Short communication

# Double burden of malnutrition in urbanized settled Tibetan communities on the Tibetan plateau

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**Background and Objectives:** A previous pilot study revealed stunted children and obese adults in urbanized settled Tibetan communities. A survey with a representative population in selected communities was conducted to test the preliminary findings. **Methods and Study Design:** A cross-sectional study on the nutritional status involving 504 children (244 boys and 260 girls, 5-16 y) and 927 adults (422 men and 505 women, 18-90 y) was conducted in communities, with anthropometric parameters measured. The z-scores for height-for-age (HAZ) and BMI-for-age (BAZ) in children were calculated according to WHO 2007 reference. **Results:** The children showed a double burden of both under- and over-nutrition. The prevalence of under-nutrition in children was high – stunting (HAZ <-2) 10.7%, underweight (BAZ <-2) 9.5%, combined prevalence of stunting and underweight 19.4%. The rate of over-nutrition was also alarming – obesity 12.7% (BAZ >2). The mean value of HAZ (-0.45±1.41) was lower than, whereas that of BAZ (0.05±1.76) was comparable to, the WHO reference. No significant differences were found in under- or over-nutrition between genders. Specifically, 8.9% of children demonstrated both short stature (HAZ <-1) and overweight (BAZ >1). By contrast, community adults showed almost a one-way direction tilted towards over-nutrition – overweight 61.4% (BMI ≥24 kg/m$^2$), obesity 30.1% (BMI ≥28 kg/m$^2$), and central obesity 62.0% (waist circumference, men ≥85 cm, women ≥80 cm). Women were marginally more likely to be obese than men ($p$=0.061). **Conclusions:** The co-existence of under- and over-nutrition in the community may have reflected the suboptimal early life nutrition and the obesogenic environment afterwards. Potential determinants need to be explored for future interventions.

Key Words: double burden of malnutrition, undernutrition, obesity, Tibetan, urbanization

## INTRODUCTION

The WHO has defined double burden of malnutrition (DBM) as the co-existence of under-nutrition along with overweight, obesity or diet-related non-communicable diseases (NCDs), within individuals, households and populations, and across the lifecourse.[1] The DBM was particularly common in low- and middle-income countries,[2] or countries or areas under nutrition transition.[3] The DBM was also not rare in the Asia and Pacific Region, as we have analyzed in a recent systematic review.[4]

The Tibetan population involved in the ecological migration and settling programs in the headwater areas of some important rivers on the Tibetan Plateau has been experiencing rapid dietary and lifestyle transition since 2005.[5,6] The urban life provided settled communities with improved infrastructure, health services and education. Meanwhile, this may have also led to a changed pattern of malnutrition. A previous pilot study on the nutritional status of children and adults in the urbanized settled Tibetan communities showed co-existence of stunted children and obese adults in the community, despite of very limited sample size.[7] To test the pilot findings in a representative population with a larger sample size, we conducted the current study.

## METHODS

### Participants

The cross-sectional survey was conducted in two urbanized settled Tibetan communities in Golmud city, which is easily accessible by both the Qinghai-Tibet railway and the highway. The geographic feature and background of the communities have been described before.[6] Briefly, both communities are located in the suburbs of the Golmud city, and are well connected to the center of the city by public buses. The residents in the communities are originally from the pure pastoral areas with extreme high altitude (usually above 4,000 meters above sea level), and then settled or semi-settled in urban areas since 2007. Thus, the target population is a unique population in transition from pastoral to urban settings. This study was approved by the Ethics Committee of Medical College, Qinghai University.

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The survey in adults was a community-based study conducted in November and December in 2018. The sampling framework has been described in details before.[6] The 1003 participants enrolled in the survey were a representative population for the surveyed communities. After excluding the participants with missing age (N=21) or an age less than 18 y (N=2), with missing data in ethnicity (N=4) or other ethnicity rather than Tibetan (N=14), with missing data in BMI (N=5), or in waist circumference (N=30), a total of 927 adults aged 18-90 y were enrolled in the analysis.

The survey in children was a school-based study. There is only one bilingual primary school (Tibetan and Mandarin) in Golmud, which is almost exclusively for the Tibetan children in the two communities. We sampled the total population of the school children, which are almost the total population of primary school-aged children in the communities.

The survey among primary school children was conducted in October 2018, and enrolled 504 children aged 5-16 y. The ages of some students were older than the expected ages of primary school children because some children started school education later in local context. In our student population, still 94.3% students were younger than 13 y, which is usually the up-limit age for primary school children.

### Anthropometric measurements and z-score calculation

The anthropometric measurements among adults have been described in detail before.[6] Underweight was defined as BMI $\leq 18.5$ kg/m$^2$, overweight was defined as BMI $\geq 24$ kg/m$^2$, obesity was defined as BMI $\geq 28$ kg/m$^2$, and central obesity was defined as waist circumference $\geq 85$ cm for men, or $\geq 80$ cm for women, according to the reference from the Working Group on Obesity in China (WGOC).[8] The BMI thresholds in Chinese criteria for overweight and obesity were lower than the WHO criteria (overweight BMI $\geq 25$ kg/m$^2$, obesity BMI $\geq 30$ kg/m$^2$). The former are derived from the data in Chinese population, whilst the latter are from the Western population.[8]

For children, the height was measured by a calibrated ruler, and weight measured by a calibrated mechanical scale (TANITA, HA-622, Dongguan, China). The measurements were performed twice by a trained field investigator, with the mean value used. The AnthroPlus software released by WHO[9] was used to calculate the z-scores of height for age (HAZ), and z-scores of BMI for age (BAZ). The WHO reference 2007 was used to define the nutritional status: stunting -HAZ <-2; severe stunting - HAZ <-3; underweight - BAZ <-2; severe underweight - BAZ <-3; overweight - BAZ >1; obesity - BAZ >2.[2,10] In addition, we used the term "short stature" to describe the status of HAZ <-1. We adopt the WHO reference 2007 rather than the Chinese growth criteria for school children[11,12] mainly for comparability with other populations. Another reason is that Chinese criteria[11,12] provided only cut-off values for categories, which did not allow the calculation of z-scores for height and BMI.

### Statistical methods

Data were presented as continuous or categorical variables. Student t test was used for continuous variables, and chi square test was applied for categorical variables. Spearman rank correlation analysis was used to calculate the correlation between age and z-scores. $p<0.05$ was considered as statistically significant.

## RESULTS

### Demographic characteristics

Among the 927 adults, 422 (45.5%) were men and 505 (54.5%) were women. The mean age of the adults was 43.3±13.9 years (18-90 y), with no statistical difference between genders.

Among the 504 children, 244 (48.4%) were boys and 260 (51.6%) were girls. The average age of the children was 9.4±2.2 years (5.8-15.9 y), with no significant difference between boys and girls.

### Nutritional status of children and adults

Table 1 shows the nutritional status of participating children and adults. The children demonstrated a double burden of both under- and over-nutrition. The prevalence of under-nutrition in children was high - stunting 10.7%, underweight 9.5%, combined prevalence of stunting and underweight 19.4%. Meanwhile, the prevalence of over-nutrition was also alarming - overweight (including obesity) 24.0%, and obesity 12.7%. No significant difference was found in under- or over-nutrition between boys and girls (all $p>0.05$). Particularly, 8.9% of children demonstrated both short stature (HAZ <-1) and overweight (BAZ >1). The distribution of children with both short stature and overweight did not differ significantly between genders, or among age groups (data not shown).

By contrast, community adults showed almost a one-way direction tilted towards over-nutrition - overweight (including obesity) 61.4%, obesity 30.1%, and central obesity 62.0%. Women were marginally more likely to be obese than men ($p=0.061$) (Table 1).

### HAZ and BAZ in children by age groups

Figure 1 specifies the nutritional status among children by age groups. Figure 1A shows that five out of seven age groups had a HAZ median below zero in boys; whereas in girls, the number was six out of seven (Figure 1B). Further analysis showed a negative spearman rank association between HAZ and age in girls ($\rho=-0.204$, $p=0.001$), while the negative association was marginally significant in boys ($\rho=-0.116$, $p=0.070$).

For BAZ, the oldest three age groups showed a median of below 0 in both boys and girls (Figure 1C, Figure 1D). A negative association between BAZ and age was shown in both boys ($\rho=-0.165$, $p<0.001$) and in girls ($\rho=-0.216$, $p<0.001$).

## DISCUSSION

This study showed the co-existence of under- and over-nutrition among children, and the epidemic of over-nutrition among adults. A unique pattern of malnutrition — delayed height growth and increased body weight — was also found in children.

The DBM in the target population in selected communities has been found at the individual level — 8.9% of children demonstrated both short stature (HAZ <-1) and overweight (BAZ >1), at the population level — both

**Table 1.** Double burden of malnutrition among children and adults in urban resettled Tibetan communities

| | Total | Boys/Men | Girls/Women | *p*-value |
|---|---|---|---|---|
| Height for age (5-16y) | | | | |
| Sample size | 504 | 244 | 260 | |
| z-score mean (SD)[†] | -0.45 (1.41) | -0.41 (1.36) | -0.48 (1.45) | 0.554 |
| % Short stature[‡] | 33.3 | 32.0 | 34.6 | 0.529 |
| % Stunting[†] | 10.7 | 11.1 | 10.4 | 0.805 |
| % Severe stunting[†] | 3.6 | 2.9 | 4.2 | 0.410 |
| BMI for age (5-16y)[†] | | | | |
| Sample size | 504 | 244 | 260 | |
| z-score mean (SD)[†] | 0.05 (1.76) | -0.01 (1.75) | 0.11 (1.78) | 0.454 |
| % Underweight [†] | 9.5 | 10.7 | 8.5 | 0.402 |
| % Severe underweight[†] | 5.2 | 5.7 | 4.6 | 0.569 |
| % Overweight[†] | 24.0 | 23.4 | 24.6 | 0.742 |
| % Obesity[†] | 12.7 | 11.1 | 14.2 | 0.286 |
| Adults (18-90 y) | | | | |
| Sample size | 927 | 422 | 505 | |
| % Underweight[§] | 2.4 | 2.4 | 2.4 | 0.995 |
| % Overweight[§] | 61.4 | 61.6 | 61.2 | 0.895 |
| % Obesity[§] | 30.1 | 27.0 | 32.7 | 0.061 |
| % Abdominal obesity[¶] | 62.0 | 59.2 | 64.4 | 0.110 |

[†]Based on WHO reference 2007: stunting – HAZ (z-score for height for age) <-2; severe stunting – HAZ <-3; underweight – BAZ (z-score for BMI for age) <-2; severe underweight – BAZ <-3; overweight – BAZ >1; obesity – BAZ >2.[2,10]
[‡]Short stature was defined as HAZ <-1.
[§]Based on China standard BMI ≥24/28 kg/m² for overweight/obesity, and BMI ≤18.5 kg/m² for underweight.[8]
[¶]Based on China reference waist ≥85/80 cm (men/women).[8]
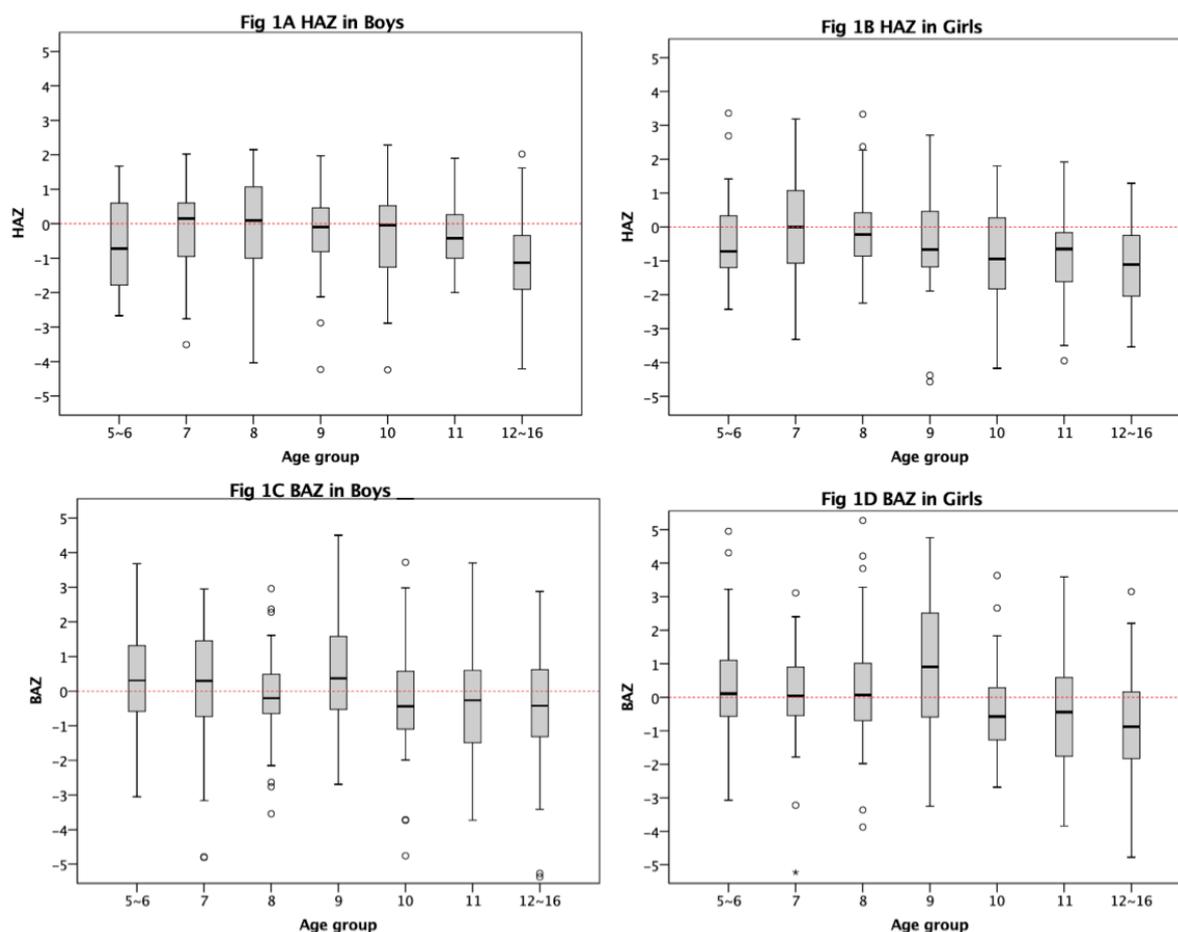


**Figure 1.** Nutritional status among children by age groups. HAZ is defined as the z-score of height for age; BAZ is defined as z-score of BMI for age. The sample sizes of boys and girls are 244 and 260, respectively.

stunting and obesity rates were over 10% in children, and probably also at the household level, given the high rates of overweight and obesity in adults (in total 61.4%), as well as the high prevalence of under-nutrition in children (combined prevalence of stunting and underweight 19.4%).

The DBM revealed in the target population was different from the pattern of malnutrition in major cities in China, where only over-nutrition is a major public health challenge in both children and adults.[13,14] Nevertheless, the findings are in line with previous reports among the indigenous/minor-ethnic populations from traditional to transitional/modern lifestyles.[15] Among the children surveyed, the prevalence of stunting was much higher (10.7% vs 3.2%) than, and the rate of underweight (9.5% vs 9.0%) was comparable to, the national average in 2012.[14] Whilst the obesity rates in adults and in children were even higher than the national average in 2012 (adults 30.1% vs 11.9%; children 12.7% vs 6.4%).[14] Despite that data for the present study were collected 6 years later than the indicated national survey, the DBM in the target population is obviously a serious public health issue.

The seemingly contradictory co-existence of under- and over-nutrition may be explained by unfavorable nutrition in early life and its further health impact till adulthoods. Among adults, the epidemic of obesity could be explained by the poor nutritional status in the first 1000 days of life and the following nutritional and lifestyle transition.[16,17] In our previous study, three major dietary patterns — the urban, western and pastoral patterns — were identified in the adult population in the same selected communities. With the common feature of frequent beef and mutton consumption, the urban dietary pattern was characterized by frequent consumption of tubers/roots, refined carbohydrates and vegetables; the western pattern characterized by sugary drinks, snacks, and desserts; and the pastoral pattern featured *tsamba* (roasted Tibetan barley), Tibetan cheese and buttered/milk tea. The three identified dietary patterns showed the mixed impacts from the urban settled and pastoral settings, implying the ongoing of dietary transition in such communities.[6] The prevalence of other lifestyle related metabolic diseases in this adult population was also high — non-alcoholic fatty liver disease 40.3%, hypertension 16.6% and dysglycemia 17.1%.[5] On the other hand, the DBM among children could be explained by the suboptimal nutrition support in early life, which led to shorter stature, and the catch-up growth in later life. The typical example is that 8.9% children in our study showed both short stature and overweight.

Beyond the biological reasons, other environmental and socio-cultural determinants may also play a role. For example, the indigenous pastoral area is vast and the population density is extremely low. Thus, the accessibility to nutritional and other support was difficult in an indigenous setting. Furthermore, gender inequalities in local culture also led to less exposure to education and health information for women, which prevented women from chances to offer their children better care. These environmental and socio-cultural factors may contribute to the current DBM at the individual and at the population level. For the pastoralists who settled in urban areas, the physical access to nutritional and other support has been greatly improved, but the socio-cultural barriers remain.

Another interesting finding is the negative association between age and HAZ, and between age and BAZ among children. Children who were born later, showing as a younger age, generally had higher HAZ and BAZ. This may be the consequence of improved nutrition in children over the years, due to the improved access to nutritional and health care support. The governmental nutritional support programs, e.g. nutrition improvement programs among rural school children, probably also played a positive role. These programs improved the nutritional status of school children, meanwhile also promoted school education in disadvantaged areas. Another explanation to the negative association may be the delayed pubertal growth in the child population, supported by an older age at menarche of Tibetan girls[18] or high-altitude Himalayan population.[19] Tanner's study showed that later maturers were shorter and lighter than early maturers of the same age in preadolescents.[20] A recent research also showed an increased gap in body weight between the premenarcheal and menarcheal girls with increased age among preadolescents and adolescents.[21] These studies were consistent with the negative association between age and HAZ, and between age and BAZ, among the school children population.

An important limitation of the present study is that we did not collect the data on socioeconomic status of children's families or other variables, which may allow further analysis into the possible determinants of DBM in communities. This should be corrected in further studies.

### Conclusion

The co-existence of under- and over-nutrition in the community may have reflected the suboptimal early life nutrition and the obesogenic environment afterwards. To tackle the rising DBM in Tibetan settled communities, and other similar urbanized communities in the rapid transitions occurring in China, it is important to regard this DBM as an important point for integrated intervention and action on malnutrition in all its forms.[1] The Developmental Origins of Health and Disease (DOHaD) theory implicated the necessity for intervention in early life from a biological perspective.[17] Meanwhile, socio-cultural determinants should also be considered in health promotion,[22] thus serving the goal of health for all, as announced in the comprehensive plan of "Healthy China 2030".[23]

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