

Nutritional intakes and associated factors among tuberculosis patients: a community-based cross-sectional study in China

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Abstract

Objectives This study evaluated nutrient intakes of tuberculosis (TB) patients and examine their associated factors. **Methods** In this cross-sectional study, 300 adult TB patients were enrolled in two poverty counties in China. Nutrient intakes were evaluated through two consecutive 24-h dietary recalls and compared with the Chinese Dietary Reference Intakes (DRIs) 2013. Corresponding information for local general population was derived from 2015 China Health and Nutrition Survey. **Results** The mean daily energy and protein intakes of TB patients were below Recommend Nutrient Intake (RNI) and Adequate Intake (AI) in both genders, and intakes of many micronutrients, except for vitamin E and sodium, were insufficient. Compared with those for local general population, TB patients' intakes of all the macronutrients and micronutrients were lower ($p < 0.05$) except total fat. In addition, Proportions of people with lower macronutrient or micronutrient intakes were higher in TB patients than in general population except for Vitamin E intake. Being unemployed was a risk factor for low energy intake and higher household income level was a protective factor ($p < 0.05$), and out-home-eating was a protective factor for low protein intake ($p < 0.01$). **Conclusions** In poor areas in China, the intakes of macronutrients and most micronutrients in TB patients were less than in general population, and were inadequate compared with DRIs, especially unemployed patients and patients with low household income level, suggesting the importance of health promotion to TB patients about significance of nutrition and further interventions in TB patients' nutritional intakes.

Introduction

Tuberculosis (TB) is an airborne disease caused by *Mycobacterium tuberculosis* and is the first leading cause of death among single infectious agents. According to World Health Organization (WHO), there were estimated 10.0 million people fell ill with TB and 1.6 million people died from TB in 2017. China is in 2th place among 30 TB high burden countries, with a reported incidence of 63 per 100,000 persons per year in 2017(1).

The interactions between tuberculosis and malnutrition are well appreciated. TB will result in malnutrition and malnutrition can predispose to TB. TB increases the basal metabolic rate (BMR)(2), thus requiring more energy to maintain body function. However, due to reduction in appetite and gastrointestinal disorders, food intake will decrease in TB patients, resulting in undernutrition. Malnutrition will in turn lead to impaired immune function(3, 4), as nutritional deficiency alters the interaction between macrophages and T-lymphocytes(5), thus increasing the risk of TB infection.

Studies have indicated that the intakes of both macronutrients and micronutrients were inadequate in TB patients. Three studies in China(6-8) reported that protein and caloric intakes in TB patients were inadequate as well as some micronutrients. Insufficient protein and caloric intakes will hinder the functions of some generalized host defense mechanisms that are essential for combating TB(9). Besides, both vitamins and minerals play important roles in immunity(10), deficiency of one or more of these nutrients will impair person's resistance to any infection(11).

Assessment of nutrient intakes is critical in nutritional management of patients with TB. Until now, only one research group conducted studies on nutrient intakes in TB patients in China, however, they did not examine associated factors about nutrient intakes. Moreover, to our knowledge, until now there are no studies conducted to evaluate the nutritional status of TB patients with reference to the latest Chinese Dietary Reference Intakes (DRIs) 2013(12). We carried out this community-based study to evaluate nutrient intake levels of TB patients by comparing them with both current dietary recommendations in China and local general population, and to examine associated factors of nutrient intakes among TB patients.

Methods

Study Context

This cross-sectional study was undertaken as part of the project “Investigation of nutrition and diet of patients with pulmonary tuberculosis in poor areas in China” supported by the WHO Regional Office in the Western Pacific. It was conducted from November 2015 to April 2017 in two counties, that is, Linyun county located in Guangxi province and Lin county located in Shanxi Province. These two counties were national poverty counties and TB control programs were carried out well. TB case notification rates in 2016 were 63.16 per 100,000 in Lin county and 106.97 per 100,000 in Linyun county, respectively.

Participants

Adult patients (age \geq 18 years) with active TB registered in *Tuberculosis management information system* from Nov 1st, 2015 through May11th, 2017 and signed consent form were recruited. Patients with extrapulmonary tuberculosis, and those aged 18 years and below or with severe complications were not eligible for the study. Pregnant or breast-feeding women, and those who refused to sign the consent form were also excluded. China Health and Nutrition Survey (CHNS) was conducted in 2015 among the general population in these two countries with the same component for nutrition assessment. The findings of the CHNS was taken as a comparison group for our study. Detailed information about CHNS 2015 was available on website <https://www.cpc.unc.edu/projects/china/about/design/sample>.

Sample Size

As BMI is commonly used in nutrition assessment, we applied the prevalence of BMI $<$ 18.5 which is also defined as malnutrition(13)],[in the calculation of sample size. We assumed that the prevalence of malnutrition in the general population in poor areas and TB patients would be 6.7% (14)and 25.0%(2), respectively, and the required sample size was calculated to detect difference in the two proportions. The probability of a type I error was set at 0.05, the power of the study was estimated at 90% and the design effect was set at 1, determining a sample size of TB patients was 77 per study site. Considering participants’ refusal, we expanded the sample size to 150 per study site, and the final sample size of TB patients was 300 totally.

As for general population, after exclusion of subjects with missing data, the sample size was 496. A multistage, random cluster process was used to draw the sample of general population in CHNS 2015.

Socio-demographic and behavioral factors

Data for associated factors were taken from a questionnaire on personal information, including socio-demographic data (age, gender, education level, marital status, occupation and household income level) and behavioral data (alcohol consumption, smoking status and eating out-of-home). Age was categorized into 3 groups, 18-49 years, 50-64 years, 65 years and above, based on Chinese Dietary Reference Intakes (DRIs) 2013(12). Education level was categorized into 2 groups(15), that is, primary school and below, junior middle school and above. Household income level was evaluated by annual household income and was categorized into 3 groups, <20,000 yuan, 20,000-40,000 yuan, and \geq 40,000 yuan(15). Alcohol consumption was defined as drinking wine, beer and Chinese spirit now or ever. A smoker was defined as smoking now or smoking previously but quitting now. Eating out-of-home was defined as eating at least one meal away from one's own home or their residents' home during the survey(16).

Assessment of Nutrient intake

Trained staff performed face-to-face interviews on each participant to obtain dietary intake data through a 2-day 24-hour dietary recall (24hr) questionnaire, which was adapted from the method of 3-day 24hr(17). Participants were instructed to record all food intake at home and away from home in the previous 2 days (one weekday and one weekend day). Consumptions of condiments were also recorded through a questionnaire. All investigations were completed after the patient registering in *Tuberculosis management information system* and before anti-tuberculosis treatment. Data for dietary intake of general population was obtained from a 3-day 24hr questionnaire (two weekdays and one weekend day).

Total energy, four kinds of macronutrients and sixteen kinds of micronutrients were evaluated. Nutrient intakes of each patient were calculated based on Chinese Food Composition Tables (CFCT) 2004(18).

We also evaluated TB patients' nutritional intake by applying Chinese dietary reference intakes (DRIs) 2013, with mean daily nutrient intakes compared with Recommended Nutrient Intakes (RNIs) and Adequate Intakes (AIs).

Statistical analysis

A Chi-square test and a Wilcoxon rank sum test were used to compare the characteristics of TB patients and the general population. Data of daily nutrient intakes were presented as means \pm standard deviation (SD). A Wilcoxon rank sum test was conducted to compare differences in daily energy and nutrient intakes of TB patients and general population. As dietary recommendations are different for men and women, we compared TB patients' and general populations' daily nutrient intakes with DRIs by gender. Comparisons in proportion of participants whose nutrient intakes were below RNI/AI were analyzed with

a Chi-square test and Fisher exact test. Since protein-calorie malnutrition (PCM) is the most common form of undernutrition in TB patients[11], we only examine factors related to insufficient energy and protein intakes using univariate and multivariate logistic regression models, and patients were classified into two groups: below RNI/AI and above RNI/AI. A P-value of less than 0.05 was considered statistically significant. All analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, NC, USA).

Quality Control

The study was carried out on the basis of CHNS 2015, from which the investigating method and tool were used in our study. All on-site investigations were carried out by the county-level CDC and interviewers were trained with a standard protocol. Data was checked for completeness and accuracy on the day of investigation and sampled by provincial CDC for verification later. All data was double-entered into a database specially designed for this project.

Results

Characteristics of the subjects

There were significant differences ($p < 0.05$) in both socio-demographic and behavioral characteristics between TB patients and the local general population, except for household income level, as shown in Table 1. Most TB patients in our study aged between 18 and 49, and were males, but the majority of general population was in the 50-64 age group and difference of percentages for different genders was not great. Most TB patients were low-educated, married and employed, with annual household income less than 20,000 RMB yuan. More general population tended to have alcohol consumption than TB patients, but the proportion of non-smokers was significantly higher in the general population than in the TB patients. Both TB patients and general population were more likely to eat at home during the survey (Table 1).

Daily energy and nutrient intakes

With reference to RNI/AI, the average daily energy and protein intakes of TB patients were inadequate in both genders (Table 2). As for micronutrients, in male TB patients, the mean daily intake of retinol, niacin, vitamin E, sodium, iron, Manganese, copper and Phosphorus were all higher than RNI/AI, while calcium intake was severely less than RNI/AI. In female TB patients, the intakes of vitamin E, copper and sodium were higher than RNI/AI. However, the intakes of riboflavin, potassium and calcium were severely inadequate.

Although the mean daily intakes of energy and protein in the general population were higher than those in the TB patients, they were still less than RNI/AI. It was also found that except for total fat, both macronutrient and micronutrient intakes in general population were higher than those in TB patients with significant difference ($p < 0.05$). Proportions of people with macronutrient or micronutrient intakes below RNI/AI were higher in TB patients than in general population except Vitamin E intake.

Factors associated with low energy and low protein intakes

As shown in table 3, univariate analysis suggested that being unemployed was associated with inadequate energy intake and annual household income with 40,000 RMB yuan and above was a protective factor. In multivariate analysis (see Table 4), after adjusting for other factors, unemployed participants were more likely to have low energy intake (OR: 3.364; 95%CI:1.499, 7.550)($p<0.01$), and, TB patients with annual household income more than 40, 000 RMB yuan were less likely to have low energy intake compared with those whose annual household income was less than 20,000 RMB yuan (OR:0.334; 95%CI:0.114, 0.978)($p<0.05$). Meanwhile, lower protein intake was associated with eating at home. The possibility of low protein intake for people eating out-of-home was much lower than those eating at home (OR: 0.330; 95CI%:0.137, 0.794)($p<0.05$).

Discussion

Our study demonstrated that intakes of both macronutrients and selected micronutrients were inadequate in most TB patients. Protein-calorie malnutrition (PCM), characterized by inadequate intakes of both protein and total calories(9), was common in TB patients, with both the male and female TB patients taking energy and protein below RNI/AI. This finding was consistent with some published studies(6-8) in China. Also, mean daily intakes of many micronutrients were below RNI/AI, especially calcium, in our study, the intake of which was much lower than RNI/AI in all the women and 99.5% of men. A survey conducted in China revealed that TB patients did not take enough fish, shrimp and dairy products(19), which are all calcium-rich food. This may explain the insufficient intake of calcium. However, sodium consumption was higher than RNI/AI in TB patients. Researches conducted in other populations(20-22) in China also showed that high sodium consumption remained a public health problem. Nevertheless, the quality of diet seemed to improve in some ways, as the daily intake of vitamin E was much higher than RNI/AI in both genders compared with previous studies(6-8)],[9],[.

Compared with the local general population, intake of total fat was a little higher among TB patients. This result was different from another study conducted in TB patients in Shandong Province(8), in which general populations' fat intake was more than TB patients'. The difference may be caused by different dietary patterns in different provinces, thus, further research is needed to confirm this.

Furthermore, we discerned that eating out-of-home was related to higher intake of protein. Relevant studies conducted among other populations in China(23-25) also demonstrated that there was an increase in protein intake while eating out-of-home. The reason for this phenomenon may be that people tend to choose food with better tastes and higher nutritional values when they eat away from home(24). We also discovered that the inadequate energy intake was significantly higher among TB patients having lower household income or unemployed, being consistent with studies(26, 27)],[conducted in other countries. This is most likely because that persons with low socio-demographic status will not be able to afford nutritious food.

Limitations and Strengthenings

There are some limitations in our study. On the one hand, we used the 24hr method to evaluate the nutrient intakes, and this method has its own shortcomings. Reliance on the memory of participants and recall bias could result in an underestimation of nutrient intakes(28). And, when measuring the consumption of condiments, we didn't take the household weighing method commonly used in nutrition survey. On the other hand, we hope to enroll all eligible TB patients in these two counties notified from Nov 1st, 2015 to May 11th, 2017. However, almost all notified TB patients in Lin county were included in our study, while TB patients enrolled in our study accounted for less than 40% of all notified TB patients in Linyun county during that period. This may result in that our findings could not be generalized to all TB patients in Linyun county.

Although limitations existed, our study has outstanding strengthenings. Firstly, different from previous hospital-based studies, our study is a community-based study initiated in comparing TB patients' nutrient intakes with the latest DRIs and examining the associated factors in TB patients' nutrient intake. This design avoids the selection bias and can represent the real nutrient intake for all TB patients. Moreover, we collected the same information for local general population and make comparisons between these two groups, avoiding the influence of different dietary patterns in various areas.

Conclusions

Our study showed that in poor areas in China, the intakes of macronutrients and most micronutrients in TB patients were less than those in local general population, and were inadequate compared with DRIs, especially for those unemployed or with low household income level. These findings suggest the public health actions in promoting education on TB patients about the significance of nutrition and further interventions in TB patients' nutritional intakes.

Abbreviations

TB: tuberculosis; DRIs: Dietary Recommended Intakes; RNI: Recommend Nutrient Intake; AI: Adequate Intake; WHO: World Health Organization; BMR: basal metabolic rate; CHNS: China Health and Nutrition Survey; 24hr: 24-hour dietary recall; CFCT: Chinese Food Composition Tables; SD: standard deviation; PCM: protein-calorie malnutrition; CDC: center for disease control and prevention.

Declarations

Ethics approval and consent to participate

The present study protocol was approved by the China CDC Institutional Ethics Review Board (NO. 201532) and The Ethic Review Committee of the WHO Regional Office in the Western Pacific (2015.22.CHN.3.STB). All those agreed to participate in the survey had to provide informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Zhewen Ren: analyzed the data, completed statistical analysis and wrote the initial draft of the manuscript. Fei Zhao: conceived the research idea, conducted the data collection. Hui Chen and Dongmei Hu: made contributions to data analysis. Wentao Yu and Xiaoli Xu: supervises the data collection and analysis. Dingwen Lin, Fuyi Luo, Yueling Fan and Haijun Wang: participated in the implementation of the study. Jun Chen and Liyun Zhao: designed the study and contributed to the protocol conception. All authors' read and approved the final manuscript.

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