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Epidemiology of dietary iron deficiency in China from 1990 to 2021: findings from the global burden of disease study 2021

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Abstract

Objective To analyze the burden of dietary iron deficiency in China from 1990 to 2021.

Methods Using the results of the 2021 Global Burden of Disease (GBD 2021) study, this study analyzed the prevalence and disability adjusted life years (DALY) of dietary iron deficiency in China from 1990 to 2021.

Results In 2021, the prevalence number of dietary iron deficiency was 795,910,75 (76,187,661–82,382,158), which decreased by 40.86% compared to that in 1990. The number of DALY were 1,689,209 (1,119,315–2,445,991), which decreased by 47.15% compared to that in 1990. The age-standardized prevalence rate (ASPR) and age-standardized DALY rate (ASDR) of dietary iron deficiency showed a downward trend from 1990 to 2021 ($P < 0.05$).

Conclusion From 1990 to 2021, the burden of dietary iron deficiency in China showed a downward trend, with the burden of females having a significantly higher than males, and the burden in females aged 20 to 49 years old increases significantly.

Keywords Dietary iron deficiency, Prevalence, Disability adjusted life years, Burden of disease, Trend

Introduction

Nutritional Deficiencies (ND) is one of the major public health challenges facing the world, affecting the health and well-being of hundreds of millions of people around the globe. There were 435 million prevalence cases and 26 million disability-adjusted life years (DALY) of ND in global in 2019, and the incidence rate of ND in children generally increased globally from 1990 to 2019, except for the years 2010–2017 [1]. In China, ND remains a major public health problem, despite significant economic development. ND includes protein energy malnutrition, dietary iron deficiency, iodine deficiency, vitamin A deficiency, and other nutritional deficiencies. Among them, dietary iron deficiency is the most common ND, which is also the primary cause of iron deficiency anemia (IDA). In 2019, it caused 264,710 DALYs in China. Moreover, the age-standardized DALY rate (ASDR) was as high as 3.69/100,000, which was higher than other ND subtypes [2]. In recent years, Chinese Government have taken a series of polices such as the National Nutrition Plan (2017–2030) to reduce anemia, improve the nutritional and health status of the nation's population. However, regional disparities in the implementation of the policy

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remain evident, especially in remote rural areas, where many families still have difficulty in obtaining balanced nutrition.

Understanding the disease burden of dietary iron deficiency in the whole country is helpful for effective disease control and prevention, which may promote improving the health for all in the future. Therefore, this study utilizes data related to 2021 Global Burden of Disease database (GBD 2021) to provide an exhaustive analysis of the burden of dietary iron deficiency and trends from 1990 to 2021, in order to provide a basis for the development of targeted prevention and treatment strategies for dietary iron deficiency.

Methods

Data sources

Data for this study were obtained from the 2021 Global Burden of Disease database (GBD 2021), which provides comprehensive data on 371 diseases and injuries across 204 countries from 1990 to 2021. Detailed methodologies, including the data sources, disease classification, and statistical models, are documented in previous publications [3]. GBD 2021 Data in China mainly come from the Death Cause Reporting System, Disease Surveillance System, Cancer Registration Data, Nutrition and Health Survey of the Chinese Center for Disease Control and Prevention, representative data in published studies and government reports [3]. The GBD 2021 data are publicly accessible via the Global Health Data Exchange website (*ghdx.healthdata.org and ghdx.healthdata.org/gbd-2021*).

Definitions

The 9th and 10th International Classification of Diseases (ICD-9 and ICD-10) were used to define dietary iron deficiency, 280-280.9 (ICD-9), and D50-D50.9 (ICD-10).

Measurements

Prevalence and DALY were used to estimate and compare the trends in the burden of dietary iron deficiency from 1990 to 2021. The burden of dietary iron deficiency was analysed across various age groups, as follows: under 5, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89, 90–95, and ≥ 95 years.

Statistical analysis

To account for the varying population structures across different periods, age-standardized rates (ASRs) of dietary iron deficiency and their changes over the study period were calculated using a global age structure as the reference point [3]. The 95% uncertainty interval (UI) is a standard indicator used in the GBD, which is calculated by taking 1000 draws from the posterior distribution in the modelling process to address the possible heterogeneity from both sampling error and non-sampling variance [3]. All reported measures included point estimates and the corresponding 95% UIs. The percentage change in rates was calculated as the difference between the rates in 2021 and 1990 divided by the rate in 1990, representing the direction and magnitude of change over the past 32 years. Temporal trends in the dietary iron deficiency ASRs from 1990 to 2021 were analysed using the average annual percentage change (AAPC). When the P-value for either AAPC was <0.05, the trend was described as increasing or decreasing; otherwise, it was considered stable.

Analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC), R version 4.0.4 (The R Foundation for Statistical Computing), and the Joinpoint Regression Program version 4.8.0.

Results (Figure 1 to Figure 3 cannot be displayed?)

Burden of dietary iron deficiency in China in 2021

In 2021, the prevalence number of dietary iron deficiency in China was 795,910,75 (76,187,661–82,382,158), including 22,728,973 (21,442,929–23,954,451) males and 56,862,101 (54,594,002–58,898,044) females, which decreased by 40.86% compared to that in 1990. The DALY caused by dietary iron deficiency were 1,689,209 (1,119,315–2,445,991), including 318,466 (205,871–482,433) for males and 1,370,742 (917,582–1,963,171) for females, compared with 1990, it decreased by 47.15% (Table 1).

Trends in the age-standardized prevalence rate and DALY rate of dietary iron deficiency by gender from 1990 to 2021

As show in Fig. 1, the age-standardizedzed prevalence rate (ASPR) and ASDR of dietary iron deficiency showed a downward trend from 1990 to 2021 ($P<0.05$). The ASPR decreased from 11,738.38/100,000 in 1990 to 5,313.24/100,000 in 2021, with a decrease of 54.74%, and AAPC = -2.51%, 95% CI:-2.52%~-2.50%, $P<0.05$. The ASDR decreased from 285.82/100,000 in 1990 to 115.30/100,000 in 2021, with a decrease of 59.66%, and AAPC = -2.84%, 95% CI: -2.86%~-2.83%, $P<0.05$. From 1990 to 2021, the ASPR and ASDR of dietary iron deficiency in females were higher than those in males. The AAPC for the ASPR of dietary iron deficiency in males was -3.79%, while that in females was -1.70%. Similarly, the AAPC for the ASDR in males was -4.93%, while that in females was -2.84%, both showed a downward trend ($P<0.05$) (Fig. 1).

Burden of dietary iron deficiency in different age groups between 1990 and 2021

Compared to 1990, the prevalence rate and DALY rate of dietary iron deficiency in all age groups was lower in

Table 1 Change of number and age-standardized rates in prevalence and DALY for dietary iron deficiency between 1990 and 2021 in China

	Prevalence		DALY	
	Number, 95%UI	**ASR, 95%UI**	**Number, 95%UI**	**ASR, 95%UI**
Male				
1990	57,937,985(55,710,073–60,166,231)	10,434.83(10,061.81–10,818.82)	1,292,686(857,446–1,876,128)	239.56(160.69–344.57)
2021	22,728,973(21,442,929–23,954,451)	3109.09(2953.45–3259.73)	318,466(205,871–482,433)	48.03(31.41–71.76)
Change(%)	-60.77	-70.20	-75.36	-79.95
AAPC(%)		-3.79(-3.82 - -3.77)		-4.93(-4.95– -4.90)
P value		< 0.05		< 0.05
Female				
1990	76,653,040(73,869,200–79,263,077)	13,215.16(12,766.5–13,670.69)	1,903,652(1,275,114–2,744,361)	335.34(226.1–481.36)
2021	56,862,101(54,594,002–58,898,044)	7731.16(7435.46–8023.89)	1,370,742(917,582–1,963,171)	186.77(124.56–268.89)
Change(%)	-25.82	-41.50	-27.99	-44.31
AAPC(%)		-1.70(-1.71– -1.69)		-1.86(-1.88– -1.84)
P value		< 0.05		< 0.05
Both				
1990	134,591,025(130,371,951–138,929,859)	11,738.38(11,390.68–12,099.90)	3,196,338(2,138,753–4,583,383)	285.82(192.63–407.64)
2021	79,591,075(76,187,661–82,382,158)	5313.24(5103.53–5502.82)	1,689,209(1,119,315–2,445,991)	115.30(76.36–166.42)
Change(%)	-40.86	-54.74	-47.15	-59.66
AAPC(%)		-2.51(-2.52– -2.50)		-2.84(-2.86– -2.83)
P value		< 0.05		< 0.05

AAPC, average annual percentage change; ASR, age-standardised rate; DALYs, disability-adjusted life years; UI, Uncertain interval

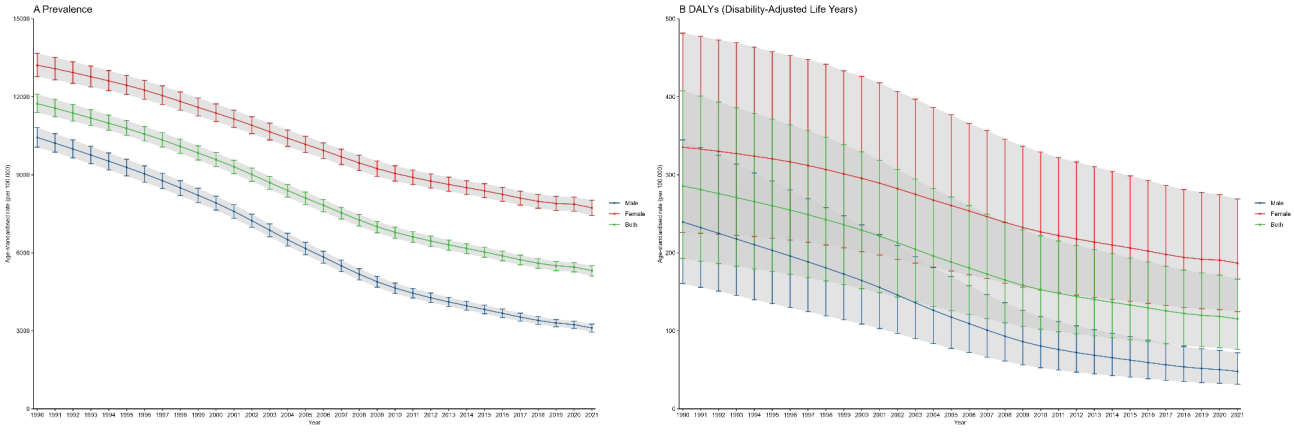

Fig. 1 Annual trends in age-standardized prevalence rate (**A**) and age-standardized DALY rate (**B**) for dietary iron deficiency in China

2021, and the trend with age remained largely consistent (Fig. 2).

Burden of dietary iron deficiency in different gender and age groups in 2021

In 2021, except for the prevalence number of dietary iron deficiency in males aged < 5 years, being higher than that in females, the number of dietary iron deficiency was higher in females across all other age groups. Among them, the highest number of dietary iron deficiency occurred in male children aged < 5 years, with 2,463,509 cases. The highest number of cases occurred in females aged 30–34 years, with 6255953 cases. Generally, the prevalence rate of dietary iron deficiency increase with age in both genders. However, it was significantly higher in women aged 20–49. The prevalence rate of dietary iron deficiency in males over 85 years old was higher than that in females (Fig. 3). The detailed DALY due to dietary iron deficiency across different age groups in China are presented in Fig. 3.

Discussion

From 1990 to 2021, both the ASPR and ASDR for dietary iron deficiency showed a downward trend in China. The burden of dietary iron deficiency was higher in females than in males. With the increase of age, the burden of dietary iron deficiency is gradually increasing, but the burden of dietary iron deficiency in females aged 20 to 49 years old increases significantly.

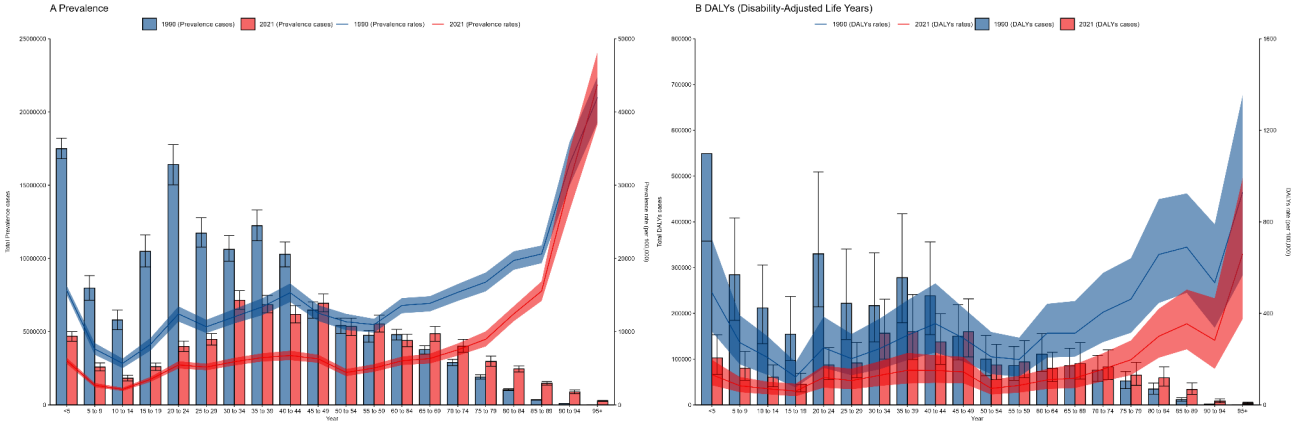

Fig. 2 Number of prevalence and prevalence rate (**A**) and number of DALY and DALY rate (**B**) of dietary iron deficiency by age in China, 1990 and 2021

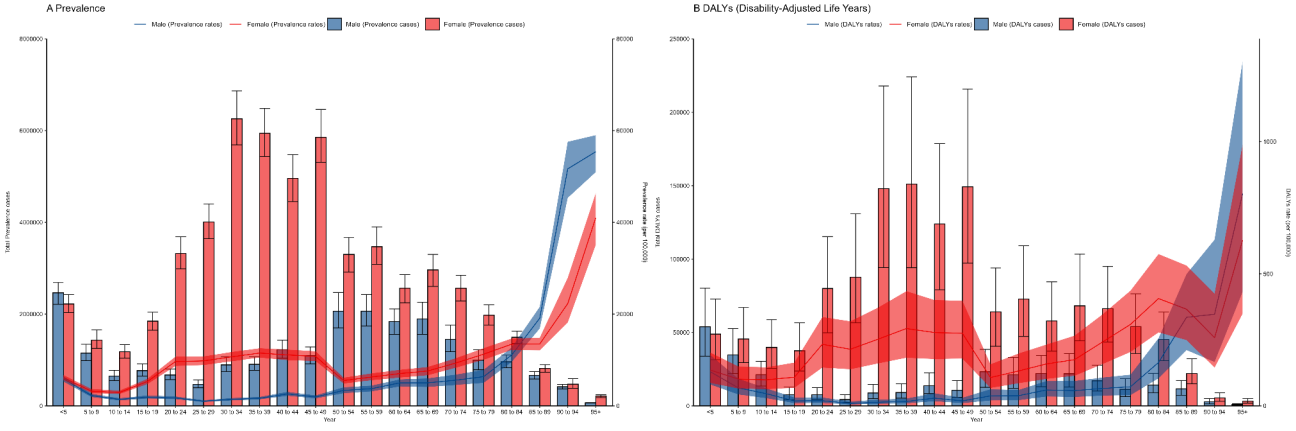

Fig. 3 Number of prevalence and prevalence rate (**A**) and number of DALY and DALY rate (**B**) of dietary iron deficiency by gender in China, 2021

The ASPR and ASDR of dietary iron deficiency in China have declined from 1990 to 2021.The causes are varied and can be multifactorial. Firstly, with economic development and rising living standards, food has become more accessible and people are able to eat a wide variety of foods from which they can obtain adequate nutrition. Secondly, The implementation of the food fortification strategies. For example, Yingyangbao (YYB), a complementary food supplement, is used in the Nutrition Improvement Project on infants and young children in poor areas of China to supply iron and reduce anemia [4]. Since 2021, YYB intervention has gradually spread to 21 provinces in China and decreased anemia prevalence significantly in infants aged 6–24 months. The anemia prevalence of children has decreased from 29.7% in 2015 to 18.1% in 2020 [5]. In addition, the Chinese government has pointed out a series of policies such as the National Nutrition Plan (2017–2030) recommends daily folic acid supplementation as a public health intervention to improve iron status and reduce the risk of anemia in women of reproductive age. Data from China Nutrition and Health Surveillance 2015–2017 showed that the prevalence of anemia among pregnant women in China was 13.6% in 2015, a decrease of 3.6% compared with 2021. The rate of Chinese adults has decreased from 10.4% in 2012 to 8.3% in 2018, with a decrease of 2.1% [6]. Thirdly, technological progress in medical care are also a significant factor. Iron supplementation new oral iron and intravenous iron formulations significantly improve the treatment of iron deficiency anemia (IDA) [7].

Our research demonstrated that the prevalence rate and DALY rate of dietary iron deficiency in females are higher than those in males, which has already been observed in several earlier studies [2, 8]. The causes are numerous. First, women are more concerned about the changes in their body shape. Many women go on a diet to lose weight and become thinner, which reduces food intake including haem iron rich foods such as red meat and eggs [9].The average median intakes iron in women aged 18–49 years in China were 16.8 mg/day, which were lower than the recommended dietary intake [10]. Secondly, the special physiological structure and period of women's life such as heavy menstrual bleeding, pregnancy state, and the postpartum period are the major causes of ID/IDA [11, 12]. On average, a menstrual cycle results in the loss of about 30–40 mL of blood, which

contains iron. In addition to menstruation, there are also a series of processes such as childbirth and breastfeeding. During pregnancy, iron requirements increase significantly. Pregnant women require 370 mg of iron for their fetus and placenta [9]. This is why our study found that the number of cases of dietary iron deficiency and DALY among reproductive-age women aged 20–45 is much higher than other age groups, and both prevalence and DALY rates significantly increase in this age group. Therefore, in the future, more attention should be paid to women's population in the prevention and control of dietary iron deficiency.

This study also found that the burden of dietary iron deficiency in children under 5 years old were higher than that in people aged 5 to 20 years old. Previous studies have shown that dietary iron deficiency mainly occurs in children under 5 years old and adults over 70 years old [2], which might be related to the dietary risk factor and absorption capacity [13, 14]. Firstly, improper addition of complementary foods for infants and young children is a prominent issue. Children under the age of 5 are in a rapid phase of growth and development. During this stage, iron stores accumulated during gestation are depleted rapidly. Prolonged exclusive breast-feeding in the absence of timely introduction of iron-rich complementary feeds [15], without the provision of iron-fortified formulas, or in cases where low-iron infant formulas and inadequately iron-rich complementary foods are used, iron deficiency frequently ensues [16]. However, only 39.8% of rural infants in China have the recommended variety of supplementary foods, compared with 65.5% of urban infants [17]. In addition, young children with poor dietary habits may prefer certain foods while neglecting other iron-rich foods, such as low fruit intake and high sugar drinks, this habit of partial feeding also might lead to insufficient iron intake. In 2016, the proportion of sweet beverage consumption was 51.7%, an increase of 31.5% compared to 2013(20.2%). The frequency of eating unhealthy foods increased from 31.2% in 2013 to 35.6% in 2016 [18]. Then, nonhame-iron absorption requires an acidic milieu. Gastric acid is crucial in iron absorption as it can reduce trivalent iron in food to divalent iron [19]. However, children's intestinal absorption function is relatively weak and gastric acid secretion is limited, which limiting factor for iron absorption. The nutrition and health status of children will be crucial for their survival and development throughout the life cycle [20, 21]. In China, more than 90% of anemia in children and adolescents is IDA [22]. IDA is associated with impaired neurodevelopment in infants and children [23]. Nutritional fortification strategies should be strengthened to promote dietary iron intake reduce anemia rates among children under five years of age. This study also found that the prevalence rate and DALY rates of dietary iron deficiency increased with age after 50 years old. The burden of dietary iron deficiency in middle-aged and elderly people was much higher than other age groups, which may be related to dietary patterns, physiological factors, and disease factors. A study showed that a high intake of high intake of rice, pork, and vegetables was positively associated with anemia among older Chinese [24]. The red meat intake among them did not reach the recommended intake. Moreover, over 95% of them had an inadequate folate intake, and more than 90% had an insufficient riboflavin intake. Inadequate riboflavin (vitamin B_2) intake limits iron utilization in older people [25, 26]. On the other hand, aging causes a decline in the body's physiological functions, particularly gastrointestinal absorption, which affects the absorption and utilization of iron. Additionally, the elderly gradually suffer from chronic diseases such as chronic kidney disease and heart failure can also affect iron metabolism and jeopardize iron homeostasis including absorption and utilization, which can also contribute to the malabsorption of iron in the intestines [27]. These findings suggest an urgent need for interventions targeting the cause of dietary iron deficiency, particularly for infants, pregnant women and other key populations with high demand for iron.

Our study has some limitations. First, the data sources for estimating nonfatal outcomes related to dietary iron deficiency are sparse and heterogeneous and rely primarily on small-scale population-based surveys. Although the strength of the GBD study lies in its use of Bayesian meta-regression modelling to generate optimal estimates in situations with limited data, our present results should be treated with caution. Second, our study did not investigate dietary iron deficiency-related risk factors owing to the scarcity of studies in the Chinese population and the lack of attributable risk factors for this condition in the GBD study. Third, our study underscores the need for greater attention to the burden of dietary iron deficiency across diverse populations, particularly in populous Asian countries. Conducting more real-world studies is essential to validate our findings. Fourth, our study cannot discuss the differential burden of dietary iron deficiency between urban and rural areas. Previous studies have shown that the burden of dietary iron deficiency in rural areas is higher than that in urban [27].

Conclusion

From 1990 to 2021, the burden of dietary iron deficiency decreased in China. The burden was significantly higher in female than male. In the future, we should conduct in-depth research on the influencing factors of dietary iron deficiency in China, take effective intervention measures, strengthen prevention and treatment for high-risk

populations, and further reduce the burden of dietary iron deficiency.

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Data availability
Research materials will be made available to other researchers at the reasonable request of the corresponding author.

Declarations

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Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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