The Association between Nutritional Status and Household Sanitation among Rural Children in the Tibetan and Sichuan Minority Areas: A Cross-Sectional Study

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Abstract
To investigate the nutritional status and household sanitation among children under 5 years in Tibetan and Sichuan minority areas and to analyse the association between nutritional status and household sanitation. A cross-sectional survey was conducted by the probability proportional to size sampling method between August and October 2016. Bivariate and multivariate logistic regression analyses were used to analyse the association between nutritional status and household sanitation. A total of 965 children under the age of 5 and their caregivers were included. The rates of stunting, underweight, wasting, overweight, obesity and normal development of children in Sichuan and Tibet were 19.8%, 8.0%, 5.2%, 4.6%, 1.8%, and 69.0%, respectively. There was statistically significant differences in children's household sanitation status with different family income. Multivariate logistic regression results showed that the other unprotected water sources, unboiled drinking water, sanitary and dry toilets, unsanitary and dry toilets, usually do not washing hands at critical times, washing hands only with water and unsanitary treatment of children’s faeces were the risk factors for stunting in children. Protected well water, other unprotected water sources, unsanitary and dry toilets, washing hands at only one critical moment, washing hands only with water and unsanitary treatment of children’s faeces were risk factors for underweight in children. The malnutrition of children under 5 years of age in the rural areas home to ethnic minorities in Sichuan and Tibet is serious. The children’s household sanitation status is poor, and household sanitation has an impact on both the height and the weight of the child. The relevant departments should increase the family’s economic income while conducting household sanitation interventions, thereby reducing the incidence and mortality due to malnutrition.

Keywords: Malnutrition, Household sanitation, Children under 5, Ethnic minority.

Introduction
The World Health Organization (WHO) estimated in 2018 that...
approximately 52 million children under the age of 5 are wasting, 17 million are severely wasting, 155 million are stunted, 41 million are overweight/obese, and approximately 45% of deaths among children under 5 are related to malnutrition [1]. Children aged 0–5 years old are the age group most likely to suffer malnutrition, and nutritional status in the early stage of life is directly related to subsequent growth and development, learning, cognitive ability and even labour productivity in adulthood [2–4]. In 2012, the World Health Assembly planned to reduce global under-five malnutrition to less than 100 million children by 2025 and to end all forms of malnutrition by 2030 [5–6].

The incidence of child malnutrition has decreased greatly since China’s economic reform. In 1990, the rate of stunting among children under 5 years of age in China was 31.3%, and the rate of underweight was 7.4%. In 2010, these figures decreased to 9.4% and 3.4%, respectively [7]. However, the differences between urban and rural areas and regions cannot be ignored; the rates are obviously higher in rural areas than in urban areas, and the rates are obviously higher in poor areas than in economically developed areas [8–11]. A previous study showed that the rate of stunting among children under 5 years of age was 15.9%, the underweight rate was 7.8%, and the wasting rate was 3.7% in poor areas of China [12]. In 2017, the National Nutrition Plan issued by the State Council of China (2017-2030) explicitly stated that the rate of stunting among children under 5 should be less than 7% in 2020 and below 5% in 2030, indicating the main development goal of child nutrition [13].

Tibet and Yi nationality areas of Sichuan are located in western China, which is a relatively backward economic area. In addition, the Tibetan and Yi ethnic minorities are the two of the most representative ethnic minorities in China, with the most complete national customs and habits and the most prominent national characteristics. A survey conducted in 2011 showed that the rates of stunting, underweight and wasting among children in the minority areas of Sichuan and Tibet were 30.5%, 16.5% and 1.6%, respectively [14], which are much higher than those of children in other parts of China; therefore, these children should receive increasing attention from relevant Chinese and international bodies.

Household sanitation refers to all family-related sanitation, including household sanitation facilities, such as toilets, drinking water sanitation and the hygiene behaviour of caregivers and children. There are many factors that affect the malnutrition of children, mainly including the family financial situation, the child’s age, feeding habits, hygiene behaviour and the child’s state of health. Studies have shown that there is a clear correlation between children’s diarrhea and family environmental hygiene [15–17]. However, there are few studies on the effect of household sanitation on chronic malnutrition in Chinese children. Therefore, the purpose of this study is to analyse the association between household sanitation and the nutritional status of children and to provide a scientific intervention strategy for improving the nutritional status of rural children in poor minority areas.

Methods and data collection

The study population included children under 5 years of age and their caregivers. A cross-sectional survey was conducted from August to October 2016, and the main investigated areas were Ganluo County and Yuxei County in Liangshan Yi Autonomous Prefecture of Sichuan and Saga County and Aung Ren County in Xigaze region of Tibet. The probability proportional to size (PPS) sampling was used to select sample villages. The main steps were as follows: step 1: 15 administrative villages were randomly selected in each county according to the PPS sampling method; step 2: 2 natural villages in each administrative village were randomly selected by PPS sampling; step 3: In Sichuan, after the natural village was determined, 8 caregivers were randomly selected from each natural village according to the family roster containing children under 5 years of age. In Tibet, administrative villages could not be divided into natural villages, and 5 caregivers were randomly selected from each administrative village according to the family roster containing children under age 5 years of age. If a sample village failed to meet the proposed sample size, another sample village was randomly selected in the same layer until the intended sample size was achieved. The number of people surveyed in each county of Sichuan needed to reach 240, and the number of people surveyed in each county of Tibet needed to reach 70. At least 620 caregivers of children under the age of five were investigated in Sichuan and Tibet. (8 or 5 households in each natural village were chosen for the survey because the Tibetan and Yi areas of Sichuan are sparsely populated.) The inclusion criteria were as follows: 1. The children’s age range: the children were born after the date of the 2011 survey; 2. Long-term local residence: the local residence time was 2/3 greater than the child’s age. The exclusion criterion was that the children were not at home at the time of the investigation.

The questionnaire was designed by the Maternal and Child Health Project expert group. The main contents included the basic characteristics of the children and their caregivers, the feeding situation of the children, the situation of household sanitation and the physical examination of the children, such as, height and weight, etc.

All investigators were uniformly trained, with an investigation team of 4 to 5 qualified investigators led by local village doctors. Using one-on-one question and answer, the investigators filled out questionnaires on the PAD on the spot. Subsequently, the questionnaires were uploaded to the database. Finally, the data verification was carried out by the evaluation team of Peking University. The physical examination of each child was carried out by two investigators using standardized equipment in accordance with the international standard method of measurement [18]. Lying length was measured of children under 2 years old; and standing height was measured of children older than 2 years old. Each child’s length/height and weight were measured twice to take the mean value. A third measurement was required if the error of the two measures was greater than 0.05 kg for weight and more than 0.1 cm for length/height.
Data analysis

The primary outcome measures were nutritional status of children, including, length/height-for-age (HAZ) < median-2 standard deviation (M-2SD) was considered stunting; weight-for-age (WAZ) < M-2SD was considered underweight; weight-for-height (WHZ) < M-2SD was considered wasting, M+2SD ~ M+3SD was considered overweight, >M+3SD was considered obese; children without stunting, underweight, wasting, overweight and obesity were defined as normally developing. Child growth and development standards published by the WHO in 2006 [18].

Basic characteristics of children and their caregivers included children's sex, age (0~, 12~, 24~, 36~ and 48~59 months), area, ethnic, caregivers, mother's educational level (illiterate/primary school, junior middle school, senior high school and above) and household per capita net income (0~, 308~, ≥769 dollars).

Household sanitation included drinking water source (purified tap water, protected well water, unprotected well water and others). Whether to boil before drinking water? (boiled and unboiled). Toilet type (flush sanitary toilet, flush unsanitary toilet, sanitary and dry toilet and unsanitary and dry toilet). Washing hands at critical moments: a total of 8 critical moments are listed: after the completion of agricultural work, before cooking, before dining, before feeding the baby, after defecation, after handling the child’s faeces, other and usually do not wash hands. The analysis was grouped by number, and the four groups include the option usually do not wash hands, 1, 2, 3 and above. Washing hand mode including soap and only water. Child’s faeces treatment including sanitary and unsanitary.

Descriptive analysis was used to present the basic characteristics of children and caregivers. Chi-square test was used to compare nutritional status of children in different ages and the household sanitation of children in different family income. We examined the association between nutritional status of children and household sanitation using bivariate and multivariate logistic regression analysis. All data analyses were performed using SPSS21.0. P <0.05 was considered statistically significant.

Results

Basic characteristics of children and their caregivers

A total of 965 children under 5 years and their caregivers were included in this study. Of these, 51.7% were boys. Those aged 0~, 12~, 24~, 36~ and 48~59 months were 33.5%, 28.2%, 20.7%, 10.5% and 7.2%, respectively. A vast majority of the respondents in Sichuan (84.5%) and most of the respondents were from Yi (71.7%). A total of 721 (74.7%) mothers were surveyed, of whom 85.4% were illiterate/had primary school education. 54.6% of respondents reported their household per capita net income. Incomes of 0~, 308~ and ≥769 dollars were reported by 36.8%, 40.0% and 23.1% of the families, respectively (Table 1).

| Variables                      | n   | %  |
|--------------------------------|-----|----|
| Sex                            |     |    |
| boy                            | 499 | 51.7|
| girl                           | 466 | 48.3|
| Age (month)                    |     |    |
| 0~                             | 323 | 33.5|
| 12~                            | 272 | 28.2|
| 24~                            | 200 | 20.7|
| 36~                            | 101 | 10.5|
| 48~59                          | 69  | 7.2 |
| Area                           |     |    |
| Sichuan                        | 815 | 84.5|
| Tibet                          | 150 | 15.5|
| Ethnic                         |     |    |
| Han                            | 117 | 12.1|
| Yi                             | 692 | 71.7|
| Tibetan                        | 156 | 16.2|
| Caregivers                     |     |    |
| mother                         | 721 | 74.7|
| others                         | 244 | 25.3|
| Mother's educational level     | (n=721) |    |
| illiterate/primary school      | 616 | 85.4|
| junior middle school           | 88  | 12.2|
| senior high school and above   | 17  | 2.4 |
| Family income (dollars)        | (n=527) |    |
| 0~                             | 194 | 36.8|
| 308~                           | 211 | 40.0|
| ≥769                           | 122 | 23.1|

Table 1: Basic characteristics of children and their caregivers (n=965).
The chi-square test results showed that there were significant differences in drinking water source, whether water was boiled before drinking, toilet type, hand washing at critical moments, washing hand mode and treatment of children’s faeces among families with different incomes (Table 3).

### Household sanitation of children

Among these 965 households, 16.0% of respondents had the source of water was purified tap water, 42.8% of respondents reported water was boiled before drinking, 13.0% of respondents had the toilet was flushed, 16.5% of caregivers reported hands were washed at three or more critical moments, 36.4% of caregivers reported hands were washed with soap and 59.4% of respondents reported the child’s faeces were treated hygienically. The chi-square test results showed that there were significant differences in drinking water source, whether water was boiled before drinking, toilet type, hand washing at critical moments, washing hand mode and treatment of children’s faeces among families with different incomes (Table 3).

### The association between nutritional status and household sanitation

After adjusting for factors including age, sex and region, other unprotected water sources (AOR=3.21,
95%CI=1.41–7.32), unboiled drinking water (AOR=2.05, 95%CI=1.41–2.97), sanitary and dry toilets (AOR=2.04, 95%CI=1.12–3.71), unsanitary and dry toilets (AOR=2.80, 95%CI=1.42–5.51), usually do not washing hands at critical moments (AOR=2.11, 95%CI=1.15–3.90), washing hands only with water (AOR=1.53, 95%CI=1.03–2.26), and unsanitary treatment of children's faeces (AOR=1.56, 95%CI=1.11–2.20) were risk factors for stunting in children (Table 4).

After adjusting for factors including age, gender and region, protected well water (AOR=4.28, 95%CI=1.46–12.52), other unprotected water sources (AOR=4.30, 95%CI=1.36–13.61), unsanitary and dry toilets (AOR=4.44, 95%CI=1.26–15.59), washing hands at only one critical moment (AOR=2.77, 95%CI=1.15–6.65), washing hands only with water (AOR=2.22, 95%CI=1.20–4.09) and unsanitary treatment of children's faeces (AOR=2.01, 95%CI=1.23–3.28) were risk factors for underweight in children (Table 4).

**Discussion**

Malnutrition is still the main public health problem affecting children in poor rural areas in China. The rates of stunting, underweight and wasting were higher than those

| Variables               | Morbidity rate(%) | COR(95%CI)       | P     | AOR(95%CI)       | P     |
|-------------------------|-------------------|-----------------|-------|-----------------|-------|
| **Stunting**            |                   |                 |       |                 |       |
| Drinking water source   | purified tap water| 13.6            | 1     |                 | 1     |
|                         | protected well water| 25.6          | 2.18 (1.12–4.25) | 0.022 | 1.98 (0.92–4.24) | 0.081 |
|                         | unprotected well water| 19.4        | 1.52 (0.92–2.51) | 0.100 | 1.38 (0.82–2.31) | 0.223 |
|                         | others            | 31.3            | 2.88 (1.43–5.80) | 0.003 | 3.21 (1.41–7.32) | 0.005 |
| Boiling before drinking | boiled            | 15.0            | 1     |                 | 1     |
|                         | unboiled         | 23.4            | 1.73 (1.24–2.41) | 0.001 | 2.05 (1.41–2.97) | <0.001 |
| Toilet type             | flush sanitary toilet| 12.0          | 1     |                 | 1     |
|                         | flush unsanitary toilet| 17.3       | 1.54 (0.63–3.77) | 0.350 | 1.91 (0.75–4.85) | 0.173 |
|                         | sanitary and dry toilet| 19.8       | 1.82 (1.02–3.22) | 0.042 | 2.04 (1.12–3.71) | 0.020 |
|                         | unsanitary and dry toilet| 26.2       | 2.60 (1.37–4.93) | 0.003 | 2.80 (1.42–5.51) | 0.003 |
| Washing hands at critical moments | usually don not wash hands| 15.1       | 1     |                 | 1     |
|                         | one               | 28.3            | 2.22 (1.24–4.01) | 0.008 | 2.11 (1.15–3.90) | 0.017 |
|                         | two               | 20.9            | 1.49 (0.91–2.43) | 0.116 | 1.52 (0.91–2.53) | 0.111 |
|                         | three and above   | 16.9            | 1.14 (0.66–1.97) | 0.635 | 1.14 (0.65–2.00) | 0.660 |
| Washing hand mode       | soap              | 15.1            | 1     |                 | 1     |
|                         | only water        | 21.0            | 1.50 (1.04–2.15) | 0.030 | 1.53 (1.03–2.26) | 0.034 |
| Child’s faeces treatment| sanitary         | 18.3            | 1     |                 | 1     |
|                         | unsanitary        | 21.9            | 1.25 (0.91–1.72) | 0.167 | 1.56 (1.11–2.20) | 0.011 |
| Underweight             | purified tap water| 3.9             | 1     |                 | 1     |
|                         | protected well water| 17.4          | 5.21 (1.94–14.00) | 0.001 | 4.28 (1.46–12.52) | 0.008 |
|                         | unprotected well water| 6.8       | 1.80 (0.76–4.30) | 0.185 | 1.87 (0.77–4.52) | 0.166 |
|                         | others            | 17.2            | 5.12 (1.80–14.53) | 0.002 | 4.30 (1.36–13.61) | 0.013 |
| Boiling before drinking | boiled            | 8.5             | 0.89 (0.56–1.42) | 0.623 | 1.20 (0.72–2.01) | 0.491 |
|                         | unboiled         | 7.6             | 0.89 (0.56–1.42) | 0.623 | 1.20 (0.72–2.01) | 0.491 |
| Toilet type             | flush sanitary toilet| 2.4             | 1     |                 | 1     |
|                         | flush unsanitary toilet| 5.8        | 2.49 (0.47–12.76) | 0.274 | 2.48 (0.48–12.77) | 0.277 |
|                         | sanitary and dry toilet| 8.1         | 3.57 (1.10–11.63) | 0.035 | 3.03 (0.92–9.98) | 0.068 |
|                         | unsanitary and dry toilet| 12.5       | 5.81 (1.69–19.94) | 0.005 | 4.44 (1.26–15.59) | 0.020 |
| Washing hands at critical moments | usually don not wash hands| 3.8       | 1     |                 | 1     |
|                         | one               | 9.2             | 2.57 (0.92–7.17) | 0.071 | 2.18 (0.77–6.13) | 0.141 |
|                         | two               | 10.2            | 2.90 (1.21–6.94) | 0.017 | 2.77 (1.15–6.65) | 0.023 |
|                         | three and above   | 6.3             | 1.71 (0.65–4.46) | 0.275 | 1.56 (0.59–4.09) | 0.370 |
| Washing hand mode       | soap              | 4.3             | 1     |                 | 1     |
|                         | only water        | 10.3            | 2.57 (1.42–4.66) | 0.002 | 2.22 (1.20–4.09) | 0.011 |
| Child’s faeces treatment| sanitary         | 5.8             | 1     |                 | 1     |
|                         | unsanitary        | 11.2            | 2.07 (1.29–3.31) | 0.002 | 2.01 (1.23–3.28) | 0.005 |

Table 4: The effect of the different household sanitation on the nutritional status of children.
according to the 2009 China Food and Nutrition Monitoring system (CFNSS) [19] and Yu [12]. It is also higher than the survey results in other ordinary rural areas, poor areas and ethnic minority areas [20-25]. The malnutrition of children in the Tibetan and Sichuan minority areas is serious, which is quite different from that in other regions.

The rate of stunting in this survey was 19.8%, which was lower than the rate of 30.5% found in 2011 [26] but still much higher than the target rate of 7% in 2025 [13]. The change may be a result of the common effects of socioeconomic changes, child-feeding habits and environmental hygiene changes. The rate of stunting increased with age, and the rate of stunting in the group of 48–59-month-old boys was 37.5%, which is consistent with the findings of previous studies [27-30]. One possible explanation is that the children were malnourished for a long time, and the higher stunting rate accompanied increasing age.

A large number of studies have shown that the higher the family’s economic level is, the lower the rate of child malnutrition [31-36]. A study conducted in Vietnam has shown that the impact of socioeconomic inequality on child malnutrition increases over time and that socioeconomic status is the first cause of inequality in stunting and the second cause of inequality in underweight [37]. The study found that the sanitation situation of the family in Sichuan and Tibet was poor, and the household sanitation of the families with different economic conditions was obviously different. The household environmental sanitation may have been affected by the economic situation of the family.

Our study showed that household sanitation had an important impact on the children’s height and weight after adjusting for confounding factors. Thus, household sanitation may be a direct factor of the nutrition of children. Although similar studies have shown that household sanitation facilities, water sources and household hygiene behaviours are major contributors to children diarrhea [38-40]. Poor sanitation is likely to have an impact on the nutritional status of children by increasing the risk that the children catch an infectious disease [41-44]. Therefore, intervention in household sanitation may reduce the malnutrition among children.

There are also several limitations bearing in mind. Due to a variety of reasons, 438 (45.4%) people were reluctant to disclose their family income, and maybe have some influence on our analysis results. Besides, this study is a cross-sectional study, which cannot be used to draw causality conclusions. Further verification research should be carried out to clarify the impact of family hygiene conditions on the nutritional status of children.

Conclusion

The malnutrition of children in the Tibetan and Sichuan minority areas is serious. Stunting, underweight and wasting among children are obvious, especially the phenomenon of stunting, which is the most serious. The household sanitation status of the children is poor, household sanitation has an impact on both the height and the weight of the child. However, household sanitation can be affected by the family’s economic level. The relevant departments should take drinking water, sanitary toilets and individual hygiene as the main household hygiene intervention items, and at the same time increase family income, thereby reducing the morbidity and mortality resulting from malnutrition.

Authors’ Contribution

HX designed and performed the study. XZ analyzed the data and results interpretation and wrote the paper. CLL and CX and MJL analyzed the data and paper modification. WJ, XPF and YJL participated in data collection and quality control. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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