0.014	0.003	<0.001	0.022	0.007	0.003	0.010	0.004	0.025	0.012	0.007	0.083
Employment (ref.: employed)												
Retired	-0.008	0.007	0.301	-0.025	0.015	0.086	0.011	0.010	0.282	-0.030	0.020	0.133
Unemployed	-0.060	0.003	<0.001	-0.094	0.008	<0.001	-0.049	0.004	<0.001	-0.072	0.005	<0.001
Marital status (ref.: single)												
Married	0.017	0.003	<0.001	0.017	0.008	0.027	0.018	0.004	<0.001	0.016	0.006	0.005
Separated/divorced/widowed	-0.004	0.004	0.342	0.011	0.011	0.327	0.001	0.006	0.931	-0.020	0.008	0.016
Location (ref.: rural)												
Urban	0.020	0.003	<0.001	0.004	0.010	0.651	0.029	0.004	<0.001	-0.003	0.005	0.475
Diseased during the past 2 weeks (ref.: Yes)												
No	0.036	0.003	<0.001	0.028	0.007	<0.001	0.048	0.005	<0.001	0.027	0.005	<0.001
Number of chronic diseases (ref.: 0)												
1	-0.039	0.002	<0.001	-0.030	0.006	<0.001	-0.045	0.003	<0.001	-0.030	0.004	<0.001
≥2	-0.083	0.003	<0.001	-0.063	0.008	<0.001	-0.093	0.005	<0.001	-0.072	0.006	<0.001
Smoking (ref.: smoker)												

Ex-smoker	-0.012	0.005	0.029	0.015	0.014	0.274	0.001	0.008	0.935	-0.028	0.009	0.002
Non-smoker	-0.003	0.003	0.314	-0.009	0.007	0.214	-0.002	0.004	0.669	-0.002	0.006	0.800
Weekly physical activities (ref.: never exercised)												
1–5 times	0.019	0.003	<0.001	0.009	0.008	0.241	0.024	0.004	<0.001	0.003	0.006	0.664
≥6 times	0.028	0.004	<0.001	0.026	0.009	0.007	0.026	0.005	<0.001	0.022	0.007	0.002

Note: Coe, coefficient; SE, standard error.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	P1,2

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	P4-5
Objectives	#3	State specific objectives, including any prespecified hypotheses	P5
Methods			
Study design	#4	Present key elements of study design early in the paper	P6-7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	P7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	P8-10

Bias	#9	Describe any efforts to address potential sources of bias	P6
Study size	#10	Explain how the study size was arrived at	P6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	P6-7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	P10-11
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	P10
Statistical methods	#12c	Explain how missing data were addressed	P10
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	P10-11
Statistical methods	#12e	Describe any sensitivity analyses	P10-11
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	P7
Participants	#13b	Give reasons for non-participation at each stage	P6

Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	P8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	P11
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	P11-12
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P12-13
Main results	#16b	Report category boundaries when continuous variables were categorized	P12-13
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	P12-13
Discussion			
Key results	#18	Summarise key results with reference to study objectives	P13

Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	P18
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	P14-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	P18
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P19

BMJ Open

Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-072854.R2
Article Type:	Original research
Date Submitted by the Author:	24-Oct-2023
Complete List of Authors:	Dou, Lei; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Shi, Zhao; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Cuomu; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Cidan, Zhuoga; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Chaofan; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University) Zhaxi, Dawa; Tibet University, Medical College; Tibet University, Center of Tibetan Studies (Everest Research Institute) Li, Shun-Ping; Shandong University, Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine; NHC Key Lab of Health Economics and Policy Research (Shandong University)
Primary Subject Heading:	Global health
Secondary Subject Heading:	Public health, Health policy, Global health
Keywords:	PUBLIC HEALTH, Quality of Life, China

Title page

Title: Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Authors:

Lei Dou[1,2,3], Zhao Shi[1,2,3], Zhaxi Cuomu[4,5], Cidan Zhuoga[4,5], Chaofan Li[1,2,3], Zhaxi Dawa[4,5*], Shunping Li[1,2,3*]

Affiliations:

[1] Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China

[2] NHC Key Lab of Health Economics and Policy Research (Shandong University), Jinan, China

[3] Center for Health Preference Research, Shandong University, Jinan, China

[4] Medical College of Tibet University, Lhasa, China

[5] Center of Tibetan Studies (Everest Research Institute), Tibet University, Lhasa, China

***Corresponding author:**

Shunping Li and Zhaxi Dawa are co- corresponding author.

Shunping Li: lishunping@sdu.edu.cn;

Zhaxi Dawa: 904397981@qq.com

Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

Abstract

Objective: Health-related quality of life (HRQoL) was an important health outcome measure for evaluating individual's overall health status. However, there was limited in the literature on HRQoL and its long-term changes of Tibetan population. This study aimed to assess HRQoL of Tibetan and its changes over time, and explore the differences in HRQoL for residents at different altitudes.

Design: Data for the cross-sectional study were extracted from the fifth and sixth waves of the National Health Services Surveys (NHSS) which conducted in 2013 and 2018. A multi-stage stratified cluster random sampling strategy was used to select representative participants.

Setting: Tibet Autonomous Region in China.

Participants: This study recruited 14752 participants in 2013 and 13106 participants in 2018, and after excluding observations with missing values for key variables, 10247 in 2013 and 6436 in 2018 were included in the study analysis.

Primary and secondary outcome measures: The EQ-5D-3L was used to measure participants' HRQoL.

Results: The mean health state utility (HSU) scores of the participants were 0.969 ± 0.078 and 0.966 ± 0.077 in 2013 and 2018, respectively. Pain/discomfort was the most frequently prevalent issue reported in 18.1% and 17.9% of the participants in 2013 and 2018, respectively. Tibetans living 3500–4000 m altitude had the best HRQoL. Age, sex, employment status, educational attainment, chronic disease, and weekly physical exercise were influencing factors associated with HRQoL.

Conclusions: The HRQoL of Tibetan population was lower than general Chinese population, and decreased over time between 5 years. There were differences in HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m having the best quality of life. More attention should be paid to those Tibetans who are older, female, unemployed and without formal education.

Strengths and limitations of this study

- We used Tibetan resident data from two National Health Service Surveys conducted in 2013 and 2018.
- This is the first study to assess the health-related quality of life and its changes of Tibetan over time.
- We divided the residents into three different altitude groups based on the international altitude standard and analysed the differences in HRQoL for residents at different altitudes.

- The same pool of participants was not characterized in the two surveys; however, some overlap may exist.

Introduction

Health-related quality of life (HRQoL) is considered an important health outcome measure in recent years to inform patient-centred care, clinical decision-making, health policy and reimbursement decisions[1]. HRQoL refers to the impact of health on the quality of life of individuals focusing on individuals' health influencing their goals, expectations, standards, and concerns. It is a multidimensional concept referring to people's physical, mental, and social domains of well-being, as well as personal beliefs, level of independence, and their relationships with the environment[2]. The HRQoL of the residents in a region could be measured through the health surveys for the resident population[3]. The HRQoL can be evaluated by generic preference-based measures (GPBMs), which provide a standardized health state classification system and a tariff of quality weights for all health states described by the classification system[4]. The EuroQol5-Dimensions (EQ-5D) is the most widely used GPBMs to measure and evaluate HRQoL in population surveys, clinical studies, and economic evaluations[5]. The EQ-5D-3L was included in the 2008 National Health Services Surveys (NHSS) for the first time to assess the population health status in China.

The Tibet Autonomous Region (TAR), located on the Qinghai-Tibet plateau in southwest China with an average altitude of 4000 m above sea level, is commonly referred to as the "Roof of the World"[6]. The TAR has an area of > 1.2 million km^2, accounting for one-eighth of China's geographic area. In 2021, the population in TAR was 3.65 million with 90% of the population being Tibetan[7]. Its social and economic development levels are relatively low among China's provinces. Most of the TAR population comprises of farmers and herders, scattered in remote rural areas with limited income source mainly depending on agriculture[8]. High-altitude areas present a complex ecology in physical environment and population characteristics including genetics, lifestyle, socioeconomic factors, and access to medical care[9], directly or indirectly impact health[10]. Previous studies have reported that high-altitude is strongly associated with the many health issues including psychiatric disorders [11, 12], hypertension[6, 13], and cardiovascular diseases[10]. China has been undergoing a period of unprecedented rates of economic growth, development, and poverty reduction in recent decades, including the TAR[14]. Various economic, educational, and health policies have been implemented for the development of society, which may have greatly affected the health of residents living in TAR[15].

Previous studies have assessed the population HRQoL in various provinces of China, such as Heilongjiang [16], Gansu [17], Shanxi [18], and Hunan[19]. However, these studies focused on low-altitude areas and used data only from a cross-sectional survey. Moreover, there are only two studies have assessed the change in HRQoL over time in the general population of mainland China[20, 21]. One study used the data from two waves of NHSS from 2008 to 2013[20], while another study used three waves of Health Services Surveys from 2008 to 2020 in Tianjin[21]. Both studies reported a slightly decreasing in HRQoL of the population and disparities in HRQoL across different demographic and socioeconomic subgroups in China. Additionally, previous studies on the health status of Tibetan population are limited due to the geographical environment, lack of basic resources and facilities, and low population density.

Therefore, this study aimed to assess the HRQoL of Tibetan population and its changes over time, and explore the differences in HRQoL for residents at different altitudes.

Methods

Study design and population

Data for the cross-sectional study were extracted from the fifth and sixth waves of the NHSS in Tibet, which were conducted in 2013 and 2018. A multi-stage stratified cluster random sampling strategy was used to select representative participants. Each stage had a systematic random sampling approach. In the first stage, 24 counties were selected in 2013 and 25 counties were selected in 2018 from the seven cities in Tibet in proportion to their population size. In the second stage, 60 towns/sub-districts selected in 2013 and 59 towns/sub-districts were selected in 2018 using the random cluster method according to population size. In the third stage, three villages/communities were randomly selected from each town or sub-district, and 155 villages/communities were selected in 2013 and 159 villages/communities were selected in 2018. The majority of the counties, towns/ sub-districts, villages/communities sampled in 2018 were the same as those sampled in 2013. In the fourth stage, 20 households from each village of community were randomly selected for participation, and 4140 households were selected in 2013 and 4232 households were selected in 2018.

Questionnaires were administered to the participants through face-to-face interviews. The students majoring in Preventive Medicine at Medical College of Tibet University were uniformly recruited and trained to be interviewers by supervisors who had participated in national training. Pre-survey training workshops were offered to all interviewers following a standardised protocol. Eligible interviewers had to demonstrate proper understanding of the purpose of the NHSS and their ability to meet data collection standards developed by the Centre for Health Statistics and Information. The interviewers visited the selected households, and all family members in a sampled household were eligible to participate in the survey. Before the survey commenced, participants were informed of the survey's purposes and procedure and then provided informed consent.

In total, 14752 participants in 2013 and 13106 participants in 2018 completed the survey. The exclusion criteria in this study were as follows: (1) participants aged < 15 years were excluded since the EQ-5D-3L is recommended to be used among ≥15 years by the user guide (n=3412 in 2013 and n=2677 in 2018); (2) participants who did not answer the questionnaires by themselves were excluded since the EQ-5D-3L need to be self-complete (n=1001 in 2013 and n=3798 in 2018); (3) participants with missing values for key variables including socio-demographic characteristics were excluded (n=4 in 2013 and n=1 in 2018); (4) participants with ethnicities other than Tibetan were excluded (n=88 in 2013 and n=194 in 2018). Overall, final sample size of 10247 in 2013 and 6436 in 2018 were included in this study for analysis.

Measurement of HRQoL

The EQ-5D-3L is one of the most widely used HRQoL measurement instruments classified into five dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD). Each dimension contains three functioning response levels (no problems, moderate problems, and extreme problems), generating 243 (3^5) possible health states, with the best state indicated by the response "11111" and the worst health state indicated by the response "33333"[22]. A single health state utility (HSU) score can be assigned to each health state using a value set, developed in a valuation study based on the general population's health preferences.

Four value sets exist for the EQ-5D-3L in China with the first value set developed in 2014 ($3L_{2014}$ value set) using a sample comprising residents mainly from urban areas[23], the second value set developed in 2018 ($3L_{2018}$ value set) adopted a more representative sample of residents from both rural and urban areas[24], the other two value set developed in 2022 ($3L_{2022}$ value set) recruited participants from rural areas of five cities[25]. In this study, we chose to adopt the $3L_{2018}$ value set. The main reason for the choice was based on the participants in the 3L2014 value set being selected conveniently from big cities in urban areas through quota sampling. While the 3L2018 value set, a more representative sample of respondents was obtained from both rural and urban areas using a random sampling method[26]. The rural population accounts for half of the Chinese population, and large disparities exist in socioeconomic status, lifestyle, and health status between urban and rural areas in China[27]. In the two waves of NHSS in the TAR, more than 75% of participants were from farming and pastoral areas. Therefore, the $3L_{2018}$ value set, which more closely matches the distribution of the Tibetan population, was used in this study. To evaluate the robustness and sensitivity of the $3L_{2018}$ value set, we also used the $3L_{2022}$ value set to analyse the main results revealing that the main results of the two value sets had the same trends

(Supplementary Table 1).

Independent variables

In this study, the independent variables were sociodemographic, altitude-related, and clinical disease variables, and health-related behaviours. Sociodemographic variables were sex, age, employment status, educational attainment, and marital status. We divided age into three groups: 15–44, 45–65, and ≥ 65 years old. Employment status was divided into employed, retired, and unemployed. Educational attainment was divided into three groups: illiterate, primary school, junior high school, and above. Marital status was divided into single, married, divorced, and other.

The altitude-related variables included location and altitude. The participants were divided into rural and urban groups based on their geographical location. The NHSS did not collect data on the altitude of their residence; therefore, we used Google Maps to obtain the precise altitude. Altitudes were defined as high (1500–3500 m), very high (3500–5500 m), and extreme altitude (>5500 m), as suggested by the International Society for Mountain Medicine[28]. The average altitude of Tibet is above 4000 m, and the high altitude (3500-5000 m) and extreme altitude areas (> 5000 m) account for 93.69% of the land area of the TAR[29]. The altitude range of the two surveys was 1974～4936 m, and the average altitude was 3863 ± 515 m, with no extreme altitude areas. In addition, we considered the number of villages and participants in different altitude groupings. Therefore, we divided the plateau areas into three altitude groups, high (1500–3500 m), very high (3500–4000 m), and extreme altitude (4000-5000 m) based on the China's policy of subsidizing plateau areas in this study [30]. The altitude classification criterion was consistent in two waves of surveys.

The clinical disease variables included diagnosis of the participant with any illness within two weeks before survey and the number of chronic diseases during the past six months. A chronic condition was defined as a condition diagnosed by a doctor with symptoms persisting or relevant medical treatment continuing over the past six months.

Health-related behavioural variables were current smoking status, divided into three groups: smoking all the time, has ever smoked, and never smoked. Participants were asked to perform weekly physical exercise during the past six months, such as climbing, ball games, equipment exercise, swimming, jogging, etc. The frequency of physical exercise was divided into three groups: never exercised, 1–5 times, and > 6 times.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Statistical analysis

Descriptive statistics were used for participants' characteristics and the reported problems on the five dimensions of the EQ-5D-3L. Continuous variable were described as mean and standard deviation (SD), whereas categorised variable was described as frequency and percentages. Student's *t* test or analysis of variance (ANOVA) was used when variables conformed to an approximately normal distribution; otherwise, the Mann-Whitney *U* test or Kruskal-Wallis H test was used. Categorical variables were compared between the groups using the chi-square test.

The importance of changes in the HSU scores was estimated using effect sizes (ES), which were calculated as the difference between the highest and the lowest HSU scores among the two surveys divided by the pooled standard deviation. The Effect sizes was defined ⩽0.5, 0.5 to 0.8 and ⩾0.8 were small, moderate and large[31]. In this study, the moderate effect size (0.5) was considered as a threshold for minimal importance of changes in the HSU scores. As the HSU score was left-skewed with a large proportion of respondents in full health, the Tobit regression model was used to assess the influencing factors associated with EQ-5D-3L HSU scores. Data were entered into Epidata3.1 and analysed using SPSS 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Participant characteristics

The characteristics of the participants are listed in Table 1. In 2013, more than half of the participants were in the 15–44 years age group (56.2%), and older participants accounted for < 15% of the participants (11.0%) and less than half of the participants were male (46.5%). Moreover, 57% of participants had never received education and 14.98% of the participants were unemployed. More than four out of five participants resided in rural areas (84.9%) with an average altitude of 3838 ± 526 m. Overall, 11.35% of participants reported having a disease during 2 weeks before data collection, while, more than half of participants (65.6%) had no chronic diseases during the past 6 months.

In 2018, the sociodemographic characteristics of the participants were basically the same as those in 2013. The average age was 45.22 ± 14.71 years, and more than half of the participants were female (56.6%). Of the participants, 52.0% never had education, 81.2% were employed, 78.3% were married, and 77.5% lived in rural areas with an average altitude of 3903 ± 495 m. Most of the participants (85.1%) were non-smokers, and 62.3% had never engaged in weekly physical exercise during the past 6 months. Compared two waves of surveys, participants in the 2018 were more female (P<0.001), reported a higher level of education (P<0.001), had a lower employed proportion (P=0.008), more lived in urban with more high altitude (P<0.001).

Participant's HRQoL and its changes

The HSU scores stratified by characteristics of participants in two surveys were listed in Table 2. The mean HSU scores of the participants were 0.969 ± 0.078 in 2013 and 0.966 ± 0.077 in 2018, which showed a significantly decreasing trend (P<0.001, ES=0.136). Figure 1 presents the distribution of participant's HSU scores in two surveys. It revealed a left-skewed distribution with skewness of -4.189 in 2013 and -4.642 in 2018, ranging from 0.170 to 1.000. The states of 11111 (no problems in any dimension) were reported in 74% and 70% of the participants in 2013 and 2018, respectively. The trend in HSU scores was observed decreased in most subgroups.

The highest proportion of reporting health problems was the pain/discomfort dimension (2013:18.1%, 2018: 17.9%). Problems with self-care dimension was least prevalent, 7.7% and 8.5% participants reported in 2013 and 2018, respectively. As compared to the 2013, reported problems increased in mobility (by 1.2%), self-care (by 0.8%), usual activities (by 0.6%), and anxiety/depression (by 3.8%) in 2018. While, reported problems in pain/discomfort decreased by 0.2% (Table 3).

HRQoL of participants at different altitudes

Two survey's findings showed that participants lived in the 3500-4000m group had the highest HSU scores. Similar to the general trend, health state scores in 2018 were slightly lower than those in 2013 at different altitude groups (Table 2). Figure 2 describes the percentage of participants with self-reported health problems by different altitude groups. The distribution trend was generally consistent in two surveys. Participants lived in 3500–4000m had the least reported problems in all five dimensions, while participants lived in 1500–3500m and 4000–5000m reported more problems in pain/discomfort, anxiety/depression and mobility dimensions.

Factors associated with HSU scores

The Tobit regression analyses of the factors associated with HSU scores were presented in Table 4. The result confirmed the decreased trend in HSU scores over time (β = -0.014, P<0.001), after adjustment for variations in the other independent variables. However, the effect sizes of this change did not reach the threshold of minimal clinical importance (ES=0.04). The elderly, the unemployed, the separated/divorced/widowed, and the healthy participants were significant predictors of the HSU score, with generally larger values of ES and reached the threshold of minimal clinical importance.

Discussion

To the best of our knowledge, this is the first study to evaluate the HRQoL of Tibetan population and its changes over time, based on a representative sample from the NHSS of Tibet in China. The HRQoL of Tibetan was lower than general Chinese population, and decreased over time in five years (2013–2018). Moreover, we found Tibetans living at 3500–4000m altitude had the best HRQoL. Our study also identified factors influencing HRQoL including females, elders, unemployed, and more chronic diseases with a negative impact. While, higher education levels, no disease during the past two weeks, and frequent weekly physical exercise had a positive impact on HRQoL of the Tibetan population.

The mean HSU scores of the Tibetan population were 0.969 (SD = 0.078) in 2013 and 0.966 (SD = 0.077) in 2018, higher than that reported in Heilongjiang, Hunan, and Shanxi in China[16, 17, 19]. This may be due to the use of two different 3L value sets used to calculate the HSU score. Compared to the $3L_{2018}$ algorithm, the $3L_{2014}$ algorithm includes a constant term and N3, resulting in a utility value gap between full health and the second-best health state, reducing the values of other health states[32]. Therefore, the $3L_{2018}$ index score was systematically higher than the $3L_{2014}$ index score at absolute levels[26]. The result also indicated that HSU scores of two waves of surveys were significantly lower than the that of the general Chinese population, confirming regional and residential disparities in HRQoL of the Chinese populations[33]. The eastern–middle–western disparities in development have existed historically. Although in recent years China's development strategy has focused more on western areas including implementing poverty alleviation policies, promoting the construction of infrastructure, low taxation, and national level fiscal transfer to the middle and western areas, a huge gap still exists between regions[27] with lower HRQoL in residents of western regions than that of those in the eastern region.

Based on the HRQoL changes between the two waves of surveys, HSU scores in 2018 were slightly lower than those in 2013, and statistical differences existed in the total population and at different demographic characteristics levels. However, the changes between 2013 and 2018 were minimal and failed to reach the threshold minimal clinically important difference of ~0.074 based on EQ-5D-3L[34]. This is consistent with previous studies on the changes in HRQoL in the Chinese population[20, 21]. This could be due to proportion of extreme problems reported by EQ-5D-3L, with 0.42 to 0.45% reporting extreme problems in anxiety/depression and pain/discomfort compared to 2013. According to the $3L_{2014}$ algorithm, the value in level-3 (L3) parameters is larger than level-2 (L2) or level-1 (L1) with increasing health state severity. Hence, for a health transition involving both improvement and deterioration, the magnitude of health gain from improvement in a certain dimension may be offset to a large extent by deterioration in another dimension[26]. Another possible reason may be related to the changing demographic and socioeconomic status in China. Between 2013 and 2018, the government implemented a series of policies, especially the targeting poverty alleviation strategy, driving continuous rapid growth of residents' income and further improving the consumption level and length of life. Life expectancy increased from 76.3–77.0 years during this time[35]. However, the aging of the population, unhealthy lifestyles, and environmental exposure have led to the rising prevalence of chronic diseases and functional limitations, related to lower HRQoL among the Tibetan population.

Pain/discomfort was the most frequently reported problem in this study similar to previous studies in China, however, the absolute proportion of each dimension reported was higher than the general population trends based on the NHSS data[33] and other provincial studies in China[16, 18, 19]. This may be due to the plateau disease[36]. Residents living on the plateau for a long time evolve a unique physiological mechanism to adapt to the environment. However, some residents gradually lose their adaptability and suffer from various acute or chronic diseases related to the plateau environment under the stimulation of continuous hypoxia and low pressure[37]. The two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in 2018, and hypertension has been reported as the most common chronic disease[38]. A previous study reported that the prevalence of hypertension in Tibet is higher than the Chinese national level and is the highest among all provinces, as well as higher than other residents living at high altitudes[39, 40]. As altitude increases, progressive reductions in barometric pressure, air temperature, and air humidity are observed. Headache, shortness of breath, chest tightness, anorexia, dizziness, limb fatigue, and sleep disturbances were common symptoms of Tibetan[38].

Compared with other high-altitudes, we found that Tibetans living at 3500–4000 m had the best HRQoL. This could be attributed to many reasons. First, most Tibetan tend to stay at their altitude of residence for extended periods of time, the complex interaction between genetic and environmental influence led to the extraordinary ability to adapt to their hypoxic environment, and less susceptible to chronic mountain sickness[41]. Second, TAR is a vast territory with a sparse population with high-altitude in the northwest and low in the southeast. The region can be divided into three regions based on altitude. The Qiangtang Plateau in the north (> 5000 m), and the central basin region and Himalayan mountains (4000–5000 m on average). The valleys of the middle and lower reaches of the Yarlung Zangbo River and the three rivers in eastern Tibet have an altitude of 3000–4000 m, and 60% of the population is concentrated there. Of the seven cities surveyed, Lhasa, Shannan, Qamdo, and Shigaze have an average altitude of 3500–4000 m with their GDP ranking among the top four in Tibet according to the Seventh National Census in 2020. Similar results have been reported previously with socioeconomic status significantly associated with higher HRQoL[20]. Socioeconomic status is detrimental to health as it affects people's living and working conditions and restricts accessibility to medical care[42]. Moreover, socioeconomic status affects people's psychological state and cognition of the world around them[43]. During the few last decades, China has implemented strong policies to facilitate economic development in the Qinghai-Tibet plateau (e.g., the Strategy of the Development of China's West). The implementation of supportive strategies should help improve socioeconomic status in the future, including improving public infrastructure, medical service capacity, and disease prevention improving HRQoL.

Those living in low-altitude areas (1500–3500m) reported the most problems in anxiety/depression consistent with previous studies. A large sample survey of the prevalence of depression among Tibetans of the Qinghai-Tibet Plateau was 28.6%, higher than that in the general Chinese population and higher than that reported in a western study with high-altitude samples[44]. The prevalence of depression is significantly correlated with climatic pressure, particularly altitude[45]. Generally, the combined effects of harsh natural environment on the plateau, high-altitude hypoxia, low atmospheric pressure, intense ultraviolet radiation, relatively weak community support caused by low population density, and lack of access to mental health resources increases the severity of depression among those living in high-altitude areas[46-48]. In this study, the area with an altitude of 1500–3500 m was located southeast of the TAR. Nyingchi City, with an average altitude of 3100 m, has the lowest altitude and wettest climate in TAR. With convenient transportation and multiple splendid sceneries, tourism is the main source of income in this area, attracting millions of people traveling for sightseeing, mountaineering, and trekking every year[49]. Previous studies have reported a significant association between tourism impact and residents' quality of life[50, 51]. Tourism provides employment opportunities and tax revenues, supports economic diversity, and services and products enjoyed by residents[52, 53]. However, negative impacts of tourisms on residents' HRQoL have been reported including crowding, traffic and parking issues, criminality, and cost of living, changes in hosts' way of life, and friction between tourists and residents[54]. The perceived negative impacts, negative emotions, pressure, and relative deprivation of the residents will affect their subjective well-being, leading to psychological problems including anxiety and depression.

This study had several limitations. First, this study did not recruit the same pool of participants in two waves of surveys, making it difficult to identify causal associations. However, the same cities were selected, and the participants may partly overlap. Second, the participants recruited in the surveys were those had lived in Tibet for more than six months; however, we could not determine if they were born in Tibet or came to work from other low-altitude areas. A small-scale survey could be conducted to refine the participant inclusion criteria to validate the study findings in the future. Third, many studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys because of its small cognitive burden. Moreover, the comparison of the two waves of surveys indicated the overall changing trends in HRQoL of participants were able to be derived from EQ-5D-3L.

Conclusion

This study revealed the HRQoL of Tibetan population was lower than general Chinese population, and decreased over time between 5 years. There were differences in HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m having the best quality of life. More attention should be paid to those Tibetans who are older, female, unemployed and without formal education. Targeted policies and strategies need to be strengthened, including plateau subsidies, poverty alleviation, primary health service capacity, standardized management of chronic diseases, and health education.

Acknowledgements

We gratefully acknowledge the contribution of the investigators from Preventive Medicine at Medical College of Tibet University, and we also thank all the participants

who participated in the study.

Funding statement

This work was supported by the Sixth National Health Service Survey Project in Tibet (grant number 18080027); and China Medical Board (grant number 11-086).

Competing interest statement

All authors declare no competing interests.

Author Contributions

SPL and ZXDW have substantial contributions to conception and design, acquisition of funding, data and interpretation of data. CDZG and ZXCM were involved in the acquisition of data. LD, ZS and CFL were responsible for the data analysis and interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM and CFL revised it critically for important intellectual content, LD and SPL was responsible for the decision to submit the manuscript, and all authors contributed to final approval of the manuscript.

Ethics statements

Patient consent for publication

Not applicable.

Ethics approval

This study involves human participants and was approved. This study was conducted with the approval of the National Health Commission of the People's Republic of China and the Health Commission of Tibet autonomous region.

Data availability statement

Data are available upon reasonable request. We have included all the data produced in the present work in the manuscript. Note that the raw data used in the study were obtained from National Health Service Surveys of China. We are unable to attach all the raw data for each participant in this paper due to the ethical restrictions.

References

1. Calvert M, Blazeby J, Altman DG, et al. Reporting of Patient-Reported Outcomes in Randomized Trials. JAMA 2013; 309:814

2. Karimi M, Brazier J. Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? Pharmacoeconomics 2016; 34:645-9

3. Macran S, Weatherly H, Kind P. Measuring population health: a comparison of three generic health status measures. Med Care 2003; 41:218-31

4. Goodwin E, Green C. A Systematic Review of the Literature on the Development of Condition-Specific Preference-Based Measures of Health. Appl Health Econ Health Policy 2016; 14:161-83

5. Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: Past, Present and Future. Appl Health Econ Health Policy 2017; 15:127-37

6. Mingji C, Onakpoya IJ, Perera R, Ward AM, Heneghan CJ. Relationship between altitude and the prevalence of hypertension in Tibet: a systematic review. Heart 2015; 101:1054-60

7. Tibet Autonomous Region Statistics Bureau. Communiqué on Main Data of the Seventh National Population Census of Tibet Autonomous Region., 2021

8. Zheng Z. Research on the village public service system innovation of agricultural and pastoral areas in tibet--from the perspective of integrated anti-poverty development. Ethnology Journal 2012:34-43

9. Beall, Cm. An ecology of high-altitude infancy. AMER J PHYS ANTHROPOL 2006

10. Mallet RT, Burtscher J, Richalet JP, Millet GP, Burtscher M. Impact of High Altitude on Cardiovascular Health: Current Perspectives. Vasc Health Risk Manag 2021; 17:317-35

11. Kious BM, Bakian A, Zhao J, et al. Altitude and risk of depression and anxiety: findings from the intern health study. Int Rev Psychiatry 2019; 31:637-45

12. Wang F, Liu S, Zhang Q, et al. Prevalence of Depression in Older Nursing Home Residents in High and Low Altitude Regions: A Comparative Study. Front Psychiatry 2021; 12:669234

13. Song C, Chongsuvivatwong V, Wangdui S, et al. Coverage and effectiveness of hypertension screening in different altitudes of Tibet autonomous region. BMC Public Health 2021; 21:33

14. Graham C, Zhou S, Zhang J. Happiness and Health in China: The Paradox of Progress. World Dev 2017:S305750X-S15308056X

15. Huang L, Wang Z, Wang H, et al. Nutrition transition and related health challenges over decades in China. Eur J Clin Nutr 2021; 75:247-52

16. Huang W, Yu H, Liu C, et al. Assessing Health-Related Quality of Life of Chinese Adults in Heilongjiang Using EQ-5D-3L. Int J Environ Res Public Health 2017; 14

17. Si L, Shi L, Chen M, Palmer AJ. Establishing benchmark EQ-5D-3L population health state utilities and identifying their correlates in Gansu Province, China. Qual Life Res 2017; 26:3049-58

18. Tan Z, Liang Y, Liu S, et al. Health-related quality of life as measured with EQ-5D among populations with and without specific chronic conditions: a population-based survey in Shaanxi Province, China. PLoS One 2013; 8:e65958

19. Deng X, Dong P, Zhang L, et al. Health-related quality of life in residents aged 18 years and older with and without disease: findings from the First Provincial Health Services Survey of Hunan, China. BMJ Open 2017; 7:e15880

20. Yao Q, Liu C, Zhang Y, Xu L. Changes in health-related quality of life of Chinese populations measured by the EQ-5D-3 L: a comparison of the 2008 and 2013 National Health Services Surveys. Health Qual Life Outcomes 2019; 17:43

21. Wang D, Xie S, Wu J, Sun B. The trend in quality of life of Chinese population: analysis based on population health surveys from 2008 to 2020. BMC Public Health 2023; 23:167
22. Brooks R. EuroQol: the current state of play. Health Policy 1996; 37:53-72
23. Liu GG, Wu H, Li M, Gao C, Luo N. Chinese time trade-off values for EQ-5D health states. Value Health 2014; 17:597-604
24. Zhuo L, Xu L, Ye J, et al. Time Trade-Off Value Set for EQ-5D-3L Based on a Nationally Representative Chinese Population Survey. Value Health 2018; 21:1330-7
25. Liu GG, Guan H, Jin X, Zhang H, Vortherms SA, Wu H. Rural population's preferences matter: a value set for the EQ-5D-3L health states for China's rural population. Health Qual Life Outcomes 2022; 20:14
26. Zhang RY, Wang W, Zhou HJ, Xuan JW, Luo N, Wang P. A head-to-head comparison of the EQ-5D-3L index scores derived from the two EQ-5D-3L value sets for China. Health Qual Life Outcomes 2022; 20:80
27. Sun S, Chen J, Johannesson M, et al. Regional differences in health status in China: population health-related quality of life results from the National Health Services Survey 2008. Health Place 2011; 17:671-80
28. Woolcott OO, Ader M, Bergman RN. Glucose homeostasis during short-term and prolonged exposure to high altitudes. Endocr Rev 2015; 36:149-73
29. Tibet Autonomous Region Tourism Development Office. Tibet's first geographic census., 2017
30. The Ministry of Labor and Personnel and the Ministry of Finance. The Ministry of Labor and Personnel and the Ministry of Finance responded to the People's Government of Tibet Autonomous Region on issues concerning the implementation of temporary subsidies for workers in plateau areas., 1984
31. Cohen J. A power primer. Psychol Bull 1992; 112:155-9
32. Pan CW, Zhang RY, Luo N, et al. How the EQ-5D utilities are derived matters in Chinese diabetes patients: a comparison based on different EQ-5D scoring functions for China. Qual Life Res 2020; 29:3087-94
33. Yao Q, Liu C, Zhang Y, Xu L. Population norms for the EQ-5D-3L in China derived from the 2013 National Health Services Survey. J Glob Health 2021; 11:8001
34. Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. Qual Life Res 2005; 14:1523-32
35. National Health Commission. 2021 China Health Statistics Yearbook. Beijing: China Union Medical University Press, 2022
36. Netzer N, Strohl K, Faulhaber M, Gatterer H, Burtscher M. Hypoxia-related altitude illnesses. J Travel Med 2013; 20:247-55
37. Crawford JE, Amaru R, Song J, et al. Natural Selection on Genes Related to Cardiovascular Health in High-Altitude Adapted Andeans. Am J Hum Genet 2017; 101:752-67
38. Deng R, Labasangzhu, Zhaxideji, et al. Illness prevalence rate in Tibet, China: data from the 2018 National Health Service Survey. BMC Public Health 2020; 20:955
39. Li K, Liang Y, Sun Y, et al. The relationship between polymorphisms at 17 gene sites and hypertension among the Aboriginal Tibetan people. Biomed Environ Sci 2012; 25:526-32
40. Wang J, Zhang L, Wang F, Liu L, Wang H. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. Am J Hypertens 2014; 27:1355-61
41. Wu T. The Qinghai-Tibetan plateau: how high do Tibetans live? High Alt Med Biol 2001; 2:489-99

42. Jiang Y, Hesser JE. Associations between health-related quality of life and demographics and health risks. Results from Rhode Island's 2002 behavioral risk factor survey. Health Qual Life Outcomes 2006; 4:14

43. Matthews KA, Gallo LC. Psychological perspectives on pathways linking socioeconomic status and physical health. Annu Rev Psychol 2011; 62:501-30

44. Golicki D, Niewada M, Jakubczyk M, Wrona W, Hermanowski T. Self-assessed health status in Poland: EQ-5D findings from the Polish valuation study. Pol Arch Med Wewn 2010; 120:276-81

45. Gamboa JL, Caceda R, Arregui A. Is depression the link between suicide and high altitude? High Alt Med Biol 2011; 12:403-4, 405

46. Wang J, Zhou Y, Liang Y, Liu Z. A Large Sample Survey of Tibetan People on the Qinghai-Tibet Plateau: Current Situation of Depression and Risk Factors. Int J Environ Res Public Health 2019; 17

47. Ding Y, Shi B, Su G, et al. Assessing Suitability of Human Settlements in High-Altitude Area Using a Comprehensive Index Method: A Case Study of Tibet, China. Sustainability 2021; 13

48. Li XY, Wu XY, Fu C, Shen XF, Wu YH, Wang T. Effects of acute mild and moderate hypoxia on human mood state. Space Med Med Eng (Beijing) 2000; 13:1-5

49. Chen Y, Zhang G, Chen Z, et al. A warming climate may reduce health risks of hypoxia on the Qinghai-Tibet Plateau. Sci Bull (Beijing) 2022; 67:341-4

50. Kim, Hyelin, Uysal, Muzaffer, Woo, Eunju. Life satisfaction and support for tourism development. Annals of tourism research: A social sciences journal 2015; 50:84-97

51.Vargas-Sanchez A, Plaza-Mejia MDLA, Porras-Bueno N. Understanding Residents' Attitudes toward the Development of Industrial Tourism in a Former Mining Community. J Travel Res 2009; 47:373-87

52. Aref F. The Effects of Tourism on Quality of Life: A Case Study of Shiraz, Iran. Life ence Journal 2011; 8:26-30

53. Andereck, Kathleen L, Nyaupane, Gyan P. Exploring the Nature of Tourism and Quality of Life Perceptions among Residents. J Travel Res 2011; 11:25-34

54. Andereck KL, Valentine KM, Knopf RC, Vogt CA. Residents' perceptions of community tourism impacts. Ann Tour Res 2005; 32:1056-76

Table 1 Characteristics of the participants

Characteristics	2013 (N=10247)		2018 (N=6436)		Total (N=16683)		*P*-value
	N	%	N	%	N	%	
Age groups							<0.001
15-44 years	5754	56.2	3159	49.1	8913	53.4	
45-64 years	3363	32.8	2568	39.9	5931	35.6	
≥65 years	1130	11.0	709	11.0	1839	11.0	
Gender							<0.001
Male	4766	46.5	2792	43.4	7558	45.3	
Female	5481	53.5	3644	56.6	9125	54.7	
Educational attainment							<0.001
Illiterate	5841	57.0	3348	52.0	9189	55.1	
Primary school	3080	30.1	2143	33.3	5223	31.3	
Junior high school and above	1326	12.9	945	14.7	2271	13.6	
Employment							0.008
Employed	8514	83.1	5228	81.3	13742	82.4	
Retired	198	1.9	131	2.0	329	2.0	
Unemployed	1535	15.0	1077	16.7	2612	15.7	
Marital status							<0.001
Single	1563	15.3	748	11.6	2311	13.9	
Married	7718	75.3	5037	78.3	12755	76.5	
Separated/divorced/widowed	966	9.4	651	10.1	1617	9.7	
Location							<0.001
Rural	8699	84.9	4988	77.5	13687	82.0	
Urban	1548	15.1	1448	22.5	2996	18.0	
Altitude, m (Mean±SD)	3838±526	-	3903 ± 495	-	3863±515	-	
Altitude groups							<0.001
1500-3500 m	2219	21.7	1123	17.5	3342	20.0	
3500-4000 m	4816	47.0	2933	45.6	7749	46.4	
4000-5000 m	3212	31.3	2380	36.9	5592	33.5	
Diseased during the past 2 weeks							0.366
Yes	1152	11.4	701	10.9	1853	11.1	
No	9002	88.6	5735	89.1	14737	88.3	
Number of chronic diseases							<0.001
0	6726	65.6	3684	57.2	10410	62.4	
1	2634	25.7	1743	27.1	4377	26.2	
≥2	887	8.7	1009	15.7	1896	11.4	
Smoking							<0.001
Smoker	1424	13.9	724	11.2	2148	12.9	
Ex-smoker	487	4.7	238	3.7	725	4.3	
Non-smoker	8336	81.4	5474	85.1	13810	82.8	

Weekly physical exercise during the past 6 months							<0.001
Never exercised	9437	92.3	4054	63.0	13491	80.9	
1–5 times	511	5.0	1247	19.4	1758	10.5	
≥6 times	279	2.7	1135	17.6	1414	8.5	

Table 2 Health state utility score stratified by characteristics of participants in two surveys

Characteristics	2013 (N=10247)	2018 (N=6436)	Effect Size (ES)	*P*-value
Age				
15-44 years	0.987(0.049)	0.987(0.041)	0.000	0.003
45-64 years	0.962(0.078)	0.959(0.076)	0.039	0.013
≥65 years	0.900(0.133)	0.899(0.139)	0.007	0.973
Gender				
Male	0.975(0.071)	0.973(0.070)	0.030	0.002
Female	0.964(0.083)	0.961(0.082)	0.036	<0.001
Employment				
Employed	0.977(0.064)	0.976(0.058)	0.016	<0.001
Retired	0.945(0.116)	0.965(0.057)	0.205	0.493
Unemployed	0.926(0.117)	0.918(0.128)	0.066	0.011
Educational attainment				
Illiterate	0.959(0.088)	0.956(0.088)	0.034	<0.001
Primary school	0.979(0.064)	0.971(0.069)	0.121	<0.001
Junior high school and above	0.990(0.046)	0.991(0.038)	0.023	0.180
Marital status				
Single	0.975(0.086)	0.979(0.068)	0.050	0.182
Married	0.973(0.069)	0.969(0.069)	0.058	<0.001
Separated/divorced/widowed	0.928(0.111)	0.925(0.124)	0.026	0.832
Location				
Rural	0.967(0.080)	0.966(0.077)	0.013	0.001
Urban	0.980(0.065)	0.967(0.080)	0.183	<0.001
Altitude groups				
1500-3500m	0.966(0.078)	0.961(0.079)	0.064	<0.001
3500-4000m	0.975(0.072)	0.970(0.073)	0.069	<0.001
4000-5000m	0.963(0.084)	0.963(0.081)	0.000	0.411
Diseased during the past 2 weeks				
Yes	0.933(0.111)	0.934(0.100)	0.009	0.303
No	0.974(0.072)	0.970(0.073)	0.055	<0.001
Number of chronic diseases				
0	0.983(0.057)	0.986(0.049)	0.055	0.331
1	0.950(0.097)	0.951(0.091)	0.010	0.663
≥2	0.920(0.113)	0.919(0.106)	0.009	0.223
Smoking				
Smoker	0.985(0.056)	0.984(0.048)	0.019	0.094
Ex-smoker	0.965(0.073)	0.954(0.089)	0.138	0.146
Non-smoker	0.967(0.081)	0.964(0.080)	0.037	<0.001
Weekly physical exercise during the past 6 months				
Never exercised	0.969(0.079)	0.961(0.086)	0.098	<0.001
1–5 times	0.967(0.071)	0.973(0.066)	0.087	0.004

≥6 times	0.985(0.044)	0.977(0.051)	0.171	<0.001
Total	0.969(0.078)	0.966(0.077)	0.136	<0.001

Table 3 health problems reported by participants based on EQ-5D-3L

EQ-5D-3L	2013		2018		χ2	*P*-value
	N	%	N	%		
Mobility					12.794	0.002
No problem	8956	87.4	5544	86.2		
Moderate problem	1221	11.9	865	13.4		
Extreme problem	70	0.7	27	0.4		
Self-care					2.791	0.248
No problem	9453	92.3	5891	91.5		
Moderate problem	733	7.1	502	7.8		
Extreme problem	61	0.6	43	0.7		
Usual activities					1.407	0.495
No problem	9014	88.0	5624	87.4		
Moderate problem	1077	10.5	714	11.1		
Extreme problem	156	1.5	98	1.5		
Pain/discomfort					7.543	0.023
No problem	8393	81.9	5283	82.1		
Moderate problem	1750	17.1	1059	16.4		
Extreme problem	104	1.0	94	1.5		
Anxiety/depression					52.078	<0.001
No problem	9111	88.9	5479	85.1		
Moderate problem	1047	10.2	874	13.6		
Extreme problem	89	0.9	83	1.3		

Table 4 Tobit regression analysis on the EQ-5D-3L HSU scores

Independent variable	β	SE	*P*-value	95%CI	Effect Size
Age years (ref.:15-44 years)					
45-64 years	-0.071	0.004	<0.001	-0.079, -0.063	0.43
≥65 years	-0.142	0.006	<0.001	-0.153, -0.130	1.26
Gender (ref.: male)					
Female	-0.025	0.004	<0.001	-0.033, -0.017	0.14
Educational attainment (ref.: illiterate)					
Primary school	0.016	0.004	<0.001	0.009,0.024	-0.22
Junior high school and above	0.055	0.007	<0.001	0.041, 0.069	-0.40
Employment (ref.: employed)					
Retired	-0.036	0.012	0.003	-0.060, -0.012	0.38
Unemployed	-0.073	0.005	<0.001	-0.082, -0.064	0.72
Marital status (ref.: single)					
Married	0.018	0.006	0.002	0.007,0.029	0.07
Separated/divorced/widowed	-0.007	0.008	0.335	-0.022 0.008	0.52
Location (ref.: rural)					
Urban	0.039	0.005	<0.001	0.029, 0.049	0.00
Altitude groups (ref.: 1500-3500m)					
3500-4000m	0.028	0.005	<0.001	0.019, 0.037	-0.11
4000-5000m	0.011	0.004	0.017	0.002, 0.021	0.03
Diseased during the past 2 weeks (ref.: Yes)					
No	0.042	0.005	<0.001	0.033, 0.052	-0.50
Number of chronic diseases (ref.: 0)					
1	-0.083	0.004	<0.001	-0.091, -0.075	0.34

≥2	-0.125	0.005	<0.001	-0.136, -0.115	0.13
Smoking (ref.: smoker)					
Ex-smoker	-0.036	0.010	<0.001	-0.055, -0.018	0.34
Non-smoker	-0.011	0.006	0.086	-.0233,0.002	0.13
Weekly physical exercise (ref.: never exercised)					
1–5 times	0.032	0.006	<0.001	0.020, 0.043	0.00
≥6 times	0.050	0.007	<0.001	0.036, 0.064	-0.13
Year (ref.: 2013)					
2018	-0.014	0.004	<0.001	-0.022, -0.007	0.04

Figure legends

Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

Figure 2a Proportions of health problems reported by participants at different altitude in 2013

Figure 2b Proportions of health problems reported by participants at different altitude in 2018

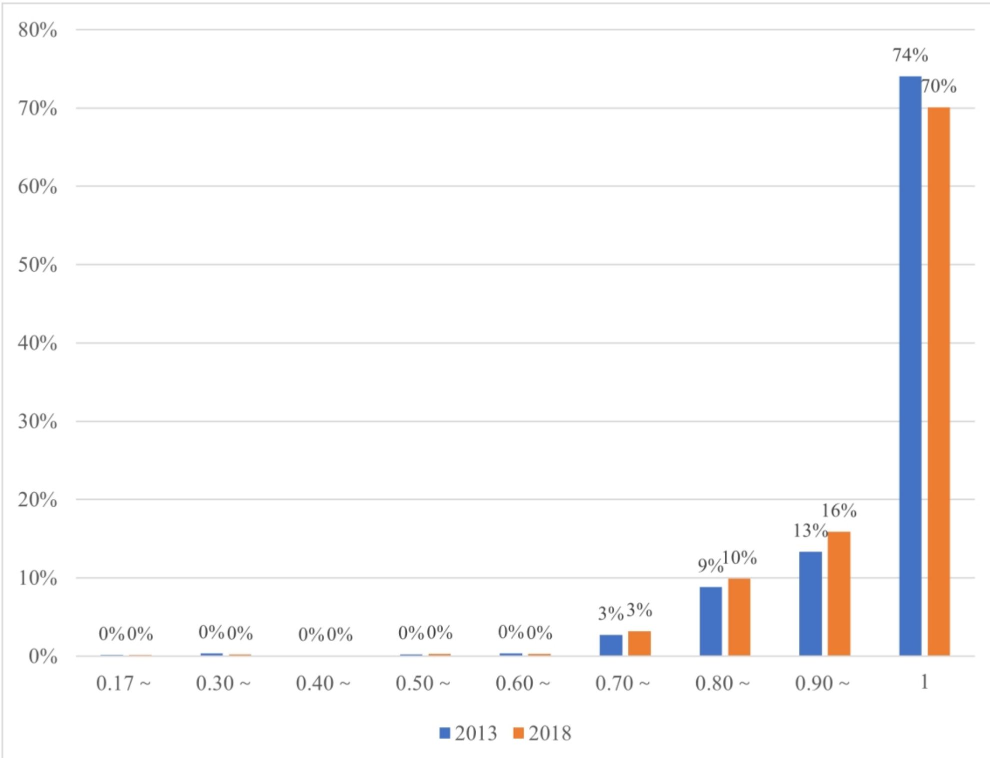

Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

146x111mm (330 x 330 DPI)

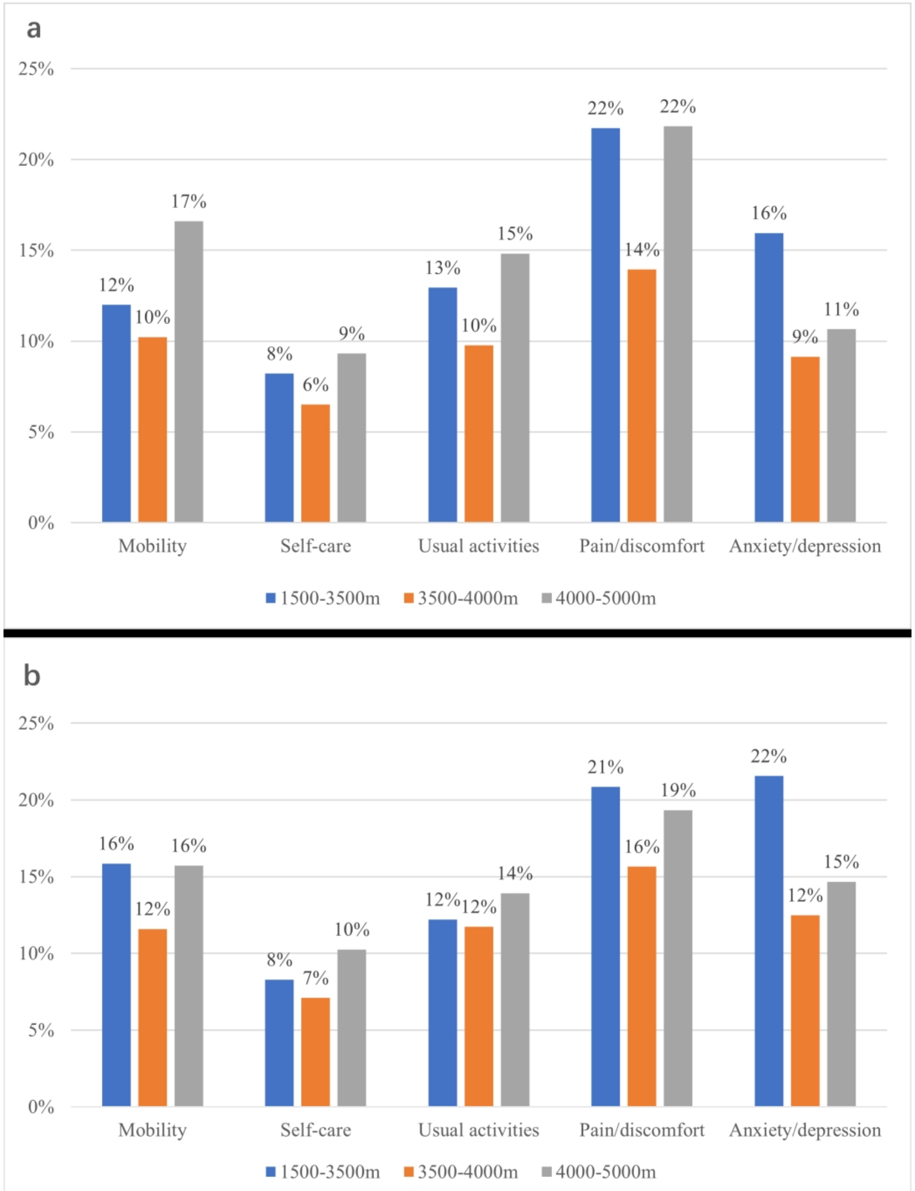

Figure 2a Proportions of health problems reported by participants at different altitude in 2013
Figure 2b Proportions of health problems reported by participants at different altitude in 2018

146x193mm (330 x 330 DPI)

Supplementary Table 1 Tobit regression analysis on the EQ-5D-3L HSU scores in different altitudes using $3L_{2022}$ value set

Characteristics	Total			<3500m			3500-4000m			>4000m		
	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value	Coe	SE	*P*-value
Age years (ref.:15-44 years)												
45-64 years	-0.032	0.002	<0.001	-0.040	0.005	<0.001	-0.027	0.003	<0.001	-0.039	0.004	<0.001
≥65 years	-0.113	0.004	<0.001	-0.111	0.009	<0.001	-0.096	0.005	<0.001	-0.136	0.007	<0.001
Gender (ref.: male)												
Female	-0.011	0.002	<0.001	-0.012	0.005	0.017	-0.006	0.003	0.071	-0.021	0.004	<0.001
Educational attainment (ref.: illiterate)												
Primary school	0.011	0.002	<0.001	0.002	0.005	0.687	0.012	0.003	<0.001	0.007	0.004	0.115
Junior high school and above	0.014	0.003	<0.001	0.022	0.007	0.003	0.010	0.004	0.025	0.012	0.007	0.083
Employment (ref.: employed)												
Retired	-0.008	0.007	0.301	-0.025	0.015	0.086	0.011	0.010	0.282	-0.030	0.020	0.133
Unemployed	-0.060	0.003	<0.001	-0.094	0.008	<0.001	-0.049	0.004	<0.001	-0.072	0.005	<0.001
Marital status (ref.: single)												
Married	0.017	0.003	<0.001	0.017	0.008	0.027	0.018	0.004	<0.001	0.016	0.006	0.005
Separated/divorced/widowed	-0.004	0.004	0.342	0.011	0.011	0.327	0.001	0.006	0.931	-0.020	0.008	0.016
Location (ref.: rural)												
Urban	0.020	0.003	<0.001	0.004	0.010	0.651	0.029	0.004	<0.001	-0.003	0.005	0.475
Diseased during the past 2 weeks (ref.: Yes)												
No	0.036	0.003	<0.001	0.028	0.007	<0.001	0.048	0.005	<0.001	0.027	0.005	<0.001
Number of chronic diseases (ref.: 0)												
1	-0.039	0.002	<0.001	-0.030	0.006	<0.001	-0.045	0.003	<0.001	-0.030	0.004	<0.001
≥2	-0.083	0.003	<0.001	-0.063	0.008	<0.001	-0.093	0.005	<0.001	-0.072	0.006	<0.001
Smoking (ref.: smoker)												

Ex-smoker	-0.012	0.005	0.029	0.015	0.014	0.274	0.001	0.008	0.935	-0.028	0.009	0.002
Non-smoker	-0.003	0.003	0.314	-0.009	0.007	0.214	-0.002	0.004	0.669	-0.002	0.006	0.800
Weekly physical activities (ref.: never exercised)												
1–5 times	0.019	0.003	<0.001	0.009	0.008	0.241	0.024	0.004	<0.001	0.003	0.006	0.664
≥6 times	0.028	0.004	<0.001	0.026	0.009	0.007	0.026	0.005	<0.001	0.022	0.007	0.002

Note: Coe, coefficient; SE, standard error.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	P1,2

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	P4-5
Objectives	#3	State specific objectives, including any prespecified hypotheses	P6
Methods			
Study design	#4	Present key elements of study design early in the paper	P6-7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	P6-7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	P7-10

Bias	#9	Describe any efforts to address potential sources of bias	P6
Study size	#10	Explain how the study size was arrived at	P6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	P6-7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	P10-11
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	P10
Statistical methods	#12c	Explain how missing data were addressed	P10
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	P10-11
Statistical methods	#12e	Describe any sensitivity analyses	P10-11
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	P11
Participants	#13b	Give reasons for non-participation at each stage	P6

Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	P11
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	P11
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	P11-12
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P12-13
Main results	#16b	Report category boundaries when continuous variables were categorized	P12-13
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	P12-13
Discussion			
Key results	#18	Summarise key results with reference to study objectives	P13-14

Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	P18-19
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	P14-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	P19
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P20

 This checklist was completed on 14. February 2023 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai