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Foreword

Multifaceted Interventions for Enhancing Nutritional Status Among Chinese Children and Adolescents

Qian Zhang^{1, #}

Childhood and adolescence represent crucial periods for growth and development, as well as the establishment of healthy behaviors. Maintaining a balanced diet and engaging in sufficient physical activity can contribute to optimizing physical fitness and promoting healthy growth. In recent years, the Chinese government has initiated a series of monitoring and evaluation efforts focused on the nutritional and health status of children and adolescents. Consequently, comprehensive policies, regulations, and initiatives have been implemented to support the healthy growth of children.

Nutrition and Health Status

A comprehensive evaluation of children and adolescents' nutrition and health status can provide scientific evidence for formulating related national policies. As such, children and adolescents have been an essential focus in the six national nutrition and health surveys conducted in China in 1959, 1982, 1992, 2002, 2010, and 2015. Analyzing a series of data reveals that since the reform and opening up more than 40 years ago, the nutritional status of children has significantly improved in both urban and rural areas in China. This improvement is evidenced by the gradual increase in the average height and weight levels of boys and girls across various age groups (1–2). For example, the average height of 9-year-old boys increased from 122.0 cm in 1982 (1) to 138.2 cm in 2017 (2), reflecting an increase of 16.2 cm. Concurrently, children in China also face a growing prevalence of overweight and obesity. According to the China Nutrition and Health System Survey and Application for Children Aged 0–18 Years conducted from 2019 to 2021, the prevalence of overweight and obesity among Chinese children aged 6–17 was 26.5% (3), representing a considerable increase from the rates in 2017 (19.0%) (2) and 2012 (16.0%) (4). Consequently, Chinese children and adolescents continue to confront multiple health challenges, including malnutrition, overweight and obesity, and micronutrient deficiencies.

Nutrition Policies and Regulations

In recent years, the Chinese government has implemented numerous policies, regulations, and standard guidelines to promote the healthy development of children and adolescents. In 2016, the State Council introduced the Healthy China 2030 Blueprint, which emphasized the importance of providing guidance on nutrition and health programs in primary and secondary schools (5). In 2019, a total of 15 Healthy China Initiatives (2019–2030) were launched to strengthen multi-departmental efforts aimed at improving health promotion, balanced diet, and physical activity in schools (6). Additionally, the Basic Medical and Health Promotion Law of the People's Republic of China, enacted in 2019, legally mandated nutritional improvement initiatives for juveniles, promoting healthy eating behaviors, and minimizing the risk of diseases associated with unhealthy diets (7).

Subsequently, various policies and standards have been established to address the issues of undernutrition and obesity among children and adolescents in China. These include the National Nutrition Plan (2017–2030) in 2017 (8), the Implementation Plan for Obesity Prevention and Control in Children and Adolescents in 2020 (9), the School Food Safety and Nutrition Health Management Regulations in 2019 (10), the Opinions on Comprehensively Strengthening and Improving School Hygiene and Health Education in the New Era in 2021 (11), and the Health Industry Standard Nutrition Guidelines for Student Meal (WS/T 554-2017) (12). These policies and guidelines aim to provide work goals and specific actions in areas such as reasonable food supply, nutrition education, health monitoring, and social environment to improve the overall health of Chinese children and adolescents.

Student Nutrition Improvement Plan

In an effort to combat malnutrition among children and adolescents in primary and secondary schools located in economically disadvantaged rural areas, the Chinese government initiated the Nutrition Improvement Program for Rural Compulsory Education Students (hereafter referred to as the “Program”) in 2011 (13). This program, funded by the Chinese central finance, offers nutritional meal subsidies to rural compulsory education students (aged 6–15 years) in national pilot counties situated in the central and western regions of the country. Initially, each student received a subsidy of 3 Chinese Yuan (CNY) per school day (200 days annually), which was increased to 4 CNY in 2014 and further raised to 5 CNY in 2021.

As of 2021, the Program encompassed over 36 million students across more than 120,000 schools in 727 national pilot counties and 1,010 local pilot counties within 28 provincial-level administrative divisions. The Chinese central finance allocated approximately 26 billion CNY toward nutritional meal subsidy funds in 2021 (14).

According to the results from the nutrition and health monitoring and evaluation conducted by the Chinese Center for Disease Control and Prevention, there has been a steady increase in the average height and weight of children aged 6–15 years in economically underdeveloped rural areas within central and western regions of China since the implementation of the Program. Furthermore, the prevalence of anemia in this demographic has decreased from 16.7% in 2012 to 12.0% in 2021 (15). The improvement in nutrition for children and adolescents promoting growth potential, enhancing disease resistance, and improving physical fitness and learning ability. This also affirms the positive social benefits associated with the adoption of national strategies for nutrition improvement. However, the prevalence of overweight and obesity has silently increased in recent years. Concurrently, public health awareness has been heightened. The dietary structure of children and adolescents attending primary and secondary schools is becoming more reasonable, with an increase in their time dedicated to physical activity and sleep.

Suggestions

Considering the present nutritional and health status of Chinese children, it is essential to reinforce the implementation of policies and regulations concerning childhood obesity prevention and control. Additionally, evaluating the cost-effectiveness of the nutrition improvement plan for rural students is crucial, as is conducting more in-depth scientific researches to identify critical aspects of policies or actions that enhance children’s health. Systematic nutrition and health education should be progressively incorporated into daily teachings and school activities for children and adolescents. This education should focus on promoting knowledge and skills related to balanced meals, healthy eating habits, and sufficient physical activity, ultimately fostering their healthy development.

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Preplanned Studies

Variations in Rope Skipping Counts Among Rural Primary and Secondary School Students — China, 2013–2021

Ruihe Luo¹; Qian Zhang¹; Peipei Xu¹; Qian Gan¹; Titi Yang¹; Wei Cao¹; Hongliang Wang¹; Hui Pan¹; Juan Xu^{1,†}

Summary

What is already known about this topic?

Physical fitness is closely associated with children's development. Limited research has been published on the changes in physical fitness among Chinese children during the implementation of the Nutrition Improvement Program for Rural Compulsory Education Students (NIPRCES).

What is added by this report?

This research utilized data from the NIPRCES between 2013 and 2021 to examine alterations in children's physical fitness levels. Over this period, there was a significant increase in the number of rope skipping counts among children. In 2021, variations in these counts were observed, which depended on factors such as age, gender, geographic location, and region.

What are the implications for public health practice?

Physical fitness has been linked to a multitude of non-communicable diseases. Enhanced nutritional measures for children lead to significant improvements in their overall physical fitness, as evidenced by NIPRCES findings. It is crucial for policymakers to implement comprehensive interventions aimed at promoting and advancing children's physical fitness.

Beginning in 2011, the Nutrition Improvement Program for Rural Compulsory Education Students (NIPRCES) was established to enhance the nutrition and health of students in rural areas and promote educational equity. The central government offers nutritional meal subsidies to compulsory education students, aged 6–15 years, in underdeveloped counties. Monitoring and evaluation have been conducted annually from 2012 to 2017 and in 2019 and 2021. Additionally, data regarding the nutritional and health status of students in the national pilot areas have been regularly collected from 2012 to 2021. NIPRCES has effectively mitigated growth retardation and anemia among rural children (1).

The current study also aimed to explore whether the

implementation of NIPRCES has positively impacted children's physical fitness, which is strongly associated with their growth. Optimal physical fitness provides numerous physiological and psychological benefits, offers protection against potential stressors, and prevents many chronic diseases (2). The primary objective was to evaluate changes in physical fitness among Chinese rural children and adolescents during the implementation of NIPRCES. Utilizing rope skipping counts as the indicator, an increase in children's performance was observed from 2013 to 2021. In 2021, the counts varied among students based on age, gender, area, and region. This study offers valuable scientific evidence for policymakers to develop effective strategies aimed at improving the physical fitness of children and adolescents.

From 2012 to 2019, key monitoring was conducted in the rural areas of 50 national pilot counties of the NIPRCES across 22 provincial-level administrative divisions (PLADs) in western and central China. In 2021, both rural and urban areas of 70 national pilot counties, 60 local pilot counties of the NIPRCES, and 30 non-pilot counties conducted key monitoring in eastern, western, and central China. This study used data on students' physical fitness extracted from end-of-semester physical education class test results in 2013, 2014, 2015, 2016, 2017, 2019, and 2021. In each key monitoring county, two primary and two secondary schools were selected. For each grade, from 1st grade (children aged 6–7 years in primary school) to 9th grade (children aged 14–15 years in junior high school), one class of approximately 40 students was chosen. Exam items in physical education classes included the standing long jump, 50-meter dash, and rope skipping, among others. Rope skipping was selected as the physical fitness indicator in this study (recorded as counts/minute) since all students from 1st to 9th grade test rope skipping in China.

For cross-sectional analysis, all data in 2021 were used. For comparisons from 2013 to 2021, data in 2021 were selected as representing the rural areas in

key monitoring counties in central and western China. Rope skipping counts were described by median, 25th percentile (P25), and 75th percentile (P75) for each year. Non-parametric Wilcoxon or Kruskal-Wallis rank sum tests were employed to determine differences between groups. When differences between groups were statistically significant, the Dwass-Steel-Critchlow-Fligner test was used for pairwise comparisons between groups. The inspection level was set at $\alpha = 0.05$. All analyses were conducted using SAS (version 9.4, SAS Institute Inc., Cary, NC, USA).

Table 1 shows the median, P25 and P75 of rope skipping counts among students by gender, grade, and region for each year from 2013 to 2021. Students' rope skipping counts displayed a general increasing trend, from 77 counts/min in 2013 to 89 counts/min in 2021, marking an increase of 15.6%. Between 2013 and 2021, the counts for male improved by 14 counts, which was more than the improvement for female (11 counts). Ninth-grade students experienced an increase of 38 counts, considerably higher than students in other grades (7–29 counts). Moreover, students in the western regions demonstrated an increase of 14 counts, surpassing those in the central regions (8 counts).

In 2021, the number of rope-skipping counts demonstrated variation based on age, gender, residential area, and region. Among 1st to 6th grade primary school students, female exhibited higher counts than male, while counts appeared similar for both genders in 7th and 8th grades but were lower for female in the 9th grade (Figure 1A). First-grade students from urban areas demonstrated 11 more counts than their counterparts in rural areas, representing the largest difference among all grade levels (ranging from 2 to 7 counts; Figure 1B). Throughout the primary school years, students from eastern China consistently had higher counts compared to those from central and western China. In contrast, during the junior high school period, this difference was reversed (Figure 1C). All identified differences were deemed statistically significant ($P < 0.05$).

DISCUSSION

This study indicated that the implementation of NIPRCES led to improvements in children's and adolescents' physical fitness, as evidenced by enhanced rope skipping performance. Nevertheless, there were still marked disparities in scores among students from different regions and areas.

In the present study, rope skipping counts were selected as a measure of students' physical fitness, given that this activity engages the entire body (upper and lower regions) and calls for rhythm, coordination, agility, speed, and strength. As students engage in rope skipping, they must maintain continuous arm rotation and coordinate their bodies during rhythmic, repetitive vertical hops (3). The body also needs to re-establish balance and generate propelling force throughout successive jumps. Previous research has demonstrated the benefits of rope skipping for both cardiovascular and respiratory systems (4).

In the NIPRCES study, our approach to enhancing students' health was through the implementation of school feeding programs. Evidence has demonstrated that these programs positively impact the physical fitness of children and adolescents, as well as their overall athletic performance. A two-year intervention that involved increasing children's intake of eggs and dairy products during school breakfasts effectively improved their strength (as measured by broad jump scores) and endurance [based on their performance in the 50 (8-meter round trip) test] of children and adolescents in China (5). Cintineo's research also indicated that protein supplementation led to increased muscle volume, muscle fiber cross-sectional area, muscle strength, and muscle explosiveness (6). By increasing the consumption of meat and eggs, which are rich sources of high-quality protein, NIPRCES's school feeding program may have aided in improving the muscle strength and rope-skipping performance of participating students.

In addition to NIPRCES, the Chinese government has placed significant emphasis on enhancing physical activity among compulsory education students. The national policy, "Notice on School Physical Education Under the Current Epidemic Situation," was introduced in 2023. This policy highlighted the need for public health practitioners to increase efforts in promoting nutrition and physical education to improve students' habits and overall physical fitness. Moving forward, NIPRCES will persist in its efforts to promote and maintain the nutritional and physical well-being of children in targeted counties throughout the nation.

This study faced several limitations. First, the investigation solely utilized rope skipping as an indicator of physical fitness. In future research, additional assessments, such as the 50-meter dash, standing long jump, and sit-and-reach, should be incorporated to provide a comprehensive evaluation of

TABLE 1. Rope skipping counts per minute among Chinese students in rural areas, 2013–2021.

Variable	2013			2014			2015			2016			2017			2019			2021			P value*
	N	M	P25 P75	N	M	P25 P75	N	M	P25 P75	N	M	P25 P75	N	M	P25 P75	N	M	P25 P75	N	M	P25 P75	
Total	42,107	77	49 102	43,534	81	56 108	37,641	85	58 109	24,709	81	56 105	31,519	86	61 108	45,710	82	59 107	100,243	89	60 118	<0.0001
Gender																						
Male	21,852	72	42 98	22,581	78	50 102	19,555	81	53 106	12,716	78	52 101	16,183	83	59 104	23,633	80	56 105	51,659	86	57 115	<0.0001
Female	20,255	81	56 107	20,953	86	62 112	18,086	88	62 112	11,993	86	61 109	15,336	87	65 110	22,077	85	61 110	48,584	92	65 120	<0.0001
Grade																						
1	5,276	36	20 60	5,512	43	21 71	4,492	44	21 73	3,117	46	25 75	3,676	47	27 75	6,160	48	24 75	12,052	50	28 77	<0.0001
2	6,230	56	32 79	6,253	62	36 84	4,759	62	35 87	3,611	64	38 85	4,345	68	42 89	6,360	68	45 88	13,996	68	44 91	<0.0001
3	6,119	73	46 94	6,482	77	55 98	5,473	77	53 98	3,671	78	56 98	4,90	79	59 99	6,608	78	56 99	14,480	80	56 102	<0.0001
4	6,333	82	59 105	6,579	87	68 108	5,371	86	64 108	3,785	85	64 104	4,724	86	65 108	6,620	85	64 105	14,701	89	65 111	<0.0001
5	6,300	89	65 112	6,645	92	72 120	5,499	94	72 116	3,716	92	68 113	4,921	90	70 114	6,300	90	69 111	14,894	99	77 123	<0.0001
6	6,414	88	68 113	6,639	96	76 124	5,644	96	75 120	3,773	96	75 118	5,113	97	77 120	6,475	95	74 115	14,753	104	81 130	<0.0001
7	1,849	97	78 129	1,815	104	78 133	2,232	103	79 133	982	100	76 121	1,327	105	89 123	2,408	117	82 148	4,982	126	95 150	<0.0001
8	1,861	102	78 137	1,762	106	79 142	2,070	110	88 135	1,138	102	79 140	1,373	103	87 126	2,471	117	84 151	4,858	130	98 155	<0.0001
9	1,725	106	80 140	1,847	110	80 147	2,101	102	85 140	916	105	84 150	1,350	107	95 140	2,308	121	82 155	5,527	144	103 163	<0.0001
Region																						
Central	10,295	79	48 106	12,496	84	57 108	9,180	82	57 109	9,079	88	67 111	7,767	86	63 108	14,274	85	61 107	32,938	87	59 112	<0.0001
Western	31,812	76	49 100	31,071	80	55 108	28,461	85	58 109	15,630	78	50 101	23,752	85	60 108	31,436	81	57 107	67,305	90	62 120	<0.0001

Abbreviation: N=number; M=median; P25=25th percentile; P75=75th percentile.

* Comparison of rope skipping counts from 2013 to 2021.

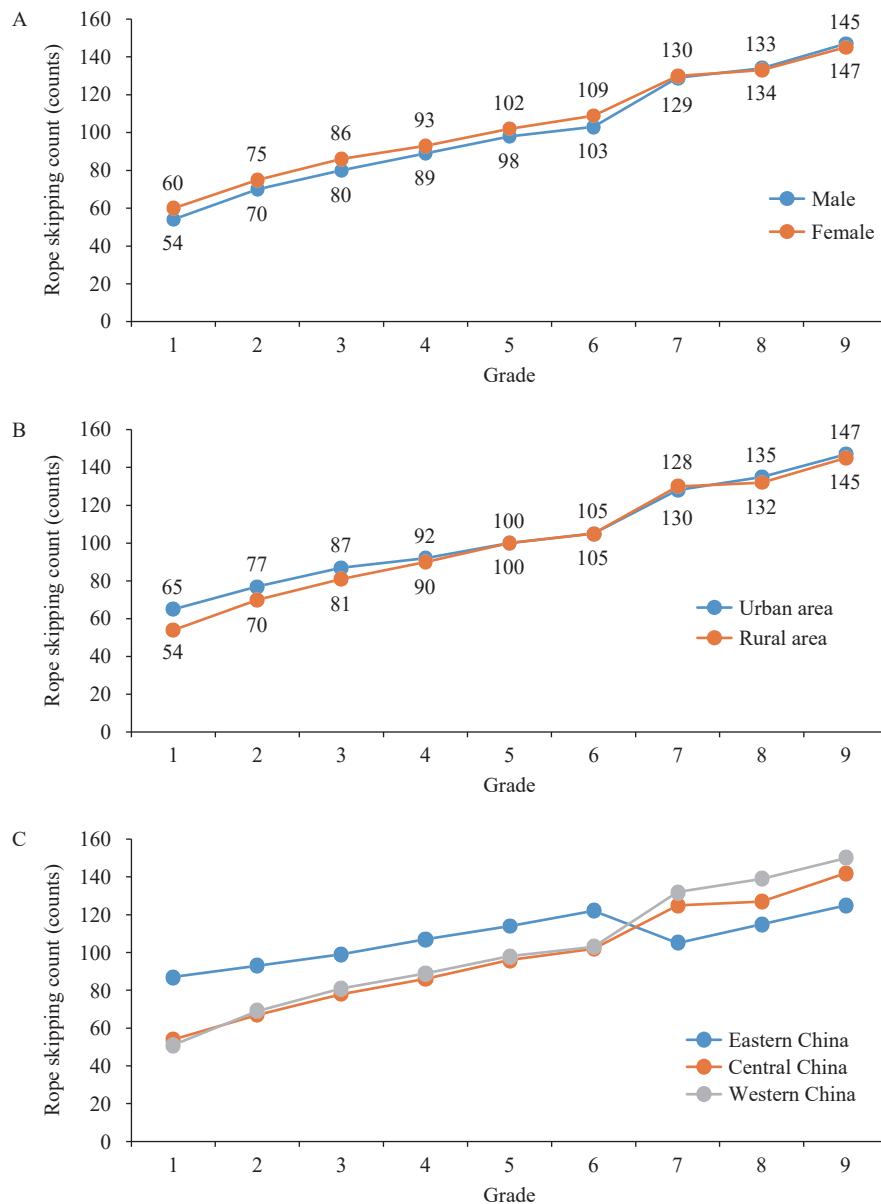


FIGURE 1. Rope skipping counts among students by gender, residential area, region, and age in 2021. (A) by gender and age; (B) by residential area type and age; (C) by region and age.

children and adolescents' physical fitness. Second, the accuracy of the results may be influenced by students' attitudes during the physical examinations, potentially leading to biased outcomes.

In conclusion, the findings from the present study suggest that children's and adolescents' physical fitness has improved during the NIPRCES period. Nonetheless, disparities in physical fitness levels were observed among children and adolescents across various regions and areas. Consequently, it is imperative that future policies implement comprehensive strategies aimed at enhancing children's health and reducing these discrepancies.

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Preplanned Studies

Frequency of Food Consumption Among Students Aged 8–15 Years — China, 2019 and 2021

Yimeng Fu¹; Juan Xu¹; Qian Gan¹; Titi Yang¹; Peipei Xu¹; Wei Cao¹; Hongliang Wang¹; Hui Pan¹; Ruihe Luo¹; Wenxin Sun¹; Zhifang Wang¹; Qian Zhang^{1,†}

Summary

What is already known about this topic?

Malnutrition continues to be the primary cause of delayed growth and development among students in economically disadvantaged rural areas of China. Ensuring adequate and appropriate dietary intake is crucial for promoting the healthy growth of these students.

What is added by this report?

In rural areas of central and western regions in China, the weekly consumption frequencies of meat, eggs, milk, legumes, fruits, and vegetables in 2021 were higher than those in 2019. However, the consumption levels remained relatively low in economically underdeveloped rural areas in 2021.

What are the implications for public health practice?

Understanding the frequency of food consumption among students can provide a solid evidence base for the development of policies and strategies aimed at controlling and preventing malnutrition.

A balanced consumption of various types of food items plays a crucial role in students' physical and intellectual development, providing the foundation for their lifelong health (1). In recent years, the living standards in China have improved, leading to a steady improvement in the intake of various foods among Chinese students (2). However, uneven socioeconomic development and differing natural environments may lead to disparities in food consumption between rural and urban students (3). The prevalence of malnutrition among rural students has decreased but remains higher than among urban students (4). Furthermore, consumption of various healthy foods increased during the coronavirus disease 2019 (COVID-19) pandemic as a means to boost immunity and promote health (5).

This report aimed to investigate the status of food consumption in 2021 and the changes in the consumption frequencies of different foods between

2019 and 2021 for Chinese students. The goal is to provide basic data for promoting the health of students in China's economically underdeveloped areas. Data were obtained from the "Nutrition Improvement Program for Rural Compulsory Education Students" (NIPRCES). The weekly frequencies of consuming meat, eggs, milk, legumes, fruits, and vegetables in 2021 were higher than those in 2019; however, they remained relatively low in rural areas in 2021. Therefore, efforts should be made to increase students' consumption of various foods rich in high-quality protein, vitamins, and minerals, which is essential for eradicating malnutrition among rural students.

Data were obtained from the NIPRCES in 2019 and 2021. A multi-stage stratified random cluster sampling method was utilized to select students aged 8–15 years from grades 3 to 9 attending primary and junior high schools in rural areas of 50 national pilot NIPRCES counties across 22 provincial-level administrative divisions (PLADs) in China's central and western regions during 2019 for key monitoring. In 2021, the key monitoring expanded to include 160 counties, encompassing students from rural and urban areas in western, central, and eastern regions, as well as national, local, and non-pilot areas.

A student questionnaire was administered to collect basic demographic information and the frequency of food intake over the previous week, including meat, eggs, milk, legumes, vegetables, and fruits. Notably, meat, eggs, milk, and legumes are protein-rich, whereas vegetables and fruits are abundant in vitamins and minerals. For the comparison of food consumption frequency differences between 2019 and 2021, only data from rural national pilot counties in central and western regions of China were included.

The frequency of food consumption among students was described using the number of cases and percentages. All statistical analyses were conducted using SAS software (version 9.4; SAS Institute, Inc., Cary, NC, USA). Chi-squared tests, Wilcoxon tests, and Kruskal-Wallis tests were employed for group

comparisons, depending on the appropriateness. A bilateral P -value of less than 0.05 was considered statistically significant.

A total of 30,882 students in 2019 and 178,509 students in 2021 were included in this study (Table 1). In 2021, 36.9% of students consumed meat, 24.5% consumed eggs, 32.5% consumed milk, and 10.2% consumed legumes, all at least once a day. The proportion of males and primary school students consuming meat, eggs, milk, and legumes at least once a day was significantly higher than that of females and junior high school students ($P<0.05$). Urban students demonstrated a higher daily consumption of meat, eggs, and milk compared to rural students, while exhibiting a lower consumption of legumes ($P<0.05$). A higher proportion of students from the eastern region consumed meat daily compared to those from central and western regions. Conversely, central region students had lower daily consumption of milk, eggs, and legumes ($P<0.05$) (Table 2).

Approximately 33.1% of students reported consuming 3 or more types of vegetables per day. The proportions of female students, rural students, and those in western regions consuming three or more kinds of vegetables daily were significantly higher than their male, urban, and eastern or central counterparts ($P<0.05$). Around 30.4% of students consumed fruits at least once a day, while 5.4% reported consuming fruit less than once a week. The proportion of female

students, primary school students, rural students, and those from eastern regions consuming fruits at least once a day was significantly higher than for male students, junior high school students, urban residents, and those from central or western regions ($P<0.05$) (Table 2).

The proportions of participants consuming meat, eggs, milk, legumes, and fruits once a day or more were 37.1%, 25.1%, 30.1%, 11.5%, and 28.0% in 2021; significantly higher than those in 2019, which were 28.5%, 13.1%, 14.0%, 8.6%, and 15.7%, respectively (all $P<0.05$). Conversely, the proportions of participants consuming meat, eggs, milk, legumes, and fruits less than once a week in 2021 were 4.6%, 8.3%, 11.6%, 16.6%, and 6.2%, respectively, and these were lower than the proportions in 2019 (9.5%, 15.3%, 19.4%, 22.0%, and 12.6%, respectively) (all $P<0.05$). Moreover, the proportion of participants consuming three or more types of fresh vegetables per day was higher in 2021 (38.3%) compared to 2019 (34.6%, $P<0.05$) (Figure 1).

DISCUSSION

Diverse dietary intakes featuring a balanced combination of various food groups are essential due to the unique nutritional characteristics of different foods. This study's findings indicate that in 2021, the frequency of daily consumption of meat, eggs, milk,

TABLE 1. Demographic characteristics of students aged 8–15 years — China, 2019 and 2021.

Variable	2019	2021
Age (years), mean±SD	12.3±2.15	11.7±2.29
Gender, n (%)		
Male	15,699 (50.9)	90,756 (50.8)
Female	15,183 (49.1)	87,753 (49.2)
School stage, n (%)		
Primary school student	18,357 (59.4)	106,418 (59.6)
Junior high school student	12,525 (40.6)	72,091 (40.4)
Area type, n (%)		
Urban	—	53,584 (30.0)
Rural	30,882 (100.0)	124,925 (70.0)
Region, n (%)		
Eastern	—	27,869 (15.6)
Central	8,895 (28.8)	58,446 (32.7)
Western	21,987 (71.2)	92,194 (51.7)
Total, n (%)	30,882 (100.0)	178,509 (100.0)

“—” means data not available.

TABLE 2. Frequency of food consumption among students aged 8–15 years — China, 2021 (*n*, %).

Variable	Total		Gender		School stage			Area type		Region		
			Male	Female	Primary	Junior high		Urban	Rural	Eastern	Central	Western
Meat*	Less than 1 time/week	7,021 (4.1)	3,560 (4.1)	3,461 (4.1)	4,281 (4.2)	2,740 (4.0)		1,763 (3.4)	5,258 (4.4) [§]	704 (2.6)	2,151 (3.8)	4,166 (4.7) [§]
	1–6 times/week	101,389 (59.0)	50,579 (58.0)	50,810 (60.1) [§]	59,272 (57.9)	42,117 (60.7) [§]		30,443 (58.5)	70,946 (59.1)	15,331 (56.2)	37,277 (66.3)	48,781 (55.2) [§]
	1 time/day and above	63,423 (36.9)	33,140 (38.0)	30,283 (35.8) [§]	38,859 (37.9)	24,564 (35.4) [§]		19,562 (37.8)	43,861 (36.5) [§]	11,239 (41.2)	16,822 (29.9)	35,362 (40.0) [§]
P-value			<0.0001		<0.0001			<0.0001			<0.0001	
Eggs*	Less than 1 time/week	14,228 (8.3)	7,144 (8.2)	7,084 (8.4)	7,054 (6.9)	7,174 (10.3) [§]		3,965 (7.7)	10,263 (8.6) [§]	2,167 (8.0)	3,793 (6.8)	8,268 (9.4) [§]
	1–6 times/week	115,365 (67.2)	58,088 (66.6)	57,277 (67.8) [§]	67,606 (66.1)	47,759 (68.8) [§]		34,467 (66.6)	80,898 (67.5) [§]	18,711 (68.7)	36,535 (65.0)	60,119 (68.1) [§]
	1 time/day and above	42,099 (24.5)	21,993 (25.2)	20,106 (23.8) [§]	27,643 (27.0)	14,456 (20.8) [§]		13,347 (25.8)	28,752 (24.0) [§]	6,356 (23.3)	15,893 (28.3)	19,850 (22.5) [§]
P-value			<0.0001		<0.0001			<0.0001			<0.0001	
Milk*	Less than 1 time/week	18,492 (10.8)	9,451 (10.8)	9,041 (10.7)	9,419 (9.2)	9,073 (13.1) [§]		4,232 (8.2)	14,260 (11.9) [§]	2,559 (9.4)	5,728 (10.2)	10,205 (11.6) [§]
	1–6 times/week	97,283 (56.7)	48,446 (55.6)	48,837 (57.9) [§]	56,519 (55.3)	40,764 (58.8) [§]		27,844 (53.8)	69,439 (58.0) [§]	14,966 (55.0)	29,525 (52.6)	52,792 (59.9) [§]
	1 time/day and above	55,756 (32.5)	29,269 (33.6)	26,487 (31.4) [§]	36,258 (35.5)	19,498 (28.1) [§]		19,666 (38.0)	36,090 (30.1) [§]	9,711 (35.7)	20,927 (37.3)	25,118 (28.5) [§]
P-value			<0.0001		<0.0001			<0.0001			<0.0001	
Legumes*	Less than 1 time/week	28,680 (16.7)	14,517 (16.7)	14,163 (16.8)	16,299 (16.0)	12,381 (17.9) [§]		7,965 (15.4)	20,715 (17.3) [§]	4,535 (16.7)	8,362 (14.9)	15,783 (17.9) [§]
	1–6 times/week	125,208 (73.0)	63,337 (72.7)	61,871 (73.4) [§]	74,351 (72.8)	50,857 (73.4) [†]		38,902 (75.2)	86,306 (72.1) [§]	20,327 (74.7)	41,032 (73.1)	63,849 (72.5) [§]
	1 time/day and above	17,557 (10.2)	9,253 (10.6)	8,304 (9.9) [§]	11,505 (11.3)	6,052 (8.7) [§]		4,857 (9.4)	12,700 (10.6) [§]	2,360 (8.7)	6,754 (12.0)	8,443 (9.6) [§]
P-value			0.0003		<0.0001			0.0033			<0.0001	
Vegetables*	Less than 1 kind/day	5,907 (3.5)	3,400 (3.9)	2,507 (3.0) [§]	3,534 (3.5)	2,373 (3.4)		2,001 (3.9)	3,906 (3.3) [§]	1,023 (3.8)	2,252 (4.0)	2,632 (3.0) [§]
	1 kind/day	38,618 (22.6)	20,245 (23.3)	18,373 (21.8) [§]	23,835 (23.4)	14,783 (21.4) [§]		12,768 (24.7)	25,850 (21.6) [§]	6,896 (25.4)	14,597 (26.0)	17,125 (19.6) [§]
	2 kinds/day	69,934 (40.9)	35,200 (40.5)	34,734 (41.2) [§]	40,047 (39.2)	29,887 (43.2) [§]		21,554 (41.8)	48,380 (40.5) [§]	12,706 (46.7)	23,447 (41.8)	33,781 (38.4) [§]
	3 kinds/day and above	56,715 (33.1)	28,104 (32.3)	28,611 (34.0) [§]	34,616 (33.9)	22,099 (32.0) [§]		15,298 (29.6)	41,417 (34.6) [§]	6,578 (24.2)	15,765 (28.1)	34,372 (39.1) [§]
P-value			<0.0001		0.4779			<0.0001			<0.0001	
Fruits*	Less than 1 time/week	9,165 (5.4)	5,158 (5.9)	4,007 (4.8) [§]	3,910 (3.8)	5,255 (7.6) [§]		1,868 (3.6)	7,297 (6.1) [§]	1,101 (4.1)	2,870 (5.1)	5,194 (5.9) [§]
	1–6 times/week	110,055 (64.3)	56,023 (64.4)	54,032 (64.1)	62,586 (61.4)	47,469 (68.6) [§]		31,290 (60.6)	78,765 (65.9) [§]	17,173 (63.1)	36,107 (64.4)	56,775 (64.6) [§]
	1 time/day and above	52,017 (30.4)	25,818 (29.7)	26,199 (31.1) [§]	35,521 (34.8)	16,496 (23.8) [§]		18,521 (35.8)	33,496 (28.0) [§]	8,930 (32.8)	17,109 (30.5)	25,978 (29.5) [§]
P-value			<0.0001		<0.0001			<0.0001			<0.0001	

* means the study subjects were partially missing.

† Chi-squared test between males and females; primary school and junior high school students; urban and rural areas; eastern, central and western regions, $P<0.05$.§ Chi-squared test between males and females; primary school and junior high school students; urban and rural areas; eastern, central and western regions, $P<0.01$.

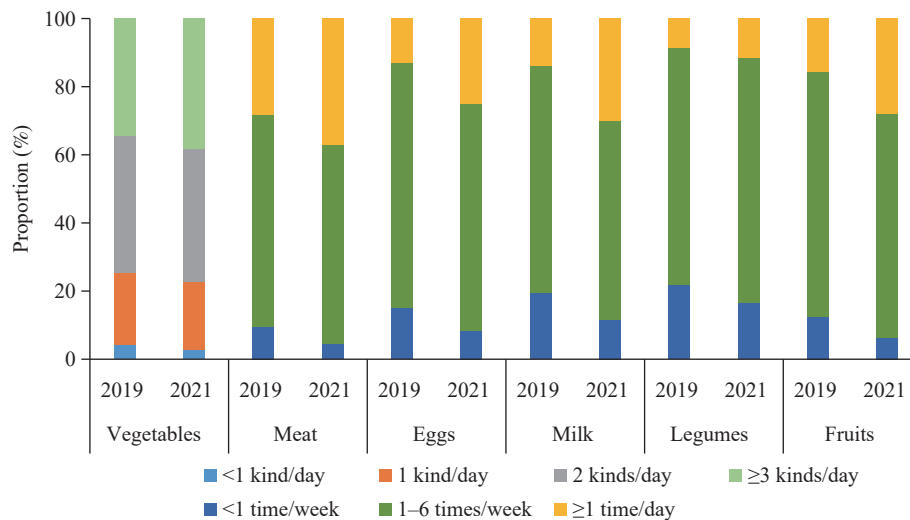


FIGURE 1. Comparison of food consumption frequency for rural students aged 8–15 years — central and western regions of China, 2019 and 2021.

legumes, and fruits in rural areas of central and western regions significantly increased compared to 2019, yet remained relatively low (1). Urban students, in contrast to their rural counterparts, exhibited higher weekly frequencies of meat, egg, milk, and fruit consumption in 2021.

Previous research has suggested that inadequate consumption frequency of various food categories may be associated with lower economic levels, limited access to healthy foods, and insufficient nutritional knowledge among students and parents in remote rural areas (6–7). This study contributes to the understanding of the two-year changes in consumption frequencies for diverse food groups among Chinese students and offers valuable insights to inform the development of policies and strategies aimed at controlling and preventing malnutrition.

Adequate consumption of foods rich in high-quality protein is a crucial strategy for addressing child malnutrition (8). The dietary guidelines for Chinese school-aged children advise moderate consumption of fish, poultry, and lean meat, one egg, and 300 g of milk daily, as well as legumes 4–7 times per week to ensure sufficient protein intake (1). Nonetheless, our study in 2021 found that only 36.5%, 24.0%, 30.1%, and 10.6% of rural students consumed meat, eggs, milk, and legumes once a day or more, respectively. A similar study conducted between 2015 and 2016 involving 2,107 students aged 6–13 years from impoverished rural areas in China reported that a mere 11.3%, 28.8%, and 24.5% of students consumed meat, eggs, and milk daily. This finding suggests that

the low frequency of protein food consumption might be associated with regional economic status (9).

Fresh vegetables and fruits are abundant in essential vitamins, minerals, and dietary fiber. For Chinese school-aged children, dietary guidelines recommend the consumption of at least three or more varieties of fresh vegetables and one serving of fresh fruit daily (1). However, our study revealed that only approximately one-third of students in rural areas consumed fruits once a day or more, and vegetables in more than three types per day. Numerous studies have indicated that children in various countries exhibit low intakes of fruits and vegetables (10–11). Heinen et al. carried out a cross-sectional study with 123,100 children aged 6–9 years across 19 European countries, demonstrating that approximately 30%–80% and 30%–90% of children did not consume fruits or vegetables daily, respectively (10).

The frequency of consumption of various types of food among students may have increased following the COVID-19 outbreak. This study observed a rise in the weekly consumption frequency of meat, eggs, milk, legumes, fresh vegetables, and fruits in 2021 compared to 2019. Several studies suggested that this increase may be attributed to parents providing their children with diverse and balanced diets aimed at improving and maintaining their health after the COVID-19 outbreak (3,12–13). Nicholas et al. conducted an online survey among 254 Canadian households and found that more than half of the families reported a healthier diet, while 42% of children increased their intake of various foods since the onset of COVID-19

(12). It is important to note that although enhancing food intake to combat the virus during the COVID-19 pandemic may decrease undernutrition among students, it could also potentially increase the risk of overweight and obesity.

This study was subject to several limitations. First, the quantity of food intake was not assessed. Some students followed the suggested frequency of consumption but ingested smaller portions each time, leading to inadequate nutritional intake, which in turn may have influenced the accuracy of the study's findings. Second, the potential varying effects of different meat types were not considered separately; for instance, excessive consumption of red or processed meat may have negative health implications. Finally, factors associated with the frequency of food consumption will be examined more thoroughly in future research.

In summary, the weekly consumption frequencies of meat, eggs, milk, legumes, fruits, and vegetables in 2021 were higher compared to those in 2019. However, students in urban areas demonstrated a higher frequency of consuming meat, eggs, and milk, but a lower frequency of legumes and vegetables consumption in 2021, compared to their rural counterparts. It is recommended that the government and health education departments gradually increase financial investment and strengthen nutrition education, while fully considering regional differences, economic conditions, and pandemic factors. This approach aims to enhance food supply, availability, and accessibility in economically underdeveloped areas of China, potentially improving the nutritional status of students. Additionally, schools and parents should work collaboratively to guide children towards adequate intake of protein-rich foods, fresh vegetables, and fruits, thereby promoting their healthy growth.

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Preplanned Studies

Perceptions of Primary Caregivers on Children's Weight Status Versus Actual Weight Status in Children Aged 6–15 Years — China, 2021

Hongliang Wang¹; Juan Xu¹; Wei Cao¹; Peipei Xu¹; Qian Gan¹; Titi Yang¹; Ruihe Luo¹; Hui Pan¹; Wenhua Zhao¹; Qian Zhang^{1,†}

Summary

What is already known about this topic?

Childhood obesity has been linked to adverse health outcomes during both childhood and adulthood. An accurate understanding of children's weight status by primary caregivers is essential for effective weight management strategies.

What is added by this report?

The data utilized in this study were obtained from the 2021 Nutrition Improvement Program for Rural Compulsory Education Students in China. It was found that over one-third of primary caregivers underestimated their children's weight status, and more than half of the primary caregivers of overweight or obese children underreported the weight status of those children. A low level of agreement was observed between primary caregivers' perceptions of their children's weight status and the actual weight status.

What are the implications for public health practice?

There is a relatively higher underestimation of children's weight in China, which necessitates more effective strategies to enhance the primary caregivers' perception of their children's weight status, especially in primary caregivers of males, younger children and children in urban areas.

The prevalence of childhood overweight and obesity has been increasing rapidly worldwide (1). In the 2020 Report on Chinese Residents' Chronic Diseases and Nutrition, the rates of overweight and obesity among Chinese children aged 6–17 years were reported to be 11.1% and 7.9%, respectively. Childhood obesity is associated with both physical and mental health problems during childhood, as well as a range of non-communicable diseases in adulthood, such as cardiovascular diseases, hypertension, and Type II diabetes (2–3). Parents who have accurate perceptions

of their children's weight status and are concerned about their health are more likely to take action to modify the weight-related behaviors of overweight or obese children (4). Primary caregivers' misperceptions may influence the weight management of their children. Therefore, enhancing primary caregivers' perception of a child's weight status is essential in the prevention and control of obesity. To the best of our knowledge, few studies have explored primary caregivers' perceptions of children's weight status among a nationwide sample of Chinese children and their primary caregivers.

The aim of this study was to examine the consistency between primary caregivers' perceptions of Chinese children's weight status and their actual weight status. Data were collected from the Nutrition Improvement Program for Rural Compulsory Education Students (NIPRCES) in China in 2021. Demographic information, anthropometric measurements of children, and primary caregivers' perceptions of children's weight status were obtained from 160 key monitoring counties between September and December 2021. The monitoring counties included 70 national pilot counties and 60 local pilot counties where NIPRCES was implemented, as well as 30 counties without NIPRCES. In each county, eight schools were selected, with approximately 40 students per class selected in each grade. The fasting weight and height of children aged 6–15 years were measured by trained investigators via standardized protocols. Weight was measured to the nearest 0.1 kg using an electronic scale and height to the nearest 0.1 cm using a height meter. Body mass index (BMI) was calculated using weight and height ($\text{BMI}=\text{kg}/\text{m}^2$). Children with stunting (assessed by height standards) were excluded. The remaining children were classified into three groups: wasting, normal weight, and overweight/obesity, according to their BMI [based on the Chinese Screening Standards for Malnutrition of

School-Age Children and Adolescents (WS/T 456-2014) and Screening for Overweight and Obesity Among School-Age Children and Adolescents (WS/T 586-2018)]. Information about the relationships of primary caregivers to children and primary caregivers' perceptions of children's weight status was collected by trained investigators using a specifically designed questionnaire. Primary caregivers' perceptions were assessed with the question, "Do you consider your child's body image to be (too thin, thin, normal weight, fat, too fat)?" The responses were categorized as "thin" (too thin and thin), "normal weight", and "fat" (fat and too fat). A total of 171,872 primary caregivers and child pairs were included in the study. The perception and weight status were considered consistent when the primary caregiver's response matched the child's actual weight status (e.g., thin *vs.* wasting; normal-weight *vs.* normal-weight; fat *vs.* overweight/obesity). The agreement between primary caregivers' perceptions and children's weight status was measured using Kappa coefficient. The Kappa values reflected the following: less than 0.00=poor agreement, 0.00–0.20=slight agreement, 0.21–0.40=fair agreement, 0.41–0.60=moderate agreement, 0.61–0.80=substantial agreement, 0.81–1.00=almost perfect agreement. Statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, USA).

The general characteristics of the children, their actual weight status, and the primary caregivers' perceptions of the children's weight status are presented in Table 1. Based on BMI data, 22.7% of the children were classified as "overweight/obesity", 70.4% as "normal weight", and 6.9% as "wasting". The prevalence of overweight/obesity was found to be higher among males, urban children, children aged 6–8 years or 9–11 years, and those residing in eastern or central China (Table 2). However, according to primary caregivers' responses, only 12.9% perceived their children as "fat", while 59.0% considered them "normal weight", and 28.1% identified them as "thin".

Most of the primary caregivers were the children's parents (88.4%), followed by grandparents (7.8%), and other relationships (3.8%). In this study, it was observed that a mere 59.9% of primary caregivers accurately gauged their child's weight status. However, 35.2% of the caregivers underestimated, and 4.9% overestimated their child's weight status (Supplementary Table S1, available in <http://weekly.chinacdc.cn>). The agreement between primary caregivers' perceptions and the actual weight status of

TABLE 1. General characteristics of children aged 6–15 years and their primary caregivers — China, 2021.

Item	N (%)
Age (years)	
6–8	47,288 (27.5)
9–11	59,666 (34.7)
12–15	64,918 (37.8)
Gender	
Male	86,909 (50.6)
Female	84,963 (49.4)
Region	
Eastern	28,983 (16.9)
Central	58,581 (34.1)
Western	84,308 (49.0)
Area	
Urban	50,838 (29.6)
Rural	121,034 (70.4)
Children's weight status	
Wasting	11,808 (6.9)
Normal weight	120,962 (70.4)
Overweight/obesity	39,102 (22.7)
Primary caregivers' perceptions	
Thin	48,333 (28.1)
Normal weight	101,418 (59.0)
Fat	22,121 (12.9)
Total	171,872 (100.0)

their children was found to be fair ($\kappa=0.253$). Among normal-weight children, 32.0% of primary caregivers underestimated their child's weight status. Furthermore, more than half (55.6%) of the primary caregivers with overweight or obese children were found to underestimate their child's weight status, classifying them as "normal weight" (51.2%) or "thin" (4.4%) (Table 3).

Consistency between primary caregivers' perceptions and children's weight status across various age groups, regions, and areas is illustrated in Supplementary Table S1 (available in <http://weekly.chinacdc.cn>). Primary caregivers of males and younger children had more underestimation about children's weight status compared to caregivers of females and older children. For example, the underestimation rate among primary caregivers of 6–8-year-old males reached 47.1%. Underestimation rates were higher among primary caregivers of children residing in eastern and central regions in China (37.9%, 38.2%) compared to those in western China (32.1%). Furthermore,

TABLE 2. Weight status categories of children aged 6–15 years — China, 2021.

Item	Wasting [n (%)]	Normal weight [n (%)]	Overweight/obesity [n (%)]	P
Age (years)				
6–8	3,423 (7.2)	32,333 (68.4)	11,532 (24.4)	<0.001
9–11	4,114 (6.9)	41,195 (69.0)	14,357 (24.1)	
12–15	4,271 (6.6)	47,434 (73.1)	13,213 (20.3)	
Gender				
Male	7,170 (8.3)	57,113 (65.7)	22,626 (26.0)	<0.001
Female	4,638 (5.5)	63,849 (75.1)	16,476 (19.4)	
Region				
Eastern	2,006 (6.9)	19,221 (66.3)	7,756 (26.8)	<0.001
Central	3,484 (5.9)	39,692 (67.8)	15,405 (26.3)	
Western	6,318 (7.5)	62,049 (73.6)	15,941 (18.9)	
Area				
Urban	3,156 (6.2)	34,253 (67.4)	13,429 (26.4)	<0.001
Rural	8,652 (7.2)	86,709 (71.6)	25,673 (21.2)	
Total	11,808 (6.9)	120,962 (70.4)	39,102 (22.7)	

TABLE 3. Consistency analysis of primary caregivers' perceptions on children's weight status and actual weight status in children aged 6–15 years — China, 2021.

Primary caregivers' perceptions	Children's weight status				Kappa (P)
	Wasting [n (%)]	Normal weight [n (%)]	Overweight/obesity [n (%)]	Total	
Thin	7,950 (67.3)	38,660 (32.0)	1,723 (4.4)	48,333 (28.1)	0.253 (<0.001)
Normal weight	3,722 (31.5)	77,682 (64.2)	20,014 (51.2)	101,418 (59.0)	
Fat	136 (1.2)	4,620 (3.8)	17,365 (44.4)	22,121 (12.9)	
Total	11,808 (100.0)	120,962 (100.0)	39,102 (100.0)	171,872 (100.0)	

underestimation rate was higher in urban areas than in rural areas (37.8% vs. 34.0%).

DISCUSSION

In the present study, a low level of agreement was observed between primary caregivers' perceptions on children's weight status and children's actual weight status. More than half of the caregivers underestimated the weight status of their overweight or obese children, which was markedly higher than the rate observed among caregivers of normal-weight children in our study. These findings align with previous researches conducted in both developing and developed countries (5–7). For instance, a Saudi Arabian study conducted in the children aged 6–10 years showed that misclassification of children's weight status was higher among parents of overweight or obese children compared to parents of normal-weight children (5). In a study that focused on Polish children aged 10–16

and their parents, parental underestimation of children's weight status increased in tandem with the children's weight, with 57.1% of parents having obese children underestimating their children's weight status (6).

Parents tended to underestimate children's weight status (8). More than a third of primary caregivers underestimated the weight status of children in our study. The underestimation of a child's weight status is associated with various factors such as the child's age, gender, and residence (9–10). In our study, it was observed that the primary caregivers of males and children in urban areas had more underestimation about children's weight compared to those of females and children in rural areas. Higher weight of males might be more acceptable than that of females for parents (11). In a study conducted by Rodrigues et al. (10) in Portugal, parents of males living in urban areas were more likely to underestimate their children's weight status. However, a study in China reported that

parents were more likely to overestimate the weight status of children living in urban areas (12). Future studies investigating the factors of residence associated with parental perception of children's weight are necessary.

Primary caregivers' accurate perception of their children's weight status can enhance efforts to prevent overweight and obesity, as demonstrated in a study conducted in China. Mothers who perceived their children as overweight were more likely to encourage them to engage in physical activity and modify their diets (13). In recent years, the prevalence of obesity has been increasing in both urban and rural areas of China. Both national and international policies encourage parental involvement in the prevention of childhood obesity (14). Parents and caregivers should establish a healthy family environment and participate in the weight management of obese children, which will contribute to the prevention of childhood obesity.

This study has some limitations worth noting. As a cross-sectional study, the direction of the relationship between primary caregivers' perceptions and children's weight status remains undetermined. Future research should investigate the factors contributing to primary caregivers' misperceptions regarding their children's weight status.

The accurate perception of a child's weight status by the primary caregiver is crucial for effective weight management. This study found only a fair agreement between primary caregivers' perceptions and the actual weight statuses of children in China in 2021. Implementing effective strategies to enhance primary caregivers' understanding of their children's weight status is necessary.

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SUPPLEMENTARY MATERIALS

SUPPLEMENTARY TABLE S1. Consistency between perceptions of primary caregivers on children's weight status and actual weight status in children aged 6–15 Years — China, 2021.

Item	Underestimation [<i>n</i> (%)]	Consistency [<i>n</i> (%)]	Overestimation [<i>n</i> (%)]	<i>P</i>
Age (years)				
6–8				
Male	11,277 (47.1)	11,952 (49.9)	725 (3.0)	<0.001
Female	9,883 (42.3)	12,621 (54.1)	830 (3.6)	
9–11				
Male	11,549 (38.3)	17,340 (57.5)	1,269 (4.2)	<0.001
Female	9,227 (31.3)	18,885 (64.0)	1,396 (4.7)	
12–15				
Male	10,669 (32.5)	20,161 (61.5)	1,967 (6.0)	<0.001
Female	7,792 (24.3)	22,038 (68.6)	2,291 (7.1)	
Region				
Eastern	10,980 (37.9)	16,991 (58.6)	1,012 (3.5)	<0.001
Central	22,383 (38.2)	33,613 (57.4)	2,585 (4.4)	
Western	27,034 (32.1)	52,393 (62.1)	4,881 (5.8)	
Area				
Urban	19,225 (37.8)	29,443 (57.9)	2,170 (4.3)	<0.001
Rural	41,172 (34.0)	73,554 (60.8)	6,308 (5.2)	
Total	60,397 (35.2)	102,997 (59.9)	8,478 (4.9)	

Recollection

Nutrition and Health Monitoring and Evaluation of the NIPRCES in China

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Ruihe Luo¹; Hui Pan¹; Xiaoqi Hu¹; Wenhua Zhao^{1,†}; Bing Zhang^{1,†}

Good nutritional status in childhood serves as the foundation for lifelong health. Malnutrition during childhood can not only impede children's growth and development, but also lead to a higher incidence of chronic diseases in adulthood, thereby increasing the socioeconomic burden. In order to improve the nutritional and health status of children living in economically underdeveloped rural areas, the Chinese government implemented the Nutrition Improvement Program for Rural Compulsory Education Students (NIPRCES) in November 2011 (1). The central government provides nutritional meal subsidies to rural compulsory education students in underdeveloped counties. Initially, NIPRCES covered rural area of 699 national pilot counties across 22 provincial-level administrative divisions (PLADs) in the central and western regions of China. By 2021, the program expanded to encompass 727 national pilot counties and 1,010 local pilot counties spanning 28 provinces in the eastern, central, and western regions of China, serving more than 36 million students.

In order to assess the impact of NIPRCES on children's growth, the former Ministry of Health and the Ministry of Education collaborated to issue the *Work Plan for Nutrition and Health Monitoring and Evaluation of NIPRCES (Trial)* in 2012 (2). Following this, China CDC released the *Technical Scheme for Nutrition and Health Monitoring and Evaluation of NIPRCES (Trial)* in 2012 and its revised edition in 2013. Then, *Nutrition and Health Monitoring and Guidance Program for Rural Compulsory Education Students* was released in 2021. With the backing of education departments, the National Institute for Nutrition and Health, Chinese Center for Disease Control and Prevention (NINH) partnered with local CDCs (provincial, city, and county levels) to organize monitoring and evaluation plans annually from 2012 to 2017 (3), as well as in 2019 and 2021. Field surveys were conducted each year from September to December between 2012 and 2017, in addition to 2021, and from March to June 2019.

OBJECTIVES

The primary aim of the Nutrition and Health Monitoring and Evaluation was to extensively gather information on various factors, including food supply or intake, children's growth and lifestyle, and associated risk factors from diverse perspectives, such as counties, schools, children, and parents. The research sought to scientifically assess changes in children's nutrition and health status and related factors in order to identify crucial elements of a balanced diet and healthy lifestyle for nutritional intervention. By evaluating the effects of implementing the NIPRCES, the study aimed to provide a robust scientific foundation for the reasonable implementation of NIPRCES in the future.

SAMPLING DESIGN METHOD

A multi-stage stratified random cluster sampling method was employed in this research. Between 2012 and 2019, the monitoring and evaluation plan encompassed rural areas of all national pilot counties, which included approximately 600 routine monitoring counties. Among these, 50 were identified as key monitoring counties. In 2021, the scope of routine monitoring expanded to encompass both urban and rural areas within national and local pilot counties. Subsequently, the number of key monitoring counties increased to 160, comprising 70 national pilot counties, 60 local pilot counties, and 30 non-pilot counties.

In the routine monitoring counties, 10% of rural primary and secondary schools were designated as routine monitoring schools. In the key monitoring counties, four primary and secondary schools were selected from the routine monitoring schools and identified as key monitoring schools, and increasing to 8 rural and urban schools. From 2012 to 2019, approximately 9,000 schools situated in about 600 counties were monitored during each round, which increased to 12,792 schools in 982 counties in 2021 (Figure 1).

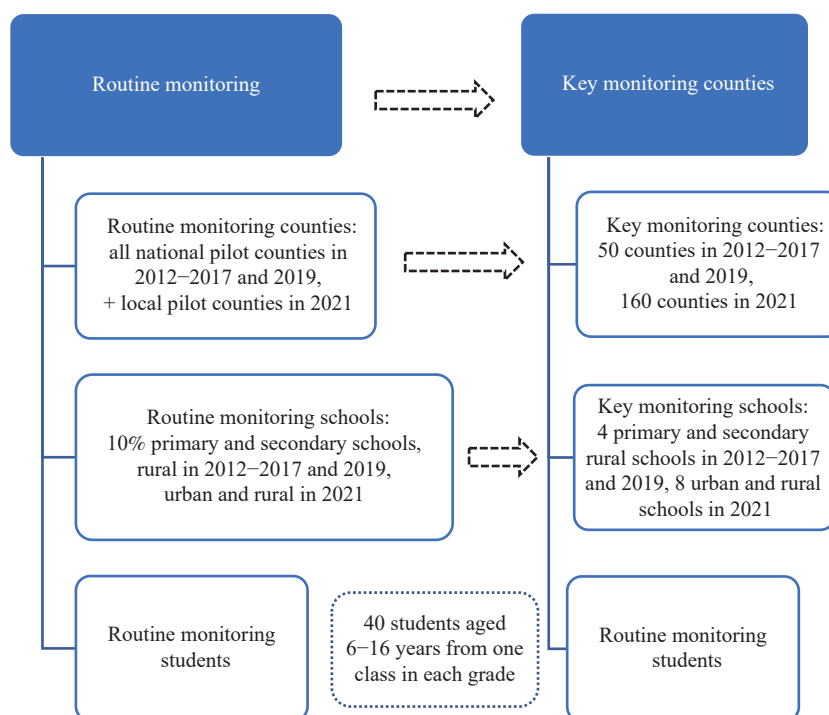


FIGURE 1. The sampling design methodology used between 2012–2017, 2019, and 2021.

In both routine and key monitoring schools, one or two class was chosen from each grade, with approximately 40 students aged 6–16 years being recruited. Between 2012 and 2019, around one million students were selected per monitoring round, whereas, in 2021, nearly two million students participated. The monitored counties, schools, and students remained relatively consistent, allowing for effective longitudinal tracking throughout the observation period.

DATA COLLECTION

The height and fasting body weight of all students aged 6–16 years were measured using standardized methods and uniform equipment in the morning. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m). Stunting or wasting was determined using age-specific and gender-specific height or BMI criteria, as per the Chinese Health Industry Standard for *Screening Malnutrition in School-age Children and Adolescents* (WS/T456-2014) (4). Overweight and obesity were identified based on age-specific and gender-specific BMI criteria, according to the Chinese Health Industry Standard for *Screening Overweight and Obesity in School-Age Children and Adolescents* (WS/T 586-2017) (5). In 2021, additional measurements, such as sitting height, waist circumference, grip strength, and blood pressure, were

obtained from students in key monitoring schools, referred to as key monitoring students.

In this study, whole blood hemoglobin (Hb) levels for the key monitoring students were assessed using the cyanide high iron hemoglobin method, as outlined in the *Method for Anemia Screening* (WS/T 441-2013). Additionally, serum vitamin A and vitamin D concentrations for a subset of these students were determined through liquid chromatography-tandem mass spectrometry (LC-MS), following the guidelines of *Method for Vitamin A Deficiency Screening* (WS/T553-2017) and *Method for Vitamin D Deficiency Screening* (WS/T667-2020). In 2021, blood lipid levels were also analyzed for a subset of the key monitoring students.

In this study, students in primary and secondary schools, who were at least in the third grade (aged 8 years and above), were asked to complete the Student Questionnaire, which gathered data on their food consumption, dietary habits, nutrition knowledge, medical history, physical activity, and lifestyle. Additionally, the Parent Questionnaire was introduced in 2021 to collect information regarding the participating families' socioeconomic status and the primary caregivers' nutritional knowledge and behaviors.

The County Questionnaire and School Questionnaire encompassed all routine monitoring and key monitoring counties and schools. They gathered

information on the implementation of NIPRCES, socioeconomic status, school feeding models, canteen construction, health education, and physical education, among other factors.

The Canteen Food Supply Questionnaire was employed to gather data on the quantities of various food items purchased and consumed, as well as the corresponding number of students and days served for breakfast, lunch, and dinner. This questionnaire was completed by the school canteen or catering center. The Student Absence Questionnaire was utilized to document the daily attendance and absence information for all students. From 2012 to 2019, these two questionnaires encompassed all routine monitoring schools and were restricted to key monitoring schools in 2021.

All data were recorded, uploaded, and provided feedback via a network platform. Data cleaning and analysis were conducted using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA).

Quality Control

To maintain the quality of monitoring and evaluation, the NINH collaborated with the Ministry of Education to conduct 2–3 annual training courses nationwide for staff members at provincial and selected county-level Disease Control Centers and education departments. Each province organized additional training courses for municipal and county-level staff to enhance their skills in nutrition and health monitoring. Moreover, NINH coordinated on-site investigations and provided guidance through collaboration with local health department experts.

The NINH conducted a comprehensive analysis of monitoring and evaluation data collected in each round, generating thematic reports that were regularly submitted to the Ministry of Health and the Ministry of Education, as well as released to the public as required. Based on these monitoring results, targeted dietary guidance and nutrition education initiatives were implemented in primary and secondary schools across the nation.

In an effort to assist schools in providing balanced diets, the Chinese Health Industry Standard *Nutrition Guidelines for School Meals* (WS/T 554-2017) (6) and the Student Electronic Nutritionist, school meal nutrition analysis system, were published. Numerous educational materials, such as the *Dietary Guidelines for School Age Children* (7), nutrition teaching reference books, posters, leaflets, and videos, were developed and disseminated for use in schools to promote nutritional

education and awareness.

This approach fostered a virtuous cycle of nutrition monitoring and education in underdeveloped rural primary and secondary schools, thereby guiding the implementation of the NIPRCES in a more effective direction. In October 2022, seven ministries, including the Ministry of Education, jointly released the *Implementation Plan for NIPRCES* (8). This plan strengthened management across seven key areas, such as balanced diets, nutrition and health education, and monitoring and evaluation. Its primary aim was to solidify the impact of NIPRCES further, in an ongoing bid to improve both the nutritional status and physical fitness of rural Chinese students.

Conflicts of interest: No conflicts of interest.

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