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

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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

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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 km², 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].

1 HRQoL refers to the impact of health on the quality of life of individuals focusing on individuals' health
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3 influencing their goals, expectations, standards, and concerns. It is a multidimensional concept referring to
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5 people's capacity to perform daily activities (i.e., functioning) in addition to their perspective and subjective
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7 management of their health[15]. Thus, HRQoL attempts to represent quality of life in the context of one's
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9 health and illness[16]. The EuroQol5-Dimensions (EQ-5D) is the most widely used preference-based
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11 instrument to measure and evaluate HRQoL in population surveys, clinical studies, and economic
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13 evaluations[17]. The EQ-5D-3L was included in the 2008 National Health Services Surveys (NHSS) for the
14
15 first time to assess the population health status in China¹⁸.
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22 Previous studies have assessed the population HRQoL using EQ-5D-3L in mainland China including
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24 Heilongjiang [18], Gansu [19], Shanxi [20], and Hunan[21]. However, these studies focused on low-altitude
25
26 areas. Thus, the health consequences of living at high-altitudes are underexplored. Moreover, all previous
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28 studies are cross-sectional, and no studies have compared data between two rounds of surveys. Additionally,
29
30 previous studies on the health status of Tibetan population are limited due to the geographical environment,
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32 lack of basic resources and facilities, and low population density. Therefore, evaluation of HRQoL and its
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34 changes in the Tibetan population is important to explore the effects of high-altitude to identify potential
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36 altitude-health risks. Therefore, the aim of this study was to assess the HRQoL of Tibetan people and its
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38 changes over time, and the impact of different high-altitudes on HRQoL based on the Health Service Survey
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40 of Tibet in 2013 and 2018.
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48 **Methods**

49 **Study design and population**

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51 In this study, data were extracted from the 2013 and 2018 NHSS of the TAR in China. A four-stage stratified
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53 cluster probability sampling strategy was used to select representative participants. Each stage had a
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1 systematic random sampling approach. In the first stage, 22 counties (both in 2013 and 2018) were selected
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3 from the seven cities in Tibet in proportion to their population size. In the second stage, 44 and 50
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5 townships/sub-districts were identified in 2013 and 2018, respectively, in the selected counties. Then, three
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7 residential villages or communities were randomly selected from each township or sub-district. Finally, 20
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9 households from each residential community or village were randomly selected for participation.
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14 Questionnaires were administered to the participants through face-to-face interviews. The students majoring
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16 in Preventive Medicine at Medical College of Tibet University were uniformly recruited and trained to be
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18 interviewers by supervisors who had participated in national training. Pre-survey training workshops were
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20 offered to all interviewers following a standardised protocol. Eligible interviewers had to demonstrate proper
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22 understanding of the purpose of the NHSS and their ability to meet data collection standards developed by the
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24 Centre for Health Statistics and Information. The interviewers visited the selected households, and all family
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26 members in a sampled household were eligible to participate in the survey. Before the survey commenced,
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28 participants were informed of the survey's purposes and procedure and then provided informed consent.
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35 In total, 14752 participants in 2013 and 13106 participants in 2018 completed the survey. The exclusion
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37 criteria in this study were as follows: (1) participants aged < 15 years (n = 3412 and 2677 in 2013 and 2018,
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39 respectively), based on the eligibility for EQ-5D-3L; (2) participants who did not answer the questions by
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41 themselves (n = 1001 and 3798 in 2013 and 2018, respectively); (3) participants with missing values for key
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43 variables (n = 4 and 1 in 2013 and 2018, respectively); and (4) participants with ethnicities other than Tibetan
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45 (n = 88 and 194 in 2013 and 2018, respectively). Overall, final sample size of 10247 in 2013 and 6436 in 2018
46
47 were included in this study.
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52 53 **Measurement of HRQoL**

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56 The EQ-5D-3L is one of the most widely used HRQoL measurement instruments classified into five
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58 dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and
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1 anxiety/depression (AD). Each dimension contains three functioning response levels (no problems, moderate
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3 problems, and extreme problems), generating 243 (3^5) possible health states, with the best state indicated by
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5 the response “11111” and the worst health state indicated by the response “33333”[22]. A single utility index
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7 score can be assigned to each health state using a value set, developed in a valuation study based on the general
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9 population’s health preferences.
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14 Four value sets exist for the EQ-5D-3L in China with the first value set developed in 2014 (3L₂₀₁₄ value
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16 set) using a sample comprising residents mainly from urban areas[23], the second value set developed in 2018
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18 (3L₂₀₁₈ value set) adopted a more representative sample of residents from both rural and urban areas[24], the
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20 other two value set developed in 2022 (3L₂₀₂₂ value set) recruited participants from rural areas of five cities[25].
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22 In this study, we chose to adopt the 3L₂₀₁₈ value set, although the 3L₂₀₁₄ value set has been used more
23
24 frequently than the 3L₂₀₁₈ value set. The main reason for the choice was based on the participants in the
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26 3L₂₀₁₄ value set being selected conveniently from big cities in urban areas through quota sampling. While
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28 the 3L₂₀₁₈ value set, a more representative sample of respondents was obtained from both rural and urban
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30 areas using a random sampling method[26]. The rural population accounts for half of the Chinese population,
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32 and large disparities exist in socioeconomic status, lifestyle, and health status between urban and rural areas
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34 in China[27]. In the two NHSS in the TAR, more than 75% of participants were from farming and pastoral
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36 areas. The theoretical utility index score of the 3L₂₀₁₈ value set ranges from 0.170–1, with 1 representing full
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38 health[24]. To evaluate the robustness and sensitivity of the 3L₂₀₁₈ value set, we also used the 3L₂₀₂₂ value set
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40 to analyse the main results revealing that the main results of the two value sets had the same trends
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42 (Supplementary Table 1).
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53 **Independent variables**

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55 In this study, the independent variables were altitude-related, sociodemographic, and clinical disease variables,
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57 and health-related behaviours. The altitude-related variables included location and altitude. The participants
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1 were divided into rural and urban groups based on their geographical location. The NHSS did not collect data
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3 on the altitude of their residence; therefore, we used Google Maps to obtain the precise altitude. Altitudes
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5 were defined as high (1500–3500 m), very high (3500–5500 m), and extreme altitude (>5500 m), as suggested
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7 by the International Society for Mountain Medicine[28]. In this study, based on the China's policy of
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9 subsidising plateau areas[29], we divided the plateau areas into three altitude groups, high (< 3500 m), very
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11 high (3500–4000 m), and extreme altitude (> 4000 m).
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15 Sociodemographic variables were sex, age, employment status, educational attainment, and marital status.
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17 We divided age into three groups: 15–44, 45–65, and ≥ 65 years old. Employment status was divided into
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19 employed, retired, and unemployed. Educational attainment was divided into three groups: illiterate, primary
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21 school, junior high school, and above. Marital status was divided into single, married, divorced, and other.
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26 The clinical disease variables included diagnosis of the participant with any illness within two weeks before
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28 survey and the number of chronic diseases during the past six months. A chronic condition was defined as a
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30 condition diagnosed by a doctor with symptoms persisting or relevant medical treatment continuing over the
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32 past six months.
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36 Health-related behavioural variables were current smoking status, divided into three groups: smoking all
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38 the time, has ever smoked, and never smoked. Participants were asked to perform weekly physical activities
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40 during the past six months, and the frequency of physical activities included three groups: exercised never,
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42 1–5 times, and > 6 times.
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47 **Patient and public involvement**

48 Patients and the public were not involved in the design, conduct, reporting or dissemination plans of this
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50 research.
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54 **Statistical analysis**

55 Descriptive statistics were used for participants' characteristics and the reported problems on the five
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1 dimensions of the EQ-5D-3L. Continuous variables were described as mean and standard deviation (SD),
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4 whereas categorised variables were described as frequency and percentages. Student's *t* test or analysis of
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6 variance (ANOVA) was used when variables conformed to an approximately normal distribution; otherwise,
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8 the Mann-Whitney *U* test or Kruskal-Wallis *H* test was used. Categorical variables were compared between
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10 the groups using the chi-square test. As the EQ-5D-3L utility index was left-skewed with a large proportion
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12 of respondents in full health, a Tobit regression model was used to assess the association between influencing
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14 factors and the EQ-5D-3L health utility index. Data were entered into Epidata3.1 and analysed using SPSS
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16 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was considered statistically significant.
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22 Results

23 Participant characteristics

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26 The baseline characteristics of the participants are listed in Table 1. In 2013, more than half of the participants
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28 were in the 16–44 years age group (56.15%), and older participants accounted for < 15% of the participants
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30 (11.03%) and less than half of the participants were male (46.51%). Moreover, 57% of participants had never
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32 received education and 14.98% of the participants were unemployed. More than four out of five participants
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34 resided in rural areas (84.89%) with an average altitude of 3838 ± 526 m. Overall, 11.35% of participants
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36 reported having a disease during 2 weeks before data collection, while, more than half of participants (65.64%)
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38 had no chronic diseases during the past 6 months.
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46 In 2018, the sociodemographic characteristics of the participants were basically the same as those in 2013.
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48 The average age was 45.22 ± 14.71 years, and more than half of the participants were female (56.62%). Of
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50 the participants, 52.02% never had education, 81.23% were employed, 78.26% were married, and 77.50%
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52 lived in rural areas with an average altitude of 3903 ± 495 m. Most of the participants (85.05%) were non-
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54 smokers, and 62.99% had never engaged in weekly physical activities during the past 6 months. Characteristics
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56 of the participants in different altitudes were shown in supplementary Table 2.
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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

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

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33 To the best of our knowledge, this is the first study to evaluate the impact of different high-altitudes on HRQoL
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35 of Tibetan people and its changes over time, based on a representative sample from the NHSS of Tibet in
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37 China. HRQoL changes over time in the Tibetan population in five years (2013–2018) are minimal, and health
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39 utility scores in 2018 were slightly lower than those in 2013. Moreover, we explored the effect of different
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41 altitudes on HRQoL, and Tibetans living at 3500–4000 m had the best HRQoL. Our study also identified
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43 factors influencing HRQoL including females, elders, unemployed, and more chronic diseases with a negative
44
45 impact. While, higher education levels, no disease during the past two weeks, and frequent weekly physical
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47 activities had a positive impact on HRQoL of the Tibetan population. Moreover, the focus should be on retired
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49 residents at < 3500 m, unmarried and rural residents living in at 3500–4000 m, and ex-smokers living at $>$
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57 4000 m.
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59 The average health utility score of the population was 0.969 (SD \pm 0.078) in 2013 and 0.966 (SD \pm 0.077)

1 in 2018, higher than that reported in Heilongjiang, Hunan, and Shanxi in China[18, 19, 21]. This may be due
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4 to the use of two different 3 L value sets used to calculate the utility index score. Compared to the 3L₂₀₁₈
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6 algorithm, the 3L₂₀₁₄ algorithm includes a constant term and N3, resulting in a utility value gap between full
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8 health and the second-best health state, reducing the values of other health states[30]. Therefore, the 3L₂₀₁₈
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10 index score was systematically higher than the 3L₂₀₁₄ index score at absolute levels[26]. The result also
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12 indicated that health utility scores of two rounds of surveys were significantly lower than the that of the general
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14 Chinese population, confirming regional and residential disparities in HRQoL of the Chinese populations[31].
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16 The eastern–middle–western disparities in development have existed historically. Although in recent years
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18 China’s development strategy has focused more on western areas including implementing poverty alleviation
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20 policies, promoting the construction of infrastructure, low taxation, and national level fiscal transfer to the
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22 middle and western areas, a huge gap still exists between regions[27] with lower HRQoL in residents of
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24 western regions than that of those in the eastern region.
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32 Based on the HRQoL changes between the two rounds of surveys, health utility scores in 2018 were
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34 slightly lower than those in 2013, and statistical differences existed in the total population and at different
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36 demographic characteristics levels. However, the changes between 2013 and 2018 were minimal and failed to
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38 reach the threshold minimal clinically important difference (MCID) of ~0.074 based on EQ-5D-3L[32]. This
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40 is consistent with a previous study on the changes in HRQoL in the Chinese population between 2008 and
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42 2013, and the combination of changing health problems resulted in a small decline in health utility score³⁴.
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44 This could be due to proportion of extreme problems reported by EQ-5D-3L, with 0.42 to 0.45% reporting
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46 extreme problems in anxiety/depression and pain/discomfort compared to 2013. According to the 3L₂₀₁₄
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48 algorithm, the value in level-3 (L3) parameters is larger than level-2 (L2) or level-1 (L1) with increasing health
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50 state severity. Hence, for a health transition involving both improvement and deterioration, the magnitude of
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52 health gain from improvement in a certain dimension may be offset to a large extent by deterioration in another
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1 dimension[26]. Another possible reason may be related to the changing demographic and socioeconomic
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3 status in China. Between 2013 and 2018, the government implemented a series of policies, especially the
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5 targeting poverty alleviation strategy, driving continuous rapid growth of residents' income and further
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7 improving the consumption level and length of life. Life expectancy increased from 76.3–77.0 years during
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9 this time³⁵. However, the aging of the population, unhealthy lifestyles, and environmental exposure have led
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11 to the rising prevalence of chronic diseases and functional limitations, related to lower HRQoL among the
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13 Tibetan population.
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19 Pain/discomfort was the most frequently reported problem in this study similar to previous studies in
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21 China, however, the absolute proportion of each dimension reported was higher than the general population
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23 trends based on the NHSS data[31] and other provincial studies in China[18, 20, 21]. This may be due to the
24
25 plateau disease[33]. Residents living on the plateau for a long time evolve a unique physiological mechanism
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27 to adapt to the environment. However, some residents gradually lose their adaptability and suffer from various
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29 acute or chronic diseases related to the plateau environment under the stimulation of continuous hypoxia and
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31 low pressure[34]. The two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in
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33 2018, and hypertension has been reported as the most common chronic disease[35]. A previous study reported
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35 that the prevalence of hypertension in Tibet is higher than the Chinese national level and is the highest among
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37 all provinces, as well as higher than other residents living at high altitudes[36, 37]. Other studies higher
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39 prevalence of oxygen-related cardiovascular diseases, chronic respiratory diseases, digestive diseases, and
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41 respiratory infections (e.g., high-altitude pulmonary oedema) with high-altitude[38]. Moreover, Tibetans
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43 living at > 5500 m altitudes with long-term residence and heavy exertion, may be at increased risk of
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45 developing chronic mountain sickness[39]. As altitude increases, progressive reductions in barometric
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47 pressure, air temperature, and air humidity are observed. Headache, shortness of breath, chest tightness,
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49 anorexia, dizziness, limb fatigue, and sleep disturbances were common symptoms of Tibetan.[35]
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1 Those living in low-altitude areas (< 3500 m) reported the most problems in anxiety/depression consistent
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3 with previous studies. A large sample survey of the prevalence of depression among Tibetans of the Qinghai-
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5 Tibet Plateau was 28.6%, higher than that in the general Chinese population and higher than that reported in
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7 a western study with high-altitude samples[40]. The prevalence of depression is significantly correlated with
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9 climatic pressure, particularly altitude[41]. Generally, the combined effects of harsh natural environment on
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11 the plateau, high-altitude hypoxia, low atmospheric pressure, intense ultraviolet radiation, relatively weak
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13 community support caused by low population density, and lack of access to mental health resources increases
14
15 the severity of depression among those living in high-altitude areas[42-44]. In this study, the area with an
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17 altitude of < 3500 m was located southeast of the TAR. Nyingchi City, with an average altitude of 3100 m,
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19 has the lowest altitude and wettest climate in TAR. With convenient transportation and multiple splendid
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21 sceneries, tourism is the main source of income in this area, attracting millions of people traveling for
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23 sightseeing, mountaineering, and trekking every year[38]. Previous studies have reported a significant
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25 association between tourism impact and residents' quality of life[45, 46]. Tourism provides employment
26
27 opportunities and tax revenues, supports economic diversity, and services and products enjoyed by
28
29 residents[47, 48]. However, negative impacts of tourism on residents' QOL have been reported including
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31 crowding, traffic and parking issues, criminality, and cost of living, changes in hosts' way of life, and friction
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33 between tourists and residents[49]. The perceived negative impacts, negative emotions, pressure, and relative
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35 deprivation of the residents will affect their subjective well-being, leading to psychological problems
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37 including anxiety and depression. Therefore, the impact of tourism development on residents' subjective well-
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39 being and happiness, should be considered.

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42 In this study, we report that Tibetans living at 3500–4000 m had the best HRQoL. Moreover, participants
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44 who were married, lived in urban areas, and engaged in physical activities 1–5 times/week had better HRQoL
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46 compared with other high-altitudes. This could be attributed to Tibet's topography, population distribution,
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1 and socioeconomic status. The TAR is a vast territory with a sparse population with high-altitude in the
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3
4 northwest and low in the southeast. The region can be divided into three regions based on altitude. The
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6 Qiangtang Plateau in the north (> 5000 m), and the central basin region and Himalayan mountains (4000–
7
8 5000 m on average). The valleys of the middle and lower reaches of the Yarlung Zangbo River and the three
9
10 rivers in eastern Tibet have an altitude of 3000–4000 m, and 60% of the population is concentrated there. Of
11
12 the seven cities surveyed, Lhasa, Shannan, Qamdo, and Shigaze have an average altitude of 3500–4000 m
13
14 with their GDP ranking among the top four in Tibet according to the Seventh National Census in 2020. Similar
15
16 results have been reported previously with socioeconomic status significantly associated with higher
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18 HRQoL[50]. Socioeconomic status is detrimental to health as it affects people’s living and working conditions
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20 and restricts accessibility to medical care[51]. Moreover, socioeconomic status affects people’s psychological
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22 state and cognition of the world around them[52]. During the few last decades, China has implemented strong
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24 policies to facilitate economic development in the Qinghai-Tibet plateau (e.g., the Strategy of the
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26 Development of China’s West). The implementation of supportive strategies should help improve
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28 socioeconomic status in the future, including improving public infrastructure, medical service capacity, and
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30 disease prevention improving HRQoL.
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40 This study had several limitations. First, this study did not recruit the same pool of participants in two
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42 rounds of surveys, making it difficult to identify causal associations. However, the same cities were selected,
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44 and the participants may partly overlap. Second, many studies have reported that EQ-5D-3L has more
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46 significant ceiling effects than EQ-5D-5L. However, EQ-5D-3L is more suitable for use in large-scale
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48 population surveys because of its small cognitive burden. Moreover, the comparison of the two rounds of
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50 surveys indicated the overall changing trends of HRQoL derived from EQ-5D-3L.
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56 **Conclusion**

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

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39 All authors declare no competing interests.
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42 **Author Contributions**

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45 SPL and ZXDW have substantial contributions to conception and design, acquisition of funding, data and
46
47 interpretation of data. CDZG and ZXCM were involved in the acquisition of data. LD, ZS and CFL were
48
49 responsible for the data analysis and interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM
50
51 and CFL revised it critically for important intellectual content, LD and SPL was responsible for the decision
52
53 to submit the manuscript, and all authors contributed to final approval of the manuscript.
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59 **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.

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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		χ^2	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	<i>P</i> -value	< 3500m	3500-4000m	>4000m	<i>P</i> -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

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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

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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

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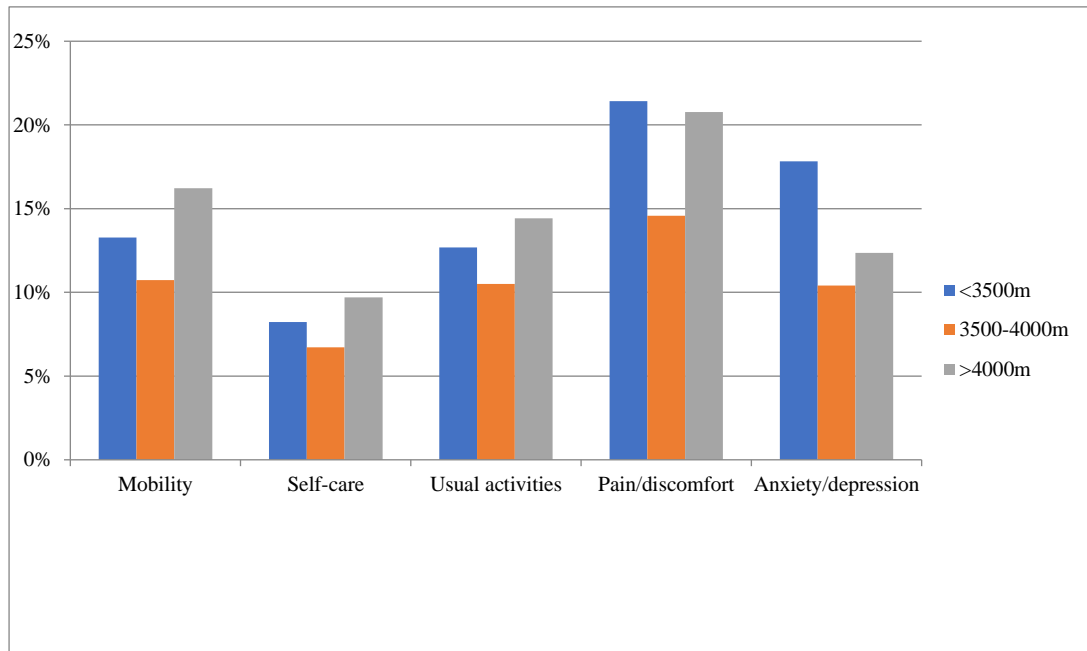


Figure 1 Proportions of problems reported on each EQ-5D-3L dimension by altitude

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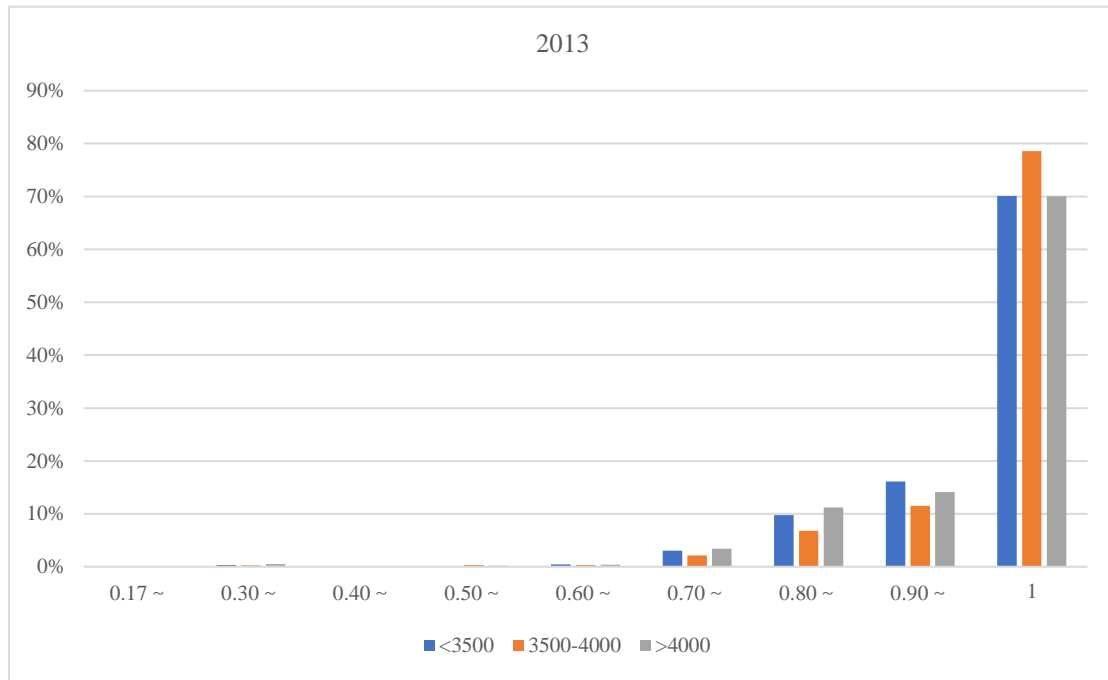


Figure 2a Distribution of health utility scores based on the EQ-5D-3L values set for China in 2013

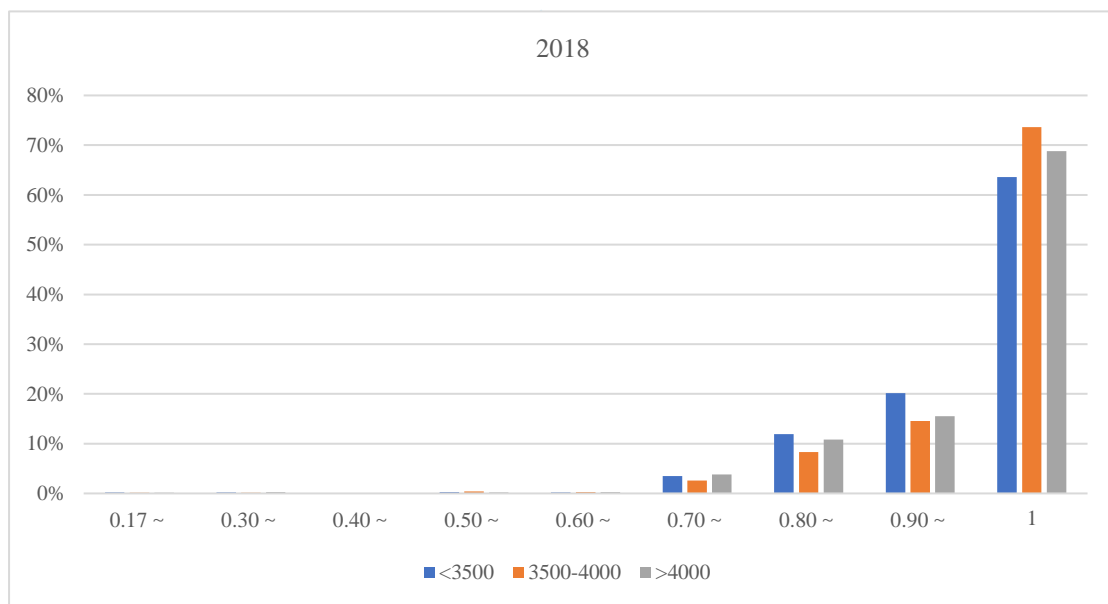


Figure 2b Distribution of health utility scores based on the EQ-5D-3L values set for China in 2018

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)												

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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.

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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		

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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 sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche 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

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2			
3	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. p5
4			
5			
6		#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable p5
7			
8			
9			
10	Data sources /	#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
11	measurement		
12			
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17	Bias	#9	Describe any efforts to address potential sources of bias P5
18			
19	Study size	#10	Explain how the study size was arrived at P5
20			
21	Quantitative	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why P6-7
22	variables		
23			
24			
25	Statistical	#12a	Describe all statistical methods, including those used to control for confounding P7-8
26	methods		
27			
28			
29	Statistical	#12b	Describe any methods used to examine subgroups and interactions P7-8
30	methods		
31			
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33	Statistical	#12c	Explain how missing data were addressed P8
34	methods		
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36			
37	Statistical	#12d	If applicable, describe analytical methods taking account of sampling strategy P8
38	methods		
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41	Statistical	#12e	Describe any sensitivity analyses P8
42	methods		
43			
44	Results		
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46			
47	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
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55	Participants	#13b	Give reasons for non-participation at each stage P8
56			
57	Participants	#13c	Consider use of a flow diagram P8
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1	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
2				
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6	Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	P8
7				
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10	Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	P8
11				
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14	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
15				
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19	Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
20				
21	Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
22				
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24				
25	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	p8-10
26				
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29	Discussion			
30				
31	Key results	#18	Summarise key results with reference to study objectives	P10
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34	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
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39	Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	P14-15
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44	Generalisability	#21	Discuss the generalisability (external validity) of the study results	P14-15
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47	Other			
48	Information			
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51	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
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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

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Secondary Subject Heading:	Public health, Health policy, Global health
Keywords:	PUBLIC HEALTH, Quality of Life, China

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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

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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.

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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 km², 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

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4 population comprises of farmers and herders, scattered in remote rural areas with
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6 limited income source mainly depending on agriculture[8]. The geographical
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8 environment of the plateau, relatively poor economic conditions, poor transportation
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10 and communication, and low access to medical services increased the health risks of
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12 residents compared to those in low-altitude areas[9]. China has been undergoing a
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14 period of unprecedented rates of economic growth, development, and poverty reduction
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16 in recent decades, including the TAR[10]. Various economic, educational, and health
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18 policies have been implemented for the development of society, which may have
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20 greatly affected the health of residents living in TAR[11].
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27 Previous studies have assessed the population HRQoL in various provinces of
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29 China, such as Heilongjiang [12], Gansu [13], Shanxi [14], and Hunan[15]. However,
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31 these studies focused on low-altitude areas and used data only from a cross-sectional
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33 survey. Moreover, there are only two studies have assessed the change in HRQoL over
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35 time in the general population of mainland China[16, 17]. One study used the data from
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37 two waves of NHSS from 2008 to 2013[16], while another study used three waves of
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39 Health Services Surveys from 2008 to 2020 in Tianjin[17]. Both studies reported a
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41 slightly decreasing in HRQoL of the population and disparities in HRQoL across
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43 different demographic and socioeconomic subgroups in China. Additionally, previous
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45 studies on the health status of Tibetan population are limited due to the geographical
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47 environment, lack of basic resources and facilities, and low population density.
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49 Therefore, this study aimed to assess the HRQoL of Tibetan population and its changes
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51 over time, and explore the differences in HRQoL for residents at different altitudes.
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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

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4 data collection standards developed by the Centre for Health Statistics and Information.

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6 The interviewers visited the selected households, and all family members in a sampled
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8 household were eligible to participate in the survey. Before the survey commenced,
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10 participants were informed of the survey's purposes and procedure and then provided
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12 informed consent.
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17 In total, 14752 participants in 2013 and 13106 participants in 2018 completed the
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19 survey. The exclusion criteria in this study were as follows: (1) participants aged < 15
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21 years were excluded since the EQ-5D-3L is recommended to be used among ≥ 15
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23 years by the user guide (n=3412 in 2013 and n=2677 in 2018); (2) participants who did
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25 not answer the questionnaires by themselves were excluded since the EQ-5D-3L need
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27 to be self-complete (n=1001 in 2013 and n=3798 in 2018); (3) participants with missing
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29 values for key variables including socio-demographic characteristics were excluded
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31 (n=4 in 2013 and n=1 in 2018); (4) participants with ethnicities other than Tibetan were
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33 excluded (n=88 in 2013 and n=194 in 2018). Overall, final sample size of 10247 in
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35 2013 and 6436 in 2018 were included in this study for analysis.
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43 **Measurement of HRQoL**

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46 The EQ-5D-3L is one of the most widely used HRQoL measurement instruments
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48 classified into five dimensions: mobility (MO), self-care (SC), usual activities (UA),
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50 pain/discomfort (PD), and anxiety/depression (AD). Each dimension contains three
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52 functioning response levels (no problems, moderate problems, and extreme problems),
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54 generating 243 (3^5) possible health states, with the best state indicated by the response
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56 "11111" and the worst health state indicated by the response "33333"[18]. A single
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4 health state utility (HSU) score can be assigned to each health state using a value set,
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6 developed in a valuation study based on the general population's health preferences.
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10 Four value sets exist for the EQ-5D-3L in China with the first value set developed in
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12 2014 (3L₂₀₁₄ value set) using a sample comprising residents mainly from urban
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14 areas[19], the second value set developed in 2018 (3L₂₀₁₈ value set) adopted a more
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16 representative sample of residents from both rural and urban areas[20], the other two
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18 value set developed in 2022 (3L₂₀₂₂ value set) recruited participants from rural areas of
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20 five cities[21]. In this study, we chose to adopt the 3L₂₀₁₈ value set. The main reason
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22 for the choice was based on the participants in the 3L₂₀₁₄ value set being selected
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24 conveniently from big cities in urban areas through quota sampling. While the
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26 3L₂₀₁₈ value set, a more representative sample of respondents was obtained from both
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28 rural and urban areas using a random sampling method[22]. The rural population
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30 accounts for half of the Chinese population, and large disparities exist in socioeconomic
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32 status, lifestyle, and health status between urban and rural areas in China[23]. In the
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34 two waves of NHSS in the TAR, more than 75% of participants were from farming and
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36 pastoral areas. Therefore, the 3L₂₀₁₈ value set, which more closely matches the
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38 distribution of the Tibetan population, was used in this study. To evaluate the robustness
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40 and sensitivity of the 3L₂₀₁₈ value set, we also used the 3L₂₀₂₂ value set to analyse the
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42 main results revealing that the main results of the two value sets had the same trends
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44 (Supplementary Table 1).
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55 56 **Independent variables**

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59 In this study, the independent variables were sociodemographic, altitude-related, and
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4 clinical disease variables, and health-related behaviours. Sociodemographic variables
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6 were sex, age, employment status, educational attainment, and marital status. We
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8 divided age into three groups: 15–44, 45–65, and ≥ 65 years old. Employment status
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10 was divided into employed, retired, and unemployed. Educational attainment was
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12 divided into three groups: illiterate, primary school, junior high school, and above.
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14 Marital status was divided into single, married, divorced, and other.
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19 The altitude-related variables included location and altitude. The participants were
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21 divided into rural and urban groups based on their geographical location. The NHSS
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23 did not collect data on the altitude of their residence; therefore, we used Google Maps
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25 to obtain the precise altitude. Altitudes were defined as high (1500–3500 m), very high
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27 (3500–5500 m), and extreme altitude (>5500 m), as suggested by the International
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29 Society for Mountain Medicine[24]. In this study, based on the China's policy of
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31 subsidising plateau areas[25], we divided the plateau areas into three altitude groups,
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33 high (1500–3500 m), very high (3500–4000 m), and extreme altitude (4000–5000 m).
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35 The altitude classification criterion was consistent in two waves of surveys.
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43 The clinical disease variables included diagnosis of the participant with any illness
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45 within two weeks before survey and the number of chronic diseases during the past six
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47 months. A chronic condition was defined as a condition diagnosed by a doctor with
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49 symptoms persisting or relevant medical treatment continuing over the past six months.
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53 Health-related behavioural variables were current smoking status, divided into three
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55 groups: smoking all the time, has ever smoked, and never smoked. Participants were
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57 asked to perform weekly physical exercise during the past six months, such as climbing,
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4 ball games, equipment exercise, swimming, jogging, etc. The frequency of physical
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6 exercise was divided into three groups: never exercised, 1–5 times, and > 6 times.
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9 10 **Patient and public involvement**

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12 Patients and the public were not involved in the design, conduct, reporting or
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14 dissemination plans of this research.
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17 18 **Statistical analysis**

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20 Descriptive statistics were used for participants' characteristics and the reported
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22 problems on the five dimensions of the EQ-5D-3L. Continuous variable were described
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24 as mean and standard deviation (SD), whereas categorised variable was described as
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26 frequency and percentages. Student's *t* test or analysis of variance (ANOVA) was used
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28 when variables conformed to an approximately normal distribution; otherwise, the
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30 Mann-Whitney *U* test or Kruskal-Wallis H test was used. Categorical variables were
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32 compared between the groups using the chi-square test.
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41 The importance of changes in the HSU scores was estimated using effect sizes (ES),
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43 which were calculated as the difference between the highest and the lowest HSU scores
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45 among the two surveys divided by the pooled standard deviation. The Effect sizes was
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47 defined ≤ 0.5 , 0.5 to 0.8 and ≥ 0.8 were small, moderate and large[26]. In this study,
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49 the moderate effect size (0.5) was considered as a threshold for minimal importance of
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51 changes in the HSU scores. As the HSU score was left-skewed with a large proportion
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53 of respondents in full health, the Tobit regression model was used to assess the
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55 influencing factors associated with EQ-5D-3L HSU scores. Data were entered into
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4 Epidata3.1 and analysed using SPSS 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was
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6 considered statistically significant.
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9 10 **Results**

11 12 **Participant characteristics**

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15 The characteristics of the participants are listed in Table 1. In 2013, more than half of
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17 the participants were in the 15–44 years age group (56.2%), and older participants
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19 accounted for < 15% of the participants (11.0%) and less than half of the participants
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21 were male (46.5%). Moreover, 57% of participants had never received education and
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23 14.98% of the participants were unemployed. More than four out of five participants
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25 resided in rural areas (84.9%) with an average altitude of 3838 ± 526 m. Overall, 11.35%
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27 of participants reported having a disease during 2 weeks before data collection, while,
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29 more than half of participants (65.6%) had no chronic diseases during the past 6 months.
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37 In 2018, the sociodemographic characteristics of the participants were basically the
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39 same as those in 2013. The average age was 45.22 ± 14.71 years, and more than half of
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41 the participants were female (56.6%). Of the participants, 52.0% never had education,
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43 81.2% were employed, 78.3% were married, and 77.5% lived in rural areas with an
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45 average altitude of 3903 ± 495 m. Most of the participants (85.1%) were non-smokers,
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47 and 62.3% had never engaged in weekly physical exercise during the past 6 months.
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49 Compared two waves of surveys, participants in the 2018 were more female ($P < 0.001$),
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51 reported a higher level of education ($P < 0.001$), had a lower employed proportion
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53 ($P = 0.008$), more lived in urban with more high altitude ($P < 0.001$).
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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.

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4 Participants lived in 3500–4000m had the least reported problems in all five dimensions,
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6 while participants lived in 1500–3500m and 4000–5000m reported more problems in
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8 pain/discomfort, anxiety/depression and mobility dimensions.
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11 12 **Factors associated with HSU scores**

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15 The Tobit regression analyses of the factors associated with HSU scores were presented
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17 in Table 4. The result confirmed the decreased trend in HSU scores over time ($\beta = -$
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19 0.014, $P < 0.001$), after adjustment for variations in the other independent variables.
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21 However, the effect sizes of this change did not reach the threshold of minimal clinical
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23 importance (ES=0.04). The elderly, the unemployed, the separated/divorced/widowed,
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25 and the healthy participants were significant predictors of the HSU score, with generally
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27 larger values of ES and reached the threshold of minimal clinical importance.
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33 34 **Discussion**

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37 To the best of our knowledge, this is the first study to evaluate the HRQoL of Tibetan
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39 population and its changes over time, based on a representative sample from the NHSS
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41 of Tibet in China. The HRQoL of Tibetan was lower than general Chinese population,
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43 and decreased over time in five years (2013–2018). Moreover, we found Tibetans living
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45 at 3500–4000m altitude had the best HRQoL. Our study also identified factors
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47 influencing HRQoL including females, elders, unemployed, and more chronic diseases
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49 with a negative impact. While, higher education levels, no disease during the past two
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51 weeks, and frequent weekly physical exercise had a positive impact on HRQoL of the
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53 Tibetan population.
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4 The mean HSU scores of the Tibetan population were 0.969 (SD = 0.078) in 2013
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6 and 0.966 (SD = 0.077) in 2018, higher than that reported in Heilongjiang, Hunan, and
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8 Shanxi in China[12, 13, 15]. This may be due to the use of two different 3L value sets
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10 used to calculate the HSU score. Compared to the 3L₂₀₁₈ algorithm, the 3L₂₀₁₄ algorithm
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12 includes a constant term and N3, resulting in a utility value gap between full health and
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14 the second-best health state, reducing the values of other health states[27]. Therefore,
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16 the 3L₂₀₁₈ index score was systematically higher than the 3L₂₀₁₄ index score at absolute
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18 levels[22]. The result also indicated that HSU scores of two waves of surveys were
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20 significantly lower than the that of the general Chinese population, confirming regional
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22 and residential disparities in HRQoL of the Chinese populations[28]. The eastern–
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24 middle–western disparities in development have existed historically. Although in recent
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26 years China’s development strategy has focused more on western areas including
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28 implementing poverty alleviation policies, promoting the construction of infrastructure,
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30 low taxation, and national level fiscal transfer to the middle and western areas, a huge
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32 gap still exists between regions[23] with lower HRQoL in residents of western regions
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34 than that of those in the eastern region.
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45 Based on the HRQoL changes between the two waves of surveys, HSU scores in
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47 2018 were slightly lower than those in 2013, and statistical differences existed in the
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49 total population and at different demographic characteristics levels. However, the
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51 changes between 2013 and 2018 were minimal and failed to reach the threshold
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53 minimal clinically important difference of ~0.074 based on EQ-5D-3L[29]. This is
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55 consistent with previous studies on the changes in HRQoL in the Chinese population[16,
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4 17]. This could be due to proportion of extreme problems reported by EQ-5D-3L, with
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6 0.42 to 0.45% reporting extreme problems in anxiety/depression and pain/discomfort
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8 compared to 2013. According to the 3L₂₀₁₄ algorithm, the value in level-3 (L3)
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10 parameters is larger than level-2 (L2) or level-1 (L1) with increasing health state
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12 severity. Hence, for a health transition involving both improvement and deterioration,
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14 the magnitude of health gain from improvement in a certain dimension may be offset
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16 to a large extent by deterioration in another dimension[22]. Another possible reason
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18 may be related to the changing demographic and socioeconomic status in China.
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20 Between 2013 and 2018, the government implemented a series of policies, especially
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22 the targeting poverty alleviation strategy, driving continuous rapid growth of residents'
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24 income and further improving the consumption level and length of life. Life expectancy
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26 increased from 76.3–77.0 years during this time³⁵. However, the aging of the population,
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28 unhealthy lifestyles, and environmental exposure have led to the rising prevalence of
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30 chronic diseases and functional limitations, related to lower HRQoL among the Tibetan
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32 population.
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43 Pain/discomfort was the most frequently reported problem in this study similar to
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45 previous studies in China, however, the absolute proportion of each dimension reported
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47 was higher than the general population trends based on the NHSS data[28] and other
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49 provincial studies in China[12, 14, 15]. This may be due to the plateau disease[30].
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51 Residents living on the plateau for a long time evolve a unique physiological
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53 mechanism to adapt to the environment. However, some residents gradually lose their
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55 adaptability and suffer from various acute or chronic diseases related to the plateau
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4 environment under the stimulation of continuous hypoxia and low pressure[31]. The
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6 two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in
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9 2018, and hypertension has been reported as the most common chronic disease[32]. A
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11 previous study reported that the prevalence of hypertension in Tibet is higher than the
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13 Chinese national level and is the highest among all provinces, as well as higher than
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15 other residents living at high altitudes[33, 34]. As altitude increases, progressive
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17 reductions in barometric pressure, air temperature, and air humidity are observed.
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19 Headache, shortness of breath, chest tightness, anorexia, dizziness, limb fatigue, and
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21 sleep disturbances were common symptoms of Tibetan[32].
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27 Compared with other high-altitudes, we found that Tibetans living at 3500–4000
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29 m had the best HRQoL. This could be attributed to Tibet's topography, population
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31 distribution, and socioeconomic status. The TAR is a vast territory with a sparse
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33 population with high-altitude in the northwest and low in the southeast. The region can
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35 be divided into three regions based on altitude. The Qiangtang Plateau in the north ($>$
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37 5000 m), and the central basin region and Himalayan mountains (4000–5000 m on
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39 average). The valleys of the middle and lower reaches of the Yarlung Zangbo River and
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41 the three rivers in eastern Tibet have an altitude of 3000–4000 m, and 60% of the
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43 population is concentrated there. Of the seven cities surveyed, Lhasa, Shannan, Qamdo,
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45 and Shigaze have an average altitude of 3500–4000 m with their GDP ranking among
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47 the top four in Tibet according to the Seventh National Census in 2020. Similar results
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49 have been reported previously with socioeconomic status significantly associated with
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51 higher HRQoL[16]. Socioeconomic status is detrimental to health as it affects people's
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4 living and working conditions and restricts accessibility to medical care[35]. Moreover,
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6 socioeconomic status affects people's psychological state and cognition of the world
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8 around them[36]. During the few last decades, China has implemented strong policies
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10 to facilitate economic development in the Qinghai-Tibet plateau (e.g., the Strategy of
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12 the Development of China's West). The implementation of supportive strategies should
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14 help improve socioeconomic status in the future, including improving public
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16 infrastructure, medical service capacity, and disease prevention improving HRQoL.
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22 Those living in low-altitude areas (1500–3500m) reported the most problems in
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24 anxiety/depression consistent with previous studies. A large sample survey of the
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26 prevalence of depression among Tibetans of the Qinghai-Tibet Plateau was 28.6%,
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28 higher than that in the general Chinese population and higher than that reported in a
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30 western study with high-altitude samples[37]. The prevalence of depression is
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32 significantly correlated with climatic pressure, particularly altitude[38]. Generally, the
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34 combined effects of harsh natural environment on the plateau, high-altitude hypoxia,
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36 low atmospheric pressure, intense ultraviolet radiation, relatively weak community
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38 support caused by low population density, and lack of access to mental health resources
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40 increases the severity of depression among those living in high-altitude areas[39-41].
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42 In this study, the area with an altitude of 1500–3500 m was located southeast of the
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44 TAR. Nyingchi City, with an average altitude of 3100 m, has the lowest altitude and
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46 wettest climate in TAR. With convenient transportation and multiple splendid sceneries,
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48 tourism is the main source of income in this area, attracting millions of people traveling
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50 for sightseeing, mountaineering, and trekking every year[42]. Previous studies have
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4 reported a significant association between tourism impact and residents' quality of
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6 life[43, 44]. Tourism provides employment opportunities and tax revenues, supports
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8 economic diversity, and services and products enjoyed by residents[45, 46]. However,
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10 negative impacts of tourism on residents' HRQoL have been reported including
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12 crowding, traffic and parking issues, criminality, and cost of living, changes in hosts'
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14 way of life, and friction between tourists and residents[47]. The perceived negative
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16 impacts, negative emotions, pressure, and relative deprivation of the residents will
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18 affect their subjective well-being, leading to psychological problems including anxiety
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20 and depression.
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27 This study had several limitations. First, this study did not recruit the same pool of
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29 participants in two waves of surveys, making it difficult to identify causal associations.
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31 However, the same cities were selected, and the participants may partly overlap. Second,
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33 the participants recruited in the surveys were those had lived in Tibet for more than six
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35 months; however, we could not determine if they were born in Tibet or came to work
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37 from other low-altitude areas. A small-scale survey could be conducted to refine the
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39 participant inclusion criteria to validate the study findings in the future. Third, many
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41 studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-
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43 5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys
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45 because of its small cognitive burden. Moreover, the comparison of the two waves of
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47 surveys indicated the overall changing trends in HRQoL of participants were able to be
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49 derived from EQ-5D-3L.
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59 **Conclusion**

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4 This study revealed the HRQoL of Tibetan population was lower than general Chinese
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6 population, and decreased over time between 5 years. There were differences in
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8 HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m
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10 having the best quality of life. More attention should be paid to those Tibetans who are
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12 older, female, unemployed and without formal education. Targeted policies and
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14 strategies need to be strengthened, including plateau subsidies, poverty alleviation,
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16 primary health service capacity, standardized management of chronic diseases, and
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18 health education.
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29
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32 who participated in the study.
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46 **Competing interest statement**

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49 All authors declare no competing interests.
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51

52 **Author Contributions**

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55 SPL and ZXDW have substantial contributions to conception and design, acquisition
56
57 of funding, data and interpretation of data. CDZG and ZXCM were involved in the
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4 acquisition of data. LD, ZS and CFL were responsible for the data analysis and
5
6 interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM and CFL revised
7
8 it critically for important intellectual content, LD and SPL was responsible for the
9
10 decision to submit the manuscript, and all authors contributed to final approval of the
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12 manuscript.
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16 17 **Ethics statements**

18 19 **Patient consent for publication**

20
21 Not applicable.
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24 25 **Ethics approval**

26
27 This study involves human participants and was approved. This study was conducted
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29 with the approval of the National Health Commission of the People's Republic of China
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31 and the Health Commission of Tibet autonomous region.
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38 39 **Data availability statement**

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41 Data are available upon reasonable request. We have included all the data produced in
42
43 the present work in the manuscript. Note that the raw data used in the study were
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45 obtained from National Health Service Surveys of China. We are unable to attach all
46
47 the raw data for each participant in this paper due to the ethical restrictions.
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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±51 5	-	
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	

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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

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

EQ-5D-3L	2013		2018		χ^2	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

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≥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

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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

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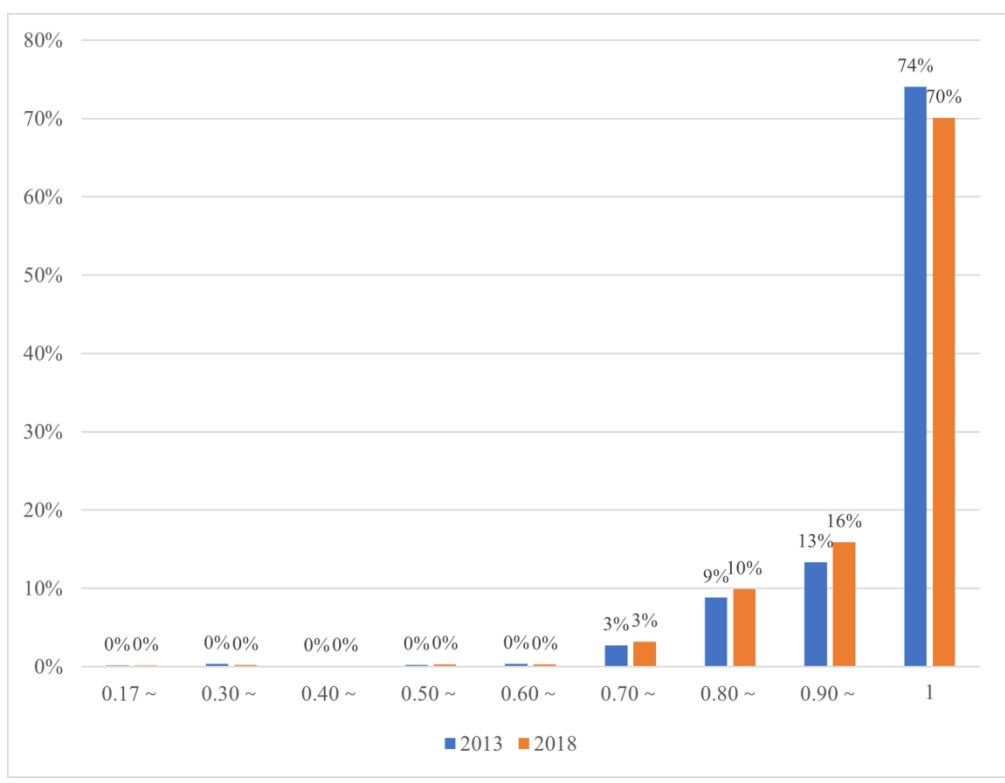


Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

146x111mm (300 x 300 DPI)

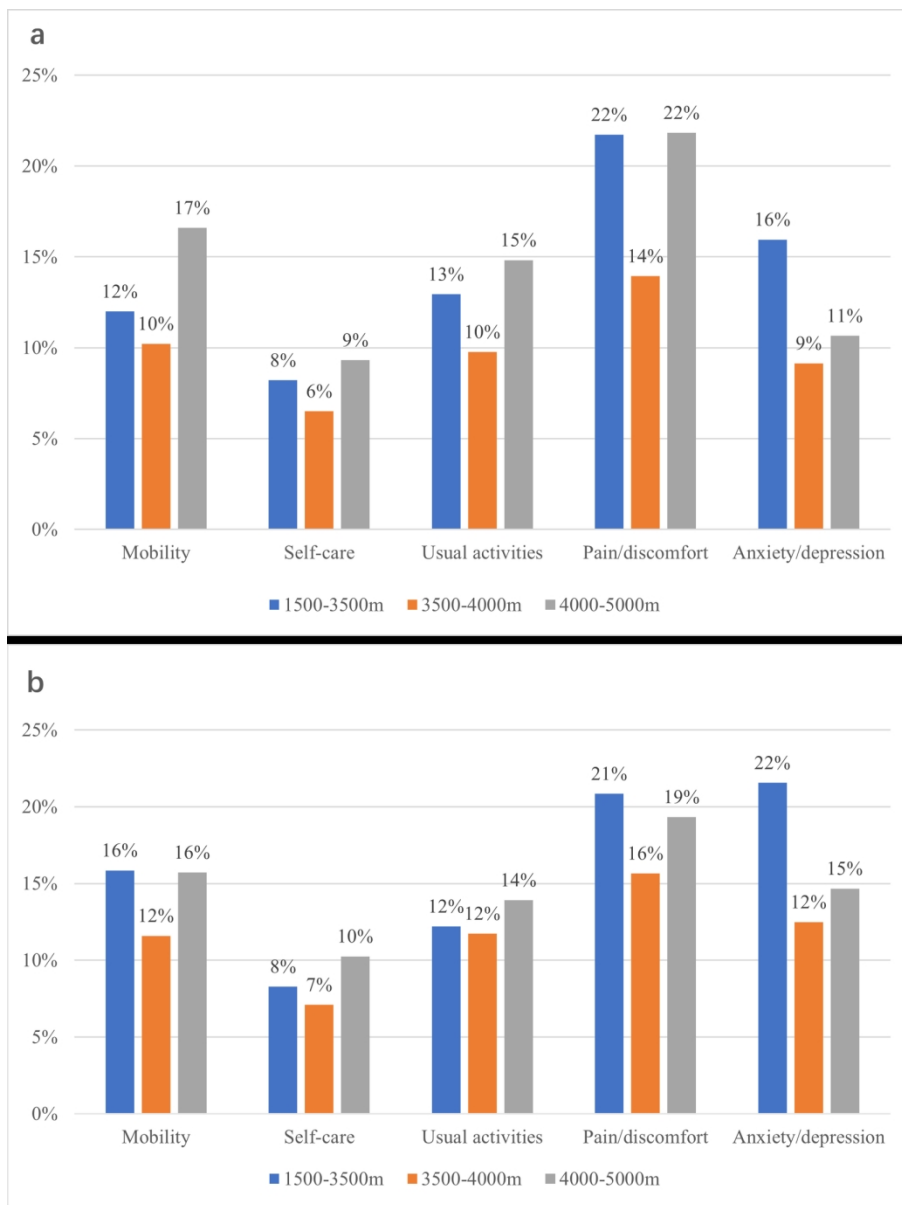


Figure 2a Proportions of health problems reported by participants at different altitude in 2013
 Figure 2b Proportions of health problems reported by participants at different altitude in 2018

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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.

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

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

1	Abstract	#1b	Provide in the abstract an informative and balanced summary	P2
2			of what was done and what was found	
3				
4				
5				
6	Introduction			
7				
8				
9				
10	Background /	#2	Explain the scientific background and rationale for the	P4-5
11	rationale		investigation being reported	
12				
13				
14				
15	Objectives	#3	State specific objectives, including any prespecified	P5
16			hypotheses	
17				
18				
19				
20	Methods			
21				
22				
23	Study design	#4	Present key elements of study design early in the paper	P6-7
24				
25				
26	Setting	#5	Describe the setting, locations, and relevant dates, including	P6
27			periods of recruitment, exposure, follow-up, and data	
28			collection	
29				
30				
31				
32				
33				
34	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of	P7
35			selection of participants.	
36				
37				
38				
39				
40		#7	Clearly define all outcomes, exposures, predictors, potential	P7
41			confounders, and effect modifiers. Give diagnostic criteria, if	
42			applicable	
43				
44				
45				
46				
47	Data sources /	#8	For each variable of interest give sources of data and details	P8-10
48	measurement		of methods of assessment (measurement). Describe	
49			comparability of assessment methods if there is more than	
50			one group. Give information separately for for exposed and	
51			unexposed groups if applicable.	
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1	Bias	#9	Describe any efforts to address potential sources of bias	P6
2				
3				
4	Study size	#10	Explain how the study size was arrived at	P6
5				
6				
7	Quantitative	#11	Explain how quantitative variables were handled in the	P6-7
8	variables		analyses. If applicable, describe which groupings were	
9			chosen, and why	
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14				
15	Statistical	#12a	Describe all statistical methods, including those used to	P10-11
16	methods		control for confounding	
17				
18				
19				
20	Statistical	#12b	Describe any methods used to examine subgroups and	P10
21	methods		interactions	
22				
23				
24				
25				
26	Statistical	#12c	Explain how missing data were addressed	P10
27	methods			
28				
29				
30				
31	Statistical	#12d	If applicable, describe analytical methods taking account of	P10-11
32	methods		sampling strategy	
33				
34				
35				
36	Statistical	#12e	Describe any sensitivity analyses	P10-11
37	methods			
38				
39				
40				
41				
42	Results			
43				
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45	Participants	#13a	Report numbers of individuals at each stage of study—eg	P7
46			numbers potentially eligible, examined for eligibility,	
47			confirmed eligible, included in the study, completing follow-	
48			up, and analysed. Give information separately for for	
49			exposed and unexposed groups if applicable.	
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57	Participants	#13b	Give reasons for non-participation at each stage	P6
58				
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1	Participants	#13c	Consider use of a flow diagram	n/a
2				
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4	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	P8
5			clinical, social) and information on exposures and potential	
6			confounders. Give information separately for exposed and	
7			unexposed groups if applicable.	
8				
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14	Descriptive data	#14b	Indicate number of participants with missing data for each	P11
15			variable of interest	
16				
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18				
19	Outcome data	#15	Report numbers of outcome events or summary measures.	P11-12
20			Give information separately for exposed and unexposed	
21			groups if applicable.	
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26				
27	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	P12-13
28			adjusted estimates and their precision (eg, 95% confidence	
29			interval). Make clear which confounders were adjusted for	
30			and why they were included	
31				
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36				
37	Main results	#16b	Report category boundaries when continuous variables were	P12-13
38			categorized	
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41				
42	Main results	#16c	If relevant, consider translating estimates of relative risk into	n/a
43			absolute risk for a meaningful time period	
44				
45				
46				
47				
48	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups	P12-13
49			and interactions, and sensitivity analyses	
50				
51				
52				
53	Discussion			
54				
55				
56	Key results	#18	Summarise key results with reference to study objectives	P13
57				
58				
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1	Limitations	#19	Discuss limitations of the study, taking into account sources	P18
2			of potential bias or imprecision. Discuss both direction and	
3			magnitude of any potential bias.	
4				
5				
6				
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8				
9	Interpretation	#20	Give a cautious overall interpretation considering objectives,	P14-18
10			limitations, multiplicity of analyses, results from similar	
11			studies, and other relevant evidence.	
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15				
16	Generalisability	#21	Discuss the generalisability (external validity) of the study	P18
17			results.	
18				
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20				
21				
22	Other Information			
23				
24				
25	Funding	#22	Give the source of funding and the role of the funders for the	P19
26			present study and, if applicable, for the original study on	
27			which the present article is based	
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Health-Related Quality of Life and its changes of Tibetan population in China: Based on the 2013 and 2018 National Health Services Surveys

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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

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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.

For peer review only

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 km², 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

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4 population comprises of farmers and herders, scattered in remote rural areas with
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6 limited income source mainly depending on agriculture[8]. High-altitude areas present
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8 a complex ecology in physical environment and population characteristics including
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10 genetics, lifestyle, socioeconomic factors, and access to medical care[9], directly or
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12 indirectly impact health[10]. Previous studies have reported that high-altitude is
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14 strongly associated with the many health issues including psychiatric disorders [11, 12],
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16 hypertension[6, 13], and cardiovascular diseases[10]. China has been undergoing a
17
18 period of unprecedented rates of economic growth, development, and poverty reduction
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20 in recent decades, including the TAR[14]. Various economic, educational, and health
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22 policies have been implemented for the development of society, which may have
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24 greatly affected the health of residents living in TAR[15].
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33 Previous studies have assessed the population HRQoL in various provinces of
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35 China, such as Heilongjiang [16], Gansu [17], Shanxi [18], and Hunan[19]. However,
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37 these studies focused on low-altitude areas and used data only from a cross-sectional
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39 survey. Moreover, there are only two studies have assessed the change in HRQoL over
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41 time in the general population of mainland China[20, 21]. One study used the data from
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43 two waves of NHSS from 2008 to 2013[20], while another study used three waves of
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45 Health Services Surveys from 2008 to 2020 in Tianjin[21]. Both studies reported a
46
47 slightly decreasing in HRQoL of the population and disparities in HRQoL across
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49 different demographic and socioeconomic subgroups in China. Additionally, previous
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51 studies on the health status of Tibetan population are limited due to the geographical
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53 environment, lack of basic resources and facilities, and low population density.
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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

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4 participated in national training. Pre-survey training workshops were offered to all
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6 interviewers following a standardised protocol. Eligible interviewers had to
7
8 demonstrate proper understanding of the purpose of the NHSS and their ability to meet
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10 data collection standards developed by the Centre for Health Statistics and Information.
11
12 The interviewers visited the selected households, and all family members in a sampled
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14 household were eligible to participate in the survey. Before the survey commenced,
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16 participants were informed of the survey's purposes and procedure and then provided
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18 informed consent.
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24
25 In total, 14752 participants in 2013 and 13106 participants in 2018 completed the
26
27 survey. The exclusion criteria in this study were as follows: (1) participants aged < 15
28
29 years were excluded since the EQ-5D-3L is recommended to be used among ≥ 15
30
31 years by the user guide (n=3412 in 2013 and n=2677 in 2018); (2) participants who did
32
33 not answer the questionnaires by themselves were excluded since the EQ-5D-3L need
34
35 to be self-complete (n=1001 in 2013 and n=3798 in 2018); (3) participants with missing
36
37 values for key variables including socio-demographic characteristics were excluded
38
39 (n=4 in 2013 and n=1 in 2018); (4) participants with ethnicities other than Tibetan were
40
41 excluded (n=88 in 2013 and n=194 in 2018). Overall, final sample size of 10247 in
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43 2013 and 6436 in 2018 were included in this study for analysis.
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50 51 **Measurement of HRQoL**

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53 The EQ-5D-3L is one of the most widely used HRQoL measurement instruments
54
55 classified into five dimensions: mobility (MO), self-care (SC), usual activities (UA),
56
57 pain/discomfort (PD), and anxiety/depression (AD). Each dimension contains three
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4 functioning response levels (no problems, moderate problems, and extreme problems),
5
6 generating 243 (3^5) possible health states, with the best state indicated by the response
7
8 “11111” and the worst health state indicated by the response “33333”[22]. A single
9
10 health state utility (HSU) score can be assigned to each health state using a value set,
11
12 developed in a valuation study based on the general population’s health preferences.
13
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17 Four value sets exist for the EQ-5D-3L in China with the first value set developed in
18
19 2014 (3L₂₀₁₄ value set) using a sample comprising residents mainly from urban
20
21 areas[23], the second value set developed in 2018 (3L₂₀₁₈ value set) adopted a more
22
23 representative sample of residents from both rural and urban areas[24], the other two
24
25 value set developed in 2022 (3L₂₀₂₂ value set) recruited participants from rural areas of
26
27 five cities[25]. In this study, we chose to adopt the 3L₂₀₁₈ value set. The main reason
28
29 for the choice was based on the participants in the 3L₂₀₁₄ value set being selected
30
31 conveniently from big cities in urban areas through quota sampling. While the
32
33 3L₂₀₁₈ value set, a more representative sample of respondents was obtained from both
34
35 rural and urban areas using a random sampling method[26]. The rural population
36
37 accounts for half of the Chinese population, and large disparities exist in socioeconomic
38
39 status, lifestyle, and health status between urban and rural areas in China[27]. In the
40
41 two waves of NHSS in the TAR, more than 75% of participants were from farming and
42
43 pastoral areas. Therefore, the 3L₂₀₁₈ value set, which more closely matches the
44
45 distribution of the Tibetan population, was used in this study. To evaluate the robustness
46
47 and sensitivity of the 3L₂₀₁₈ value set, we also used the 3L₂₀₂₂ value set to analyse the
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49 main results revealing that the main results of the two value sets had the same trends
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(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

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4 classification criterion was consistent in two waves of surveys.
5

6 The clinical disease variables included diagnosis of the participant with any illness
7 within two weeks before survey and the number of chronic diseases during the past six
8 months. A chronic condition was defined as a condition diagnosed by a doctor with
9 symptoms persisting or relevant medical treatment continuing over the past six months.
10
11

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

31 Patients and the public were not involved in the design, conduct, reporting or
32 dissemination plans of this research.
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39 **Statistical analysis**

40 Descriptive statistics were used for participants' characteristics and the reported
41 problems on the five dimensions of the EQ-5D-3L. Continuous variable were described
42 as mean and standard deviation (SD), whereas categorised variable was described as
43 frequency and percentages. Student's *t* test or analysis of variance (ANOVA) was used
44 when variables conformed to an approximately normal distribution; otherwise, the
45 Mann-Whitney *U* test or Kruskal-Wallis H test was used. Categorical variables were
46 compared between the groups using the chi-square test.
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4 The importance of changes in the HSU scores was estimated using effect sizes (ES),
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6 which were calculated as the difference between the highest and the lowest HSU scores
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8 among the two surveys divided by the pooled standard deviation. The Effect sizes was
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10 defined ≤ 0.5 , 0.5 to 0.8 and ≥ 0.8 were small, moderate and large[31]. In this study,
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12 the moderate effect size (0.5) was considered as a threshold for minimal importance of
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14 changes in the HSU scores. As the HSU score was left-skewed with a large proportion
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16 of respondents in full health, the Tobit regression model was used to assess the
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18 influencing factors associated with EQ-5D-3L HSU scores. Data were entered into
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20 Epidata3.1 and analysed using SPSS 24.0, and STATA 15.0. A two-tailed $p < 0.05$ was
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22 considered statistically significant.
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30 **Results**

31 **Participant characteristics**

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33 The characteristics of the participants are listed in Table 1. In 2013, more than half of
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35 the participants were in the 15–44 years age group (56.2%), and older participants
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37 accounted for < 15% of the participants (11.0%) and less than half of the participants
38
39 were male (46.5%). Moreover, 57% of participants had never received education and
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41 14.98% of the participants were unemployed. More than four out of five participants
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43 resided in rural areas (84.9%) with an average altitude of 3838 ± 526 m. Overall, 11.35%
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45 of participants reported having a disease during 2 weeks before data collection, while,
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47 more than half of participants (65.6%) had no chronic diseases during the past 6 months.
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57 In 2018, the sociodemographic characteristics of the participants were basically the
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59 same as those in 2013. The average age was 45.22 ± 14.71 years, and more than half of
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4 the participants were female (56.6%). Of the participants, 52.0% never had education,
5
6 81.2% were employed, 78.3% were married, and 77.5% lived in rural areas with an
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8 average altitude of 3903 ± 495 m. Most of the participants (85.1%) were non-smokers,
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10 and 62.3% had never engaged in weekly physical exercise during the past 6 months.
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12 Compared two waves of surveys, participants in the 2018 were more female ($P<0.001$),
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14 reported a higher level of education ($P<0.001$), had a lower employed proportion
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16 ($P=0.008$), more lived in urban with more high altitude ($P<0.001$).
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23 **Participant's HRQoL and its changes**

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26 The HSU scores stratified by characteristics of participants in two surveys were listed
27
28 in Table 2. The mean HSU scores of the participants were 0.969 ± 0.078 in 2013 and
29
30 0.966 ± 0.077 in 2018, which showed a significantly decreasing trend ($P<0.001$,
31
32 $ES=0.136$). Figure 1 presents the distribution of participant's HSU scores in two
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34 surveys. It revealed a left-skewed distribution with skewness of -4.189 in 2013 and -
35
36 4.642 in 2018, ranging from 0.170 to 1.000. The states of 11111 (no problems in any
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38 dimension) were reported in 74% and 70% of the participants in 2013 and 2018,
39
40 respectively. The trend in HSU scores was observed decreased in most subgroups.
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48 The highest proportion of reporting health problems was the pain/discomfort
49
50 dimension (2013:18.1%, 2018: 17.9%). Problems with self-care dimension was least
51
52 prevalent, 7.7% and 8.5% participants reported in 2013 and 2018, respectively. As
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54 compared to the 2013, reported problems increased in mobility (by 1.2%), self-care (by
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56 0.8%), usual activities (by 0.6%), and anxiety/depression (by 3.8%) in 2018. While,
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4 reported problems in pain/discomfort decreased by 0.2% (Table 3).
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7 **HRQoL of participants at different altitudes**

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10 Two survey's findings showed that participants lived in the 3500-4000m group had the
11 highest HSU scores. Similar to the general trend, health state scores in 2018 were
12 slightly lower than those in 2013 at different altitude groups (Table 2). Figure 2
13 describes the percentage of participants with self-reported health problems by different
14 altitude groups. The distribution trend was generally consistent in two surveys.
15
16 Participants lived in 3500–4000m had the least reported problems in all five dimensions,
17 while participants lived in 1500–3500m and 4000–5000m reported more problems in
18 pain/discomfort, anxiety/depression and mobility dimensions.
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31 **Factors associated with HSU scores**

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35 The Tobit regression analyses of the factors associated with HSU scores were presented
36 in Table 4. The result confirmed the decreased trend in HSU scores over time ($\beta = -$
37 0.014 , $P < 0.001$), after adjustment for variations in the other independent variables.
38
39 However, the effect sizes of this change did not reach the threshold of minimal clinical
40 importance ($ES = 0.04$). The elderly, the unemployed, the separated/divorced/widowed,
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42 and the healthy participants were significant predictors of the HSU score, with generally
43 larger values of ES and reached the threshold of minimal clinical importance.
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54 **Discussion**

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57 To the best of our knowledge, this is the first study to evaluate the HRQoL of Tibetan
58 population and its changes over time, based on a representative sample from the NHSS
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4 of Tibet in China. The HRQoL of Tibetan was lower than general Chinese population,
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6 and decreased over time in five years (2013–2018). Moreover, we found Tibetans living
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8 at 3500–4000m altitude had the best HRQoL. Our study also identified factors
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10 influencing HRQoL including females, elders, unemployed, and more chronic diseases
11
12 with a negative impact. While, higher education levels, no disease during the past two
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14 weeks, and frequent weekly physical exercise had a positive impact on HRQoL of the
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16 Tibetan population.
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22 The mean HSU scores of the Tibetan population were 0.969 (SD = 0.078) in 2013
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24 and 0.966 (SD = 0.077) in 2018, higher than that reported in Heilongjiang, Hunan, and
25
26 Shanxi in China[16, 17, 19]. This may be due to the use of two different 3L value sets
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28 used to calculate the HSU score. Compared to the 3L₂₀₁₈ algorithm, the 3L₂₀₁₄ algorithm
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30 includes a constant term and N3, resulting in a utility value gap between full health and
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32 the second-best health state, reducing the values of other health states[32]. Therefore,
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34 the 3L₂₀₁₈ index score was systematically higher than the 3L₂₀₁₄ index score at absolute
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36 levels[26]. The result also indicated that HSU scores of two waves of surveys were
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38 significantly lower than the that of the general Chinese population, confirming regional
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40 and residential disparities in HRQoL of the Chinese populations[33]. The eastern–
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42 middle–western disparities in development have existed historically. Although in recent
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44 years China’s development strategy has focused more on western areas including
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46 implementing poverty alleviation policies, promoting the construction of infrastructure,
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48 low taxation, and national level fiscal transfer to the middle and western areas, a huge
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50 gap still exists between regions[27] with lower HRQoL in residents of western regions
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4 than that of those in the eastern region.
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7 Based on the HRQoL changes between the two waves of surveys, HSU scores in
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9 2018 were slightly lower than those in 2013, and statistical differences existed in the
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11 total population and at different demographic characteristics levels. However, the
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13 changes between 2013 and 2018 were minimal and failed to reach the threshold
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15 minimal clinically important difference of ~ 0.074 based on EQ-5D-3L[34]. This is
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17 consistent with previous studies on the changes in HRQoL in the Chinese population[20,
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19 21]. This could be due to proportion of extreme problems reported by EQ-5D-3L, with
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21 0.42 to 0.45% reporting extreme problems in anxiety/depression and pain/discomfort
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23 compared to 2013. According to the 3L₂₀₁₄ algorithm, the value in level-3 (L3)
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25 parameters is larger than level-2 (L2) or level-1 (L1) with increasing health state
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27 severity. Hence, for a health transition involving both improvement and deterioration,
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29 the magnitude of health gain from improvement in a certain dimension may be offset
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31 to a large extent by deterioration in another dimension[26]. Another possible reason
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33 may be related to the changing demographic and socioeconomic status in China.
34
35 Between 2013 and 2018, the government implemented a series of policies, especially
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37 the targeting poverty alleviation strategy, driving continuous rapid growth of residents'
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39 income and further improving the consumption level and length of life. Life expectancy
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41 increased from 76.3–77.0 years during this time[35]. However, the aging of the
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43 population, unhealthy lifestyles, and environmental exposure have led to the rising
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45 prevalence of chronic diseases and functional limitations, related to lower HRQoL
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47 among the Tibetan population.
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4 Pain/discomfort was the most frequently reported problem in this study similar to
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6 previous studies in China, however, the absolute proportion of each dimension reported
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8 was higher than the general population trends based on the NHSS data[33] and other
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10 provincial studies in China[16, 18, 19]. This may be due to the plateau disease[36].
11
12 Residents living on the plateau for a long time evolve a unique physiological
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14 mechanism to adapt to the environment. However, some residents gradually lose their
15
16 adaptability and suffer from various acute or chronic diseases related to the plateau
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18 environment under the stimulation of continuous hypoxia and low pressure[37]. The
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20 two-week illness prevalence rate of residents aged ≥ 15 years in Tibet was 20.1% in
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22 2018, and hypertension has been reported as the most common chronic disease[38]. A
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24 previous study reported that the prevalence of hypertension in Tibet is higher than the
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26 Chinese national level and is the highest among all provinces, as well as higher than
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28 other residents living at high altitudes[39, 40]. As altitude increases, progressive
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30 reductions in barometric pressure, air temperature, and air humidity are observed.
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32 Headache, shortness of breath, chest tightness, anorexia, dizziness, limb fatigue, and
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34 sleep disturbances were common symptoms of Tibetan[38].

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45 Compared with other high-altitudes, we found that Tibetans living at 3500–4000
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47 m had the best HRQoL. This could be attributed to many reasons. First, most Tibetan
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49 tend to stay at their altitude of residence for extended periods of time, the complex
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51 interaction between genetic and environmental influence led to the extraordinary ability
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53 to adapt to their hypoxic environment, and less susceptible to chronic mountain
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55 sickness[41]. Second, TAR is a vast territory with a sparse population with high-altitude
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4 in the northwest and low in the southeast. The region can be divided into three regions
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6 based on altitude. The Qiangtang Plateau in the north (> 5000 m), and the central basin
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8 region and Himalayan mountains (4000–5000 m on average). The valleys of the middle
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10 and lower reaches of the Yarlung Zangbo River and the three rivers in eastern Tibet
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12 have an altitude of 3000–4000 m, and 60% of the population is concentrated there. Of
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14 the seven cities surveyed, Lhasa, Shannan, Qamdo, and Shigaze have an average
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16 altitude of 3500–4000 m with their GDP ranking among the top four in Tibet according
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18 to the Seventh National Census in 2020. Similar results have been reported previously
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20 with socioeconomic status significantly associated with higher HRQoL[20].
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22 Socioeconomic status is detrimental to health as it affects people's living and working
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24 conditions and restricts accessibility to medical care[42]. Moreover, socioeconomic
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26 status affects people's psychological state and cognition of the world around them[43].
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28 During the few last decades, China has implemented strong policies to facilitate
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30 economic development in the Qinghai-Tibet plateau (e.g., the Strategy of the
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32 Development of China's West). The implementation of supportive strategies should
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34 help improve socioeconomic status in the future, including improving public
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36 infrastructure, medical service capacity, and disease prevention improving HRQoL.
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48 Those living in low-altitude areas (1500–3500m) reported the most problems in
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50 anxiety/depression consistent with previous studies. A large sample survey of the
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52 prevalence of depression among Tibetans of the Qinghai-Tibet Plateau was 28.6%,
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54 higher than that in the general Chinese population and higher than that reported in a
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56 western study with high-altitude samples[44]. The prevalence of depression is
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4 significantly correlated with climatic pressure, particularly altitude[45]. Generally, the
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6 combined effects of harsh natural environment on the plateau, high-altitude hypoxia,
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8 low atmospheric pressure, intense ultraviolet radiation, relatively weak community
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10 support caused by low population density, and lack of access to mental health resources
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12 increases the severity of depression among those living in high-altitude areas[46-48].
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14 In this study, the area with an altitude of 1500–3500 m was located southeast of the
15
16 TAR. Nyingchi City, with an average altitude of 3100 m, has the lowest altitude and
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18 wettest climate in TAR. With convenient transportation and multiple splendid sceneries,
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20 tourism is the main source of income in this area, attracting millions of people traveling
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22 for sightseeing, mountaineering, and trekking every year[49]. Previous studies have
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24 reported a significant association between tourism impact and residents' quality of
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26 life[50, 51]. Tourism provides employment opportunities and tax revenues, supports
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28 economic diversity, and services and products enjoyed by residents[52, 53]. However,
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30 negative impacts of tourisms on residents' HRQoL have been reported including
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32 crowding, traffic and parking issues, criminality, and cost of living, changes in hosts'
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34 way of life, and friction between tourists and residents[54]. The perceived negative
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36 impacts, negative emotions, pressure, and relative deprivation of the residents will
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38 affect their subjective well-being, leading to psychological problems including anxiety
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40 and depression.
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53 This study had several limitations. First, this study did not recruit the same pool of
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55 participants in two waves of surveys, making it difficult to identify causal associations.
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58 However, the same cities were selected, and the participants may partly overlap. Second,
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4 the participants recruited in the surveys were those had lived in Tibet for more than six
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6 months; however, we could not determine if they were born in Tibet or came to work
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9 from other low-altitude areas. A small-scale survey could be conducted to refine the
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11 participant inclusion criteria to validate the study findings in the future. Third, many
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13 studies have reported that EQ-5D-3L has more significant ceiling effects than EQ-5D-
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15 5L. However, EQ-5D-3L is more suitable for use in large-scale population surveys
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17 because of its small cognitive burden. Moreover, the comparison of the two waves of
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19 surveys indicated the overall changing trends in HRQoL of participants were able to be
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21 derived from EQ-5D-3L.
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28 **Conclusion**

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31 This study revealed the HRQoL of Tibetan population was lower than general Chinese
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33 population, and decreased over time between 5 years. There were differences in
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35 HRQoL among Tibetan at different altitudes, with residents living at 3500-4000m
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37 having the best quality of life. More attention should be paid to those Tibetans who are
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39 older, female, unemployed and without formal education. Targeted policies and
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41 strategies need to be strengthened, including plateau subsidies, poverty alleviation,
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43 primary health service capacity, standardized management of chronic diseases, and
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45 health education.
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56
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4 who participated in the study.
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11
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16 **Competing interest statement**

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19 All authors declare no competing interests.
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22 **Author Contributions**

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25
26 SPL and ZXDW have substantial contributions to conception and design, acquisition
27
28 of funding, data and interpretation of data. CDZG and ZXCM were involved in the
29
30 acquisition of data. LD, ZS and CFL were responsible for the data analysis and
31
32 interpretation of data. LD drafted the manuscript, ZS, CDZG, ZXCM and CFL revised
33
34 it critically for important intellectual content, LD and SPL was responsible for the
35
36 decision to submit the manuscript, and all authors contributed to final approval of the
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38 manuscript.
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45 **Ethics statements**

46 47 **Patient consent for publication**

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51 Not applicable.
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54 **Ethics approval**

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57 This study involves human participants and was approved. This study was conducted
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4 with the approval of the National Health Commission of the People's Republic of China
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6 and the Health Commission of Tibet autonomous region.
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9 **Data availability statement**

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13 Data are available upon reasonable request. We have included all the data produced in
14
15 the present work in the manuscript. Note that the raw data used in the study were
16
17 obtained from National Health Service Surveys of China. We are unable to attach all
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19 the raw data for each participant in this paper due to the ethical restrictions.
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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±51 5	-	
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	

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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

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

EQ-5D-3L	2013		2018		χ^2	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

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4 **Figure legends**
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6 Figure 1 Distribution of participant's health state utility scores in 2013 and 2018
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9 Figure 2a Proportions of health problems reported by participants at different altitude
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11 in 2013
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14 Figure 2b Proportions of health problems reported by participants at different altitude
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16 in 2018
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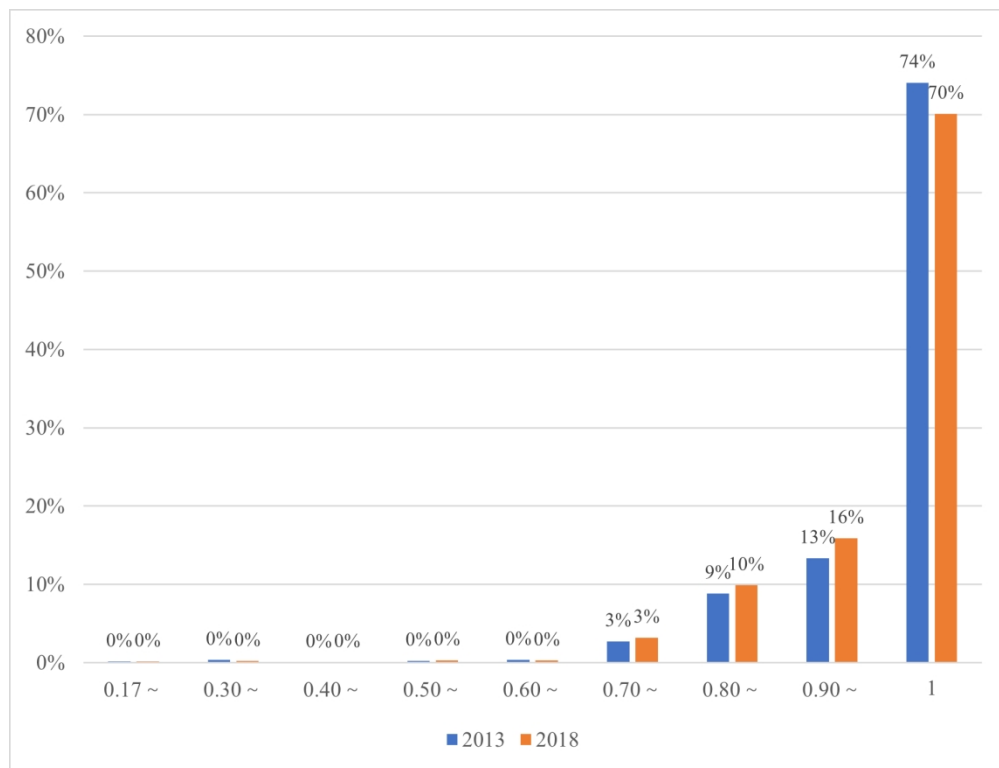


Figure 1 Distribution of participant's health state utility scores in 2013 and 2018

146x111mm (330 x 330 DPI)

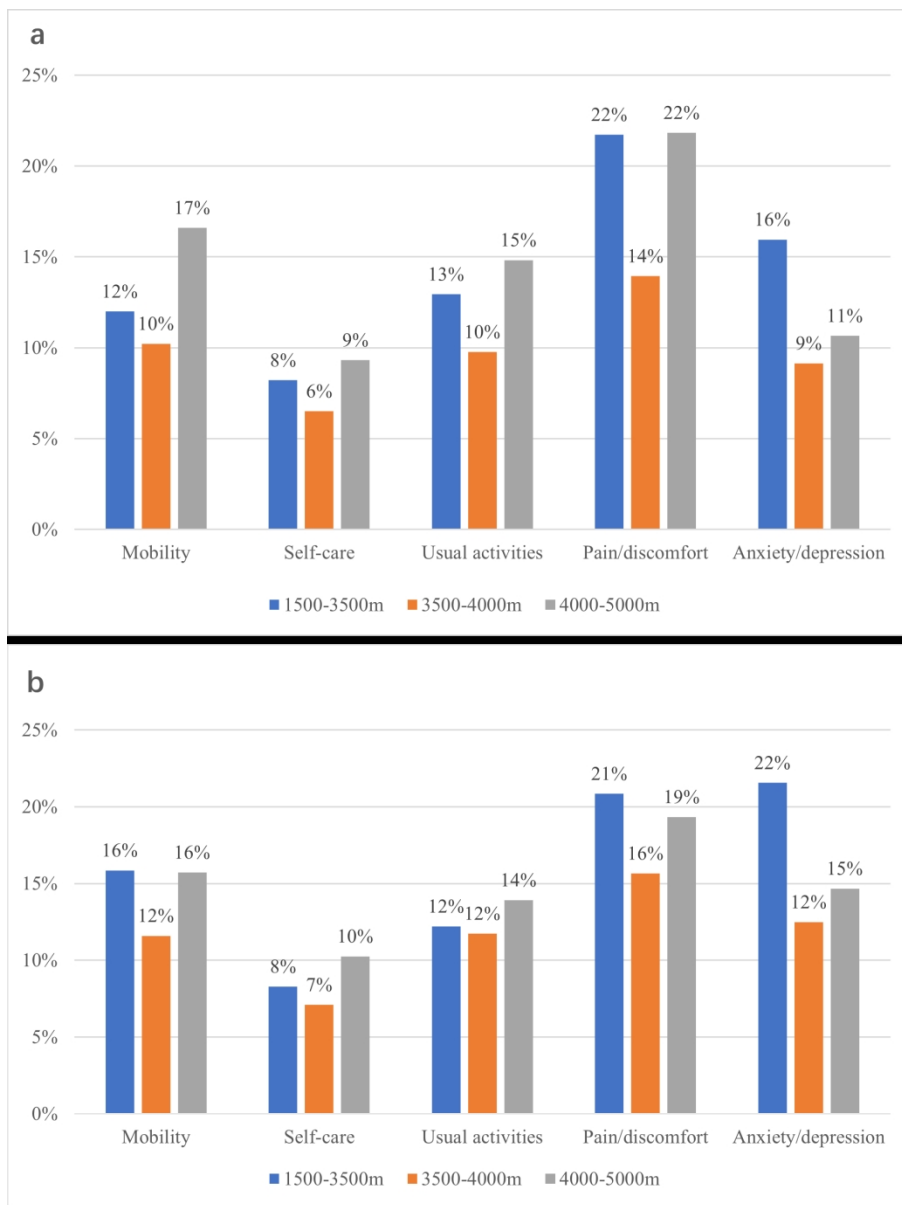


Figure 2a Proportions of health problems reported by participants at different altitude in 2013
 Figure 2b Proportions of health problems reported by participants at different altitude in 2018

146x193mm (330 x 330 DPI)

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

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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.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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

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

1	Abstract	#1b	Provide in the abstract an informative and balanced summary	P2
2				
3			of what was done and what was found	
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6	Introduction			
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10	Background /	#2	Explain the scientific background and rationale for the	P4-5
11				
12	rationale		investigation being reported	
13				
14				
15	Objectives	#3	State specific objectives, including any prespecified	P6
16				
17			hypotheses	
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20	Methods			
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23	Study design	#4	Present key elements of study design early in the paper	P6-7
24				
25				
26	Setting	#5	Describe the setting, locations, and relevant dates, including	P6
27				
28			periods of recruitment, exposure, follow-up, and data	
29				
30			collection	
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34	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of	P6-7
35				
36			selection of participants.	
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40		#7	Clearly define all outcomes, exposures, predictors, potential	P7
41				
42			confounders, and effect modifiers. Give diagnostic criteria, if	
43				
44			applicable	
45				
46				
47	Data sources /	#8	For each variable of interest give sources of data and details	P7-10
48				
49	measurement		of methods of assessment (measurement). Describe	
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51			comparability of assessment methods if there is more than	
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53			one group. Give information separately for for exposed and	
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55			unexposed groups if applicable.	
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1	Bias	#9	Describe any efforts to address potential sources of bias	P6
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4	Study size	#10	Explain how the study size was arrived at	P6
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7	Quantitative	#11	Explain how quantitative variables were handled in the	P6-7
8	variables		analyses. If applicable, describe which groupings were	
9			chosen, and why	
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15	Statistical	#12a	Describe all statistical methods, including those used to	P10-11
16	methods		control for confounding	
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20	Statistical	#12b	Describe any methods used to examine subgroups and	P10
21	methods		interactions	
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26	Statistical	#12c	Explain how missing data were addressed	P10
27	methods			
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31	Statistical	#12d	If applicable, describe analytical methods taking account of	P10-11
32	methods		sampling strategy	
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36	Statistical	#12e	Describe any sensitivity analyses	P10-11
37	methods			
38				
39				
40				
41				
42	Results			
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45	Participants	#13a	Report numbers of individuals at each stage of study—eg	P11
46			numbers potentially eligible, examined for eligibility,	
47			confirmed eligible, included in the study, completing follow-	
48			up, and analysed. Give information separately for for	
49			exposed and unexposed groups if applicable.	
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57	Participants	#13b	Give reasons for non-participation at each stage	P6
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1	Participants	#13c	Consider use of a flow diagram	n/a
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4	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	P11
5			clinical, social) and information on exposures and potential	
6			confounders. Give information separately for exposed and	
7			unexposed groups if applicable.	
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14	Descriptive data	#14b	Indicate number of participants with missing data for each	P11
15			variable of interest	
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18				
19	Outcome data	#15	Report numbers of outcome events or summary measures.	P11-12
20			Give information separately for exposed and unexposed	
21			groups if applicable.	
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27	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	P12-13
28			adjusted estimates and their precision (eg, 95% confidence	
29			interval). Make clear which confounders were adjusted for	
30			and why they were included	
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37	Main results	#16b	Report category boundaries when continuous variables were	P12-13
38			categorized	
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42	Main results	#16c	If relevant, consider translating estimates of relative risk into	n/a
43			absolute risk for a meaningful time period	
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48	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups	P12-13
49			and interactions, and sensitivity analyses	
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53	Discussion			
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56	Key results	#18	Summarise key results with reference to study objectives	P13-14
57				
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1	Limitations	#19	Discuss limitations of the study, taking into account sources	P18-19
2			of potential bias or imprecision. Discuss both direction and	
3			magnitude of any potential bias.	
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9	Interpretation	#20	Give a cautious overall interpretation considering objectives,	P14-18
10			limitations, multiplicity of analyses, results from similar	
11			studies, and other relevant evidence.	
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16	Generalisability	#21	Discuss the generalisability (external validity) of the study	P19
17			results.	
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22	Other Information			
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25	Funding	#22	Give the source of funding and the role of the funders for the	P20
26			present study and, if applicable, for the original study on	
27			which the present article is based	
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