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Micronutriens Associated with the Risk of Chronic Non-Communicable Diseases among Rural-to-Urban Nong Zhuan Fei Migrants in Northern China

Weilun Cheng[1,#], Zhiying Zhang[2,3,#], Weiyu Zhou[2], Yujing Wang[2], Jian Li[3], Haiqiao Yu[2], Yuanxin Xu[2], Shuang Yan[2,3,*]

[1]The Second Affiliated Hospital of Harbin Medical University, Harbin, China
[2]The Fourth Affiliated Hospital of Harbin Medical University, Harbin, China
[3]Harbin Medical University, Harbin, China
[#]*These authors contributed equally to this work.*
*Corresponding author: 002577@hrbmu.edu.cn

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Abstract In China, Nong Zhuan Fei (NZF) rural-to-urban migrants living in rural villages were reocated and moved into newly constructed urban apartments. NZF rural-to-urban migrants face drastic changes in their lifestyle and dietary habits after moving to cities, and this could affect their risk for non-communicable diseases (NCDs). We investigated the association between the prevalence of NCDs and dietary habits (especially micronutriens intake habits)in urbanized migrants in Harbin, China. This was a community-based cross-sectional study conducted in a NZF community of 3,184 residents in the Harbin of north China. NZF adult articipants completed a questionnaire addressing demographics, medical history, and life and dietary habits. The subjects completed 24-hr dietary recall for 3 days and a three-day physical activity recall. Anthropometric measurements, blood pressure, and fasting blood glucose were measured. Include statistical analyses a total of 1150 subjects completed the study (response rate of 64.9%). The prevalence of diabetes, hypertension, and stroke was 11.6%, 23.3%, and 13.3%, respectively. The rates of vitamin and mineral intake below the recommendations in female were higher than that in male ($p<0.05$). Inadequate vitamin B1 and B6 intakes contributed to diabetes (B1: OR=0.568, 95%CI: 0.344-0.938; B6: OR=0.333, 95%CI: 0.114-0.979), while high calcium intake contributed to diabetes (OR=1.001, 95%CI: 1.000-1.002). High vitamin B1 (OR=1.601, 95%CI: 1.198-2.140) and manganese (OR=1.159, 95%CI: 1.064-1.262) intakes contributed to hypertension, whereas high zinc was negatively associated with hypertension (OR=0.910, 95%CI: 0.860-0.963) and stroke (OR=0.935, 95%CI: 0.888 to 0.984). This NZF rural-to-urban migrants in Northeast China shows a high prevalence of NCDs (diabetes, hypertension, and stroke), and the intake of vitamins and minerals is below the recommendations. So the prevalence of NCDs was associated with the change from a rural to an urban lifestyle, especially the intake of vitamins and minerals. Action is needed to prevent a possible NCDs crisis in NZF migrants by public health professionals in the future.

Keywords: *micronutrients, lifestyle, non-communicable diseases, risk factors, rural-to-urban migrants*

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1. Introduction

As the leading cause of death globally, non-communicable diseases (NCDs) were responsible for 38 million (68%) of the world's 56 million deaths in 2012, and deaths from NCDs are projected to increase to 52 million by 2030 [1]. NCDs are chronic diseases, cannot be transmitted from person to person, are of long duration, and generally display a slow progression. NCDs is a chronic continuously progressing, and almost incurable disease. It causes serious damage to health. The four main types of NCDs are cardiovascular diseases (like heart attack and stroke), cancer, chronic respiratory diseases (such as chronic obstructed pulmonary diseases and asthma), and diabetes [2]. Patients with NCDs are often affected both physically and psychosocially, and the consequences of the NCDs place a burden on individuals and healthcare systems [3].

Nearly 82% of these NCDs deaths occurred in low- and middle-income countries [4,5], and China is a typical one. NCDs like diabetes, hypertension, and stroke are major public health burdens, accounting for 86.8% of the total mortality among Chinese in 2012 [6]. Currently, China has undergone dramatic economic and environmental

development, both of which impact greatly on daily life and health of each individual. Among the various dimensions of change, the most outstanding one has been "nutrition transition". The China Health and Nutrition Survey (CHNS) during 1991–2009 has shown the shift in the form of either nutrients or food items or dietary patterns and this dietary shift is associated with education, income, urbanicity, and macro food environment and policy [7]. A study examining the level of NCDs and health knowledge of NZF residents in Chongqing, China, found that two-thirds of NZF residents 50 years of age suffered from NCDs, with more than half having two or more chronic non-communicable diseases [8].

The nutrition transition from traditional diets (high in cereal and fiber, low in fat and micronutrients) to more Western pattern diets (high in sugars, fat, and animal-source foods, low in micronutrients and carbohydrate) [9,10]. Nutrients derived from the diet are essential for life by providing a vital energy source (macronutrients) and also provide essential cofactors required for enzymes to function, structural moieties, and transport (micronutrients). Absorption and utilization of nutrients are influenced by physiological and diet-related factors. Nutrients include macronutrients and micronutrients. Macronutrients include protein, lipid, carbohydrate. Micronutrients include vitamins and minerals. Macronutrients are mainly responsible for providing energy, and micronutrients are involved in the biological functions of metabolism [11].

In addition, as China's society and economy are rapidly developing, a large number of rural dwellers are moving to cities. Before moving, the dietary habits of those NZF rural-to-urban migrants were still nearer the traditional Chinese dietary habits, but moving to cities will lead to changes in lifestyle and dietary habits [12]. Hence, the large communities of NZF migrants face lifestyle-based risk factors (For example: Changes in Diet, changes in work patterns, reduced physical activity, reduced voluntary movement) for NCDs. Lifestyle changes affect disease health and affect the occurrence and development of NCDs. In particular, current research found that NCDs is not only related to macro-nutrients, but also related to micronutrients [13].

There are some studies from the urban and rural Chinese populations that showed that diets high in refined cereal and low in fruit and vegetables are associated with increased risk of type 2 diabetes mellitus (T2DM), hypertension, and stroke [14]. However, there is a lack of such data from urbanized migrants in northeast China. Therefore, the present study was to assess the dietary intake of a northeast China's NZF migrant population in relation to the dietary recommendations for Chinese. Hence, this study investigated the association between the prevalence of NCDs and dietary habits among this population of NZF migrants. The findings may contribute to formulating dietary guidelines for the prevention of NCDs for the huge NZF migrant population in China. The few Chinese-language studies that have been conducted document a high prevalence of chronic disease among NZF community residents.

In this study, the permanent population of the Golden Star community in Harbin (China) was selected. All individuals in this community are people who changed from agricultural life to urban life. The Chinese government aims to integrate an additional 250 million people into cities by 2050 [15]. Therefore, more efforts are needed to reverse the rise of NCDs among NZF migrants in China.

2. Materials and Methods

2.1. Study Design and Subjects

This was a community-based cross-sectional study conducted in the Golden Star Community of Harbin in the Heilongjiang province of Northeast China. A door-to-door recruitment method was used from May to September 2021 to identify the potential participants. According to committee records, at the time of data gathering, there were believed to be 1,310 families and approximately 3,184 residents living in Golden Star Community, ranging in age from newborn to 92 years. If nobody was home, an attempt was made over the weekend. If the potential subject was not home for 2 consecutive weeks, they were considered withdrawn from the study.

The study was approved by the Ethics Committee of Harbin Medical University (HMU20200320). All subjects provided written informed consent for participation.

The inclusion criteria were: (1) permanent residents ≥17 years of age in the Golden Star community; and (2) volunteered to participate in the study and signed the informed consent form.

2.2. Data Collection

A door-to-door recruitment method identified 1,772 eligible residents, who were then invited to participate in the study.

Participants completed study questionnaire as directed by an investigator, including: age, sex, educational level, annual income. Height, weight, waist circumference, hip circumference, and blood pressure were measured at the subjects' home. Weight and height were measured according to a standard protocol. Body mass index (BMI) was calculated as weight (kg) divided by squared height (m). BMI was classified using the Working Group on Obesity in China (WGOC) standards (obesity was BMI ≥28 kg/m2, and overweight was BMI 24-28 kg/m2) [16]. The waist-to-hip ratio (WHR) was calculated as waist circumference (cm) divided by hip circumference (cm) [17,18]. Fasting blood glucose was measured using a glucometer on the following morning in the building of the community neighborhood committee. Each participant was given a full physical examination by a medical professional.

Medical history was recorded, including any history of diabetes mellitus, coronary heart disease, chronic obstructive pulmonary disease, hypertension, and ischemic stroke. To identify self-reported chronic diseases, participants were asked, "Have you ever been diagnosed by a health professional as having (name of disease: e.g., diabetes, hypertension, cardiovascular disease, chronic obstructive pulmonary disease)?" We included both undiagnosed and diagnosed diabetes. We coded participants as having diabetes if: (1) they responded "yes"

to self-reported diabetes question; or (2) they responded "no" to the question but had a fasting blood glucose level ≥7.0 mmol/l. Blood pressure was measured manually using the non-dominant arm after 15 min of rest [19]. We coded participants as having hypertension if: (1) they responded "yes" to self-reported hypertension; or (2) responded "no" to the question but had a systolic blood pressure of ≥140 mmHg.

Alcohol consumption (number of drinks per day over the past 30 days; a drink was defined as a glass of wine, 0.5 bottles of beer, 125g of fruit wine, or 40g of white spirit) and current smoking status (having consecutively or cumulatively smoked for 6 month during lifetime) were recorded [20].

A 3-day food questionnaire was conducted by trained interviewers using food models and common household measures to help participants estimate food portions over the past two weekdays and one weekend day. A 24-h food recall questionnaire was conducted to validate the dietary behavior and habits (e.g., portions sizes, and where, when, and how often meals are consumed), fiber, vitamins, and minerals.

A 3-day physical activity recall questionnaire was used to estimate participants' typical activity patterns for the previous 3 days [21]. The mean levels of metabolic equivalents (METs) were calculated for the 3 previous days (METs/day/person). Because the values were highly skewed (skewness = 2.9), tertiles were used to reflect low (≤32.0), moderate (>32.0 to <36.8), or high (≥36.8) levels of physical activity.

Complete data were gathered from 1,150 residents; 272 residents who refused to participate and 350 residents who contributed data on the first day but failed to return the following day for the fasting blood glucose test were not included in the study, as shown in Figure 1. The database was established by input of the diet type and consumption with the software of EPIDERATA3.0. The energy intake and food composition were evaluated with the standard version V2.5 of Feihua Nutrition Calculator.

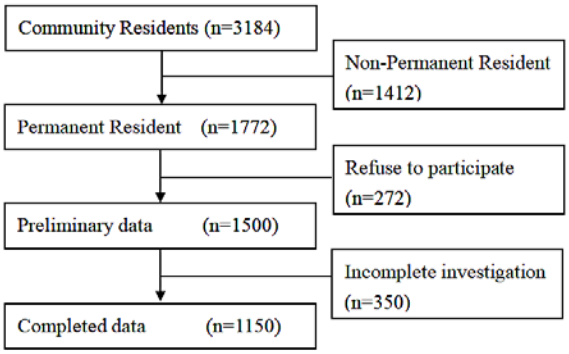

Figure 1. Flowchart of Data collection

2.3. Statistical Analysis

Normal distribution of continuous data was tested by the Kolmogorov-Smirnov test; all data were found to be not normally distributed, and nutritional data are presented as median (interquartile range). Dietary data were analyzed using FeiHua nutritional calculator standard version V2.5 (Chinese Center for Disease Control, Beijing, China). Participant's dietary intake was compared with the recommended intake of "Chinese Resident Dietary Nutrient Reference Intake" designated by the Chinese Nutrition Society in 2013 [22]. Univariable and multivariable logistic regression analyses were used to determine the association of factors with NCDs. For all tests, p values <0.05 were considered statistically significant. All statistical analyses were performed using SPSS 20.0 (IBM, Armonk, NY, USA).

3. Results

3.1. Subjects

Table 1. Demographic features of the study population (n=1150)

Characteristic	N	Percent [a] (%)
Age (years)		
17-29	128	11.1
30-39	150	13.0
40-49	227	19.7
50-59	328	28.5
60-69	199	17.3
≥70	118	10.3
Sex		
Male	436	37.9
Female	714	62.1
Education		
None	100	8.7
Primary school	313	27.2
Middle school	443	38.5
Senior/technical school	180	15.6
Junior college	67	5,8
≥University	47	4.1
Annual income (in Yuan)		
<10,000	214	18.6
10,001-30,000	418	36.4
30,001-50,000	364	31.6
50,001-100,000	126	11.0
100,001-200,000	28	2.4
BMI (kg/m^2) [b]		
Normal (≤24.0)	532	46.3
Overweight (24.0-27.9)	441	38.3
Obese (≥28.0)	177	15.4
Smoking (yes) [c]	352	30.6
Alcohol (yes) [d]	317	27.6
Diabetes (yes)	133	11.6
Hypertension (yes)	268	23.3
Cardiovascular (yes)	238	20.7
Chronic obstructive pulmonary disorder (yes)	33	2.9
Stroke (yes)	153	13.3
Physical activity [e]		
Low (≤32.0)	310	27.0
Moderate (32.1-36.7)	548	47.6
High (≥36.8)	292	25.4
Central obesity (waist circumference ≥90 cm in men, ≥80 cm in women)	716	62.3

a Percentage may not sum to 100 because of rounding.
b (Ying-Xiu and Shu-Rong 2012)
c Defined as having smoked daily for at least six months during one`s life.
d Defined as having up to drink per day for women and up to two drinks per day for men.
e Calculated as the mean level of metabolic equivalents for the three previous days.
BMI: body mass index.

During the study period, 1772 eligible residents were invited to participate: 272 refused to participate, and 350 responded to the questionnaire but declined measurements on the following day. Therefore, 1150 residents were included in the study. The majority of the study population was female (62.1%, n=714). The subjects were mostly ≥50 years of age (56.1%). Most participants had a middle school education, or lower (74.4%), and more than half had an annual family income of ≤30,000 Yuan. The frequencies of overweight and obesity were 38.8% (n=441) and 15.4% (n=177), respectively. Smoking and drinking were 30.6% (n=352) and 27.6% (n=317), respectively. The majority of the participants had a moderate physical activity (n=548, 47.6%), 27.0% had low physical activity, and 25.4% had high physical activity. About two-thirds (62.3%) had central obesity according to waist circumference (waist circumference ≥90 cm for men or ≥ 85cm for women) (Table 1).

3.2. Dietary Intake

The energy intake and food composition were evaluated with the standard version V2.5 of Feihua Nutrition Calculator.

Median fiber intake was only 9.20 g/day for the study population (Table 2). The majority of the participants had an improper intake of calcium (96.6%), selenium (83.4%), manganese (56.9%), magnesium (72.1%), and potassium (72.2%). On the other hand, the prevalence of inadequate iron (26.7%), phosphorus (30.1%), zinc (49.5%), and copper (9.0%) intakes was low (Table 2 and Figure 2). Proportion of inadequacies of calcium, iron, phosphorus, potassium, copper, manganese, and selenium in female were more higher than that in male (Table 2 and Figure 3). Proportion of inadequacies of some vitamins (including vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin D, and folic acid) were all >80% (from 84.4% to 99.99%). Proportion of inadequacies of vitamin C (68.7%), vitamin E (67.7%), and nicotinic acid (35.5%) were lower than the other vitamins as mentioned above(vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin D, and folic acid) (Table 2 and Figure 2). Proportion of inadequacies of vitamins in female were more higher than that in male either (Table 2 and Figure 3). Of note, the rates of vitamin intake below the recommendations in female were higner than the rates in male ($p<0.05$) (Figure 3).

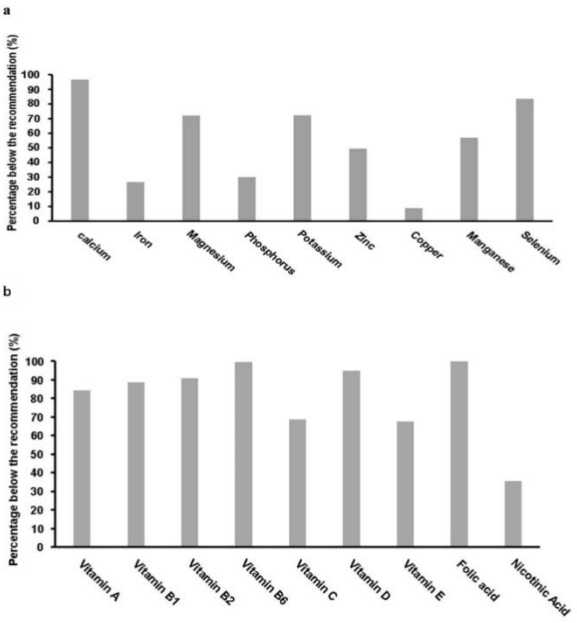

Figure 2. Percentage of participants below the recommended dietary intake of minerals and vitamins. (a) minerals; (b) vitamins

3.3. Diabetes

The prevalence of diabetes was 11.6% (n=133). In the multivariable logistic regression model, older age (OR=1.046, 95%CI: 1.030-1.062), higher education level (OR=1.191, 95%CI: 1.011-1.402), obesity (OR=1.084, 95%CI: 1.023-1.150), higher WHR (OR=1.396, 95%CI: 1.327-1.494), high calcium intake (OR=1.001, 95%CI: 1.000-1.002), low vitamin B1 intake (OR=0.568, 95%CI: 0.344-0.938), low vitamin B6 intake (OR=0.333, 95%CI: 0.114-0.979) and were independently associated with diabetes (Figure 4a).

Table 2. Nutritional recommendation and median daily nutrient intake according to the food frequency questionnaire in all subjects and according to sex

Variables	EAR/RNI/AI/AMDR [a]	Median	Q_{25}	Q_{75}	Inadequacies (%)		
					Total	Males	Females
Dietary Fiber [b], g/d	25-35	9.20	6.76	12.40	97.83%	99.30%	98.52%
Vitamin A[b],μg RAE/d	700-800	359.67	220.33	584.17	84.43%	32.17%	52.26%
Vitamin B1[b], mg/d	1.2-1.4	0.67	0.50	0.94	88.52%	30.78%	57.74%
Vitamin B2[b],mg/d	1.2-1.4	0.73	0.57	0.93	90.78%	33.22%	57.57%
Vitamin B6[b], mg/d	1.4-1.6	0.22	0.13	0.36	99.57%	37.83%	61.74%
Vitamin C[b], mg/d	100	78.45	52.33	110.98	68.70%	26.00%	42.70%
Vitamin D[b], μg/d	10-15	1.05	0.37	2.87	94.96%	34.96%	59.65%
Vitamin E[b], mg/d	14	11.00	7.56	15.20	67.65%	23.13%	44.52%
Folic acid[b], μg/d	400	28.95	14.62	52.06	99.99%	37.91%	62.00%
Nicotinic acid[b], mg/d	10-15	14.58	11.07	19.13	35.48%	12.17%	23.30%
Calcium	800-1000	345.83	247.67	472.92	96.61%	35.22%	61.39%
Iron[b]mg/d	10-20	18.53	14.23	23.61	26.70%	2.43%	24.26%
Magnesium[b] mg/d	310-330	265.17	207.00	338.00	72.09%	3.91%	6.78%
Phosphorus[b] mg/d	670-720	858.83	679.83	1070.74	30.09%	8.26%	21.83%
Potassium[b] mg/d	2000	1590.50	1245.50	2067.33	72.17%	23.30%	48.87%
Zinc[b] mg/d	7.5-12.5	9.15	7.01	11.81	49.48%	24.26%	25.22%
Copper[b] mcg/d	0.8	1.38	1.05	1.84	8.96%	1.39%	7.57%
Manganese[b] mg/d	4.5	4.22	3.29	5.39	56.87%	17.22%	39.65%
Selenium[b] μg/d	60	36.91	25.61	51.88	83.39%	27.30%	56.09%

a According to Dietary Reference Intakes for Chinese
b Recommend nutrient intake

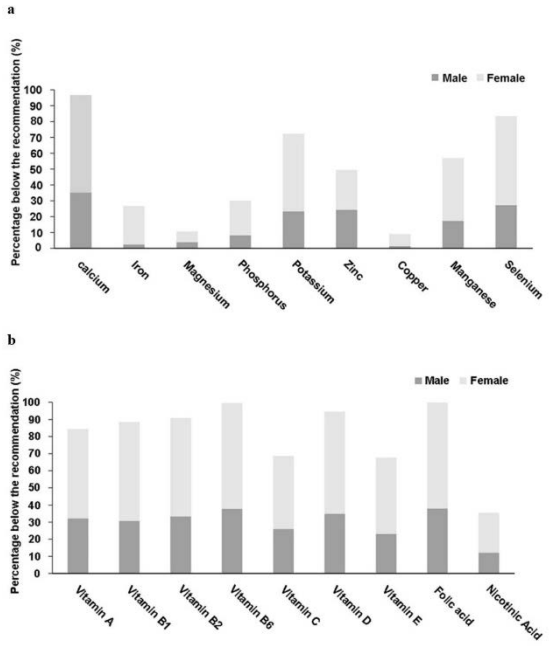

Figure 3. Percentage of participants below the recommended dietary intake of minerals and vitamins, according to sex. (a) minerals; (b) vitamins

3.4. Hypertension

Hypertension prevalence was 23.3% (n=268). The multivariable logistic regression analysis showed that older age (OR=1.057, 95%CI: 1.047-1.069), drinking (OR=1.663, 95%CI: 1.197-2.311), obesity (OR=1.137, 95%CI: 1.084-1.193), higher neck circumference (OR=1.088, 95%CI: 1.029-1.149), high vitamin B1 intake (OR=1.601, 95%CI: 1.198-2.140), high manganese intake (OR=1.159, 95%CI: 1.064-1.262), low zinc (OR=0.910, 95%CI: 0.860-0.963), and were independently associated with hypertension (Figure 4b).

3.5. Stroke

Stroke prevalence was 13.3% (n=153). In the multivariable logistic regression model, older age (OR=1.071, 95%CI: 1.055-1.807), higher waist circumference (OR=1.040, 95%CI: 1.019-1.061), and low zinc intake (OR=0.935, 95%CI: 0.888 to 0.984) were independently associated with stroke (Figure 4c).

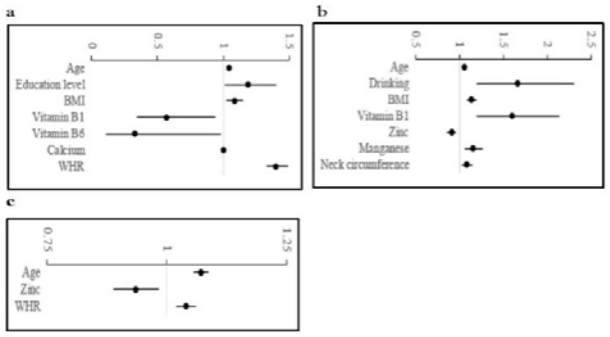

Figure 4. The relationship between NCDs and various variables frequenc questionnaire in all subjects and according to sex. (a) The relationship between diabetes and various variables; (b) The relationship between hypertension and various variables; (c) The relationship between stroke and various variables BMI: body mass index: WHR: waist-to-hip ratio

4. Discussion

It has been reported that the Chinese government plans to move as many as 250 million more people from farms to cities by 2025 [15]. Songbei experienced 48% population growth from 2004 to 2012. Thus, residents who were moved from agricultural villages in 2004–2009 and resettled in urban low-rise apartments are living in a rapidly urbanizing area and are likely to be adopting more urban lifestyles. Studies have documented a strong positive relationship between NCDs (diabetes, Hypertension, Stroke) prevalence and urbanization. According to the most recently published data, diabetes prevalence in Heilongjiang Province is 6.3% [23]; the higher level of diabetes among Golden Star Community's NZF residents (11.6%) is consistent with the more rapid urbanization occurring in Songbei District compared with other parts of Heilongjiang Province [24]. The prevalence of hypertension in this study was 23.3%. Similarly, Wang Z reported that 23.2% (estimated 244.5 million) of the Chinese adult population aged ≥18 years had hypertension (urban: 23.4%, rural: 23.1%) [25]. The latest research suggests that: Prevalence of stroke (with 95%CI) in the Heilongjiang rural is 2.20%, and in the urban is 1.44%, which is the highest in the 31. provincial regions (Total: 1.29%). The level of stroke among Golden Star Community's NZF residents (13.3%) is higher compared with other urban parts of Heilongjiang Province [26].

As in our previous study, the national study found that age, level of income obesity, and systolic blood pressure were among the factors contributing to higher odds of having diabetes. However, our study also found that intake of vitamin and mineral (below the recommendations) was related to higher odds of having NCDs, such as diabetes, hypertension, and stroke, This result correlates with changes in the traditional diet of the Chinese population (For example, the over-consumption of vegetable oils and animal-source products and decreasing consumption of coarse staple foods) [27]. Our findings a are consistent with those of a study using national census data to explain the emergence of chronic diseases in China either [14].

Previous studies have focused on the relationship between macronutrients and NCDs, but recent studies have found that vitamins and minerals are closely related to NCDs either. We observed a general low intake in micronutrients the Rural-to-Urban NZF migrants, and vitamin (Vitamin B6, Vitamin B1) and mineral (calcium, zinc, and manganese) intake is associated with diabetes, hypertension and stroke.

The present study found that Vitamin B6 (PLP, pyridoxine, pyridoxal) and Vitamin B1 (thiamine) may lower the risk of diabetes, and Vitamin B1 may lower the risk of hypertension. Our findings were consistent with previous studies. Studies have shown that a deficiency of Vitamin B6 was associated with impaired gluconeogenesis and impaired glucose tolerance and proper Vitamin B6 status can be deemed an important factor in the care of type 2 diabetes for the prevention of degenerative complications [28]. In addition, evidence showed that Vitamin B6 prevents insulin resistance [29]. Deficiency of Vitamin B6 was prevalent in type 2 diabetes. Incipient nephropathy was associated with more pronounced alterations in VitaminB6 metabolism and

stronger indications of endothelial dysfunction and inflammation [30].

On the other hand, Vitamin B1 has beneficial roles in the treatment of the complications of type 2 diabetes, but there is currently limited evidence for preventing diabetes [31]. The present study is supported by a previous study that showed that high-dose vitamin B1 supplements might have beneficial effects on the blood pressure of individuals with hyperglycemia [32]. Previous studies of our group have shown that Vitamin B1 intervention in LHP mode has an effect on the number and function of EPC and the expression of bcl-2 / Bax Gene, which may improve complications of diabetes.

The present study also found that minerals such as calcium, zinc, and manganese were associated with NCDs in this population. Data description that zinc intake may be helpful to prevent hypertension, as supported by Kunutsor et al, who showed that higher serum zinc concentration was positively and independently associated with incident hypertension in men [33]. In addition, Kim et al found that dietary zinc intake may be an independent risk factor of elevated systolic blood pressure in obese Korean women [34]. Therefore, Proper zinc intake has a positive effect on high blood pressure. And to our knowledge, the present study is the first to reveal that proper zinc intake can lower the occurrence of stroke in an urbanized migrant population in Northeast China. There is a lack of studies in humans about the role of zinc in preventing stroke [35], but zinc supplementation has been shown to improve the outcomes of stroke [36]. The possible mechanism of the effect of Zinc on cardiovascular and cerebrovascular system is that: 1) Zn2+ contributes to BP regulation via modulating renal Na+ transport, 2) renal mediates Zn deficiency-induced hypertension and 3) NCC is a Zn2+-regulated transporter that is upregulated by Zn deficiency [37].

While calcium had an adverse effect on diabetes. A study reported that intracellular calcium dynamics in vivo showed an early decline preceding the onset of diabetes [38]. The physiological significance of the1,25(OH)2 D 3 effects on Ca 2+ in pancreatic-cells (Ca 2+oscillations) may be related to its regulatory roles of insulin secretion under steady-state glucose concentrations in blood [39].

And a study in Pregnant woman results might suggest the blood Mn level during early stage of pregnancy as a potential risk factor for increasing the risk of gestational blood pressure [40].

In the gender-specific cohort study, we further observed that female's intakes were lower than male's. The phenomenon may be linked to factors of females such as Gene expression, estrogen levels, eating less and engaging in less physical activity. Women ate significantly less carbohydrates than men, especially after migration, and less whole grains, leading to a reduction in carbohydrate micronutrient.

The present study has limitations. The study population was limited to a single urbanized migrant population from a single city in China. But the data in this population is statistically significant. In addition, this is the first report on the relationship between Micronutriens and NCDs of Rural-to-Urban Nong Zhuan Fei Migrants in Northeast China. Additional studies are still necessary to determine the exact status and risk factors of NCDs in China.

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