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Social determinants of child malnutrition outcomes: Evidence from CHNS in China

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ABSTRACT

China is committed to reduce child malnutrition outcomes (CMO) rates to less than 5 % by 2030 in order to meet the Sustainable Development Goal (SDG). Yet, this is still an enormous challenge for China, particularly in disadvantaged areas, due to regional and urban-rural disparities. Using China Health and Nutrition Survey (CHNS) data from 1991 to 2015 and fixed-effect models, this study investigates the social determinants of stunting ($n = 4012$) measured by height-for-age z score (HAZ) and wasting ($n = 4229$) measured by weight-for-height z score (WHZ) in children under the age of five. According to the empirical findings, the significant social determinants of child stunting encompassed whether the child is insured ($p < 0.01$), maternal education level (primary school ($p < 0.01$) low middle school ($p < 0.01$); vocational school ($p < 0.01$)), maternal employment status ($p < 0.05$), mother's average working days ($p < 0.05$), average household per capita income ($p < 0.01$), household asset index ($p < 0.01$), urbanization index living in a community (medium ($p < 0.05$); higher ($p < 0.01$); highest ($p < 0.01$)) and living regions (west ($p < 0.01$); northeast ($p < 0.05$)). Children's maternal employment status ($p < 0.05$), mother's average working days ($p < 0.05$), living areas ($p < 0.05$) and living regions (central ($p < 0.01$); west ($p < 0.01$); north-east ($p < 0.05$)) are the significant factors impacting child wasting. Furthermore, the interaction impact between maternal employment and have one additional working day per week is positive. To attain SDGs, the Chinese government should priorities lowering stunting and wasting among 5-year-olds in the western region, particularly in impoverished regions. Also, it is possible to develop tailored policies for the growth and development of children under the age of five by addressing pertinent socio-economic factors.

1. Introduction Background

In underdeveloped countries across the world, child malnutrition outcomes (CMO) continue to be a serious health hazard that threatens children's survival, growth, and development [1,2]. In the realm of policy formulation, epidemiologists, nutrition scientists, and health economists conduct a nuanced examination of CMO, encompassing factors of intrauterine genetic predisposition, dietary elements, and socio-economic disparities. Simultaneously, a substantial body of literature provides compelling evidence that CMO carries long-term implications, transcending short-term mortality and morbidity outcomes. It not only hampers the linear growth of children's physical development, cognitive development, schooling, labor productivity, and income in adulthood but also increases the

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risks of non-communicable chronic diseases prevalent in contemporary society, like high blood pressure and diabetes, and eventually restrains the accumulation of heath human capital in adulthood [2–12]. This enduring inequality engenders an intergenerational cycle, trapping individuals in a downward spiral of deteriorating health and chronic poverty. From the macro perspective, CMO have a non-negligible impact on the overall health of the population, the quality of the labor force and the long-term economic development of the country [13,14]. This influence is particularly conspicuous in developing countries that hinge on demographic dividends.

Based on World Health Organization's (WHO) definition, CMO refers to a wide range of nutritional problems, including deficiencies, overnutrition, and imbalances. Common physical criteria employed to assess CMO in the literature are child stunting and wasting. Child stunting, characterized by a reduced stature in children, can also be construed as a failure to attain one's genetic potential for height. This is regarded as the foremost indicator to estimate children's welling and reflect social equalities in the early life stage [3]. Conversely, child wasting is viewed as a manifestation of acute malnutrition due to food shortage or high incidence of infectious diseases, especially diarrhea. Notably, it ranks as the most dependable metric and a significant predictor of mortality in children under the age of five [2].

In China, Chinese government has initiated the Program for Development of Chinese Children every decade, prioritizing the enhancement of children's nutrition to align with Sustainable Development Goals (SDGs) [15]. Impressively, China has achieved great progress against combatting child stunting and wasting, with up to 38 % of children under 5 who were considered stunted, had dramatically declined to 6.1 % between 1992 and 2015. However, a noticeable disparity persists when comparing the prevalence of child stunting to that in developed countries [16]. Given China's largest population, out of the 165 million children worldwide who are stunted at age 5, China shoulders 8.059 million cases, accounting for 5 % of the global stunting burden. Likewise, among the 52 million wasted children worldwide, China has 1.891 million cases, ranked as the sixth highest global burden of wasting [17].

Evidently, regional disparities and urban-rural divide in CMO remains a pressing concern [18]. Among the regions, western provinces have been shown to be the most challenged regions [19]. The period from 1990 to 2013 witnessed a considerable urban-rural divide, the prevalence of child stunting in urban children declined from 11.4 % to 4.3 %, whereas in rural children, it decreased from 40.3 % to 11.2 %. Currently, the prevalence of child stunting continues to be a significant concern, particularly in impoverished rural regions [20,21]. With the aim of achieving the SDGs by 2030, notably the eradication of all forms of malnutrition, the National Nutrition Plan (2017–2030) outlines the objective that by 2030, the prevalence of CMO in children under 5 should be curtailed to below 5 % [22]. Research findings have predicted that urban areas are making progress toward this target, but rural areas, especially underprivileged area, face a more challenging path in achieving the expected prevalence [20]. While several nutrition intervention strategies within China in have been progressively introduced, the majority predominantly concentrate on infants and school-aged children in economically challenged rural counties [23]. The period of 0–5 years stands as a pivotal phase for child growth and development, underscoring the critical importance of nutritional interventions that span the entirety of this formative developmental stage. Concurrently, while nutritional interventions in impoverished rural regions are indispensable, due consideration must also be given to the nutritional status of children, especially those who have accompanied their migrant worker parents in the transition to urban living within the swiftly urbanizing landscape of contemporary China.

Grounded in UNICEF's framework for child survival and thriving, CMO is influenced by a range of determinants that have direct, indirect, or interactive impacts [24]. While some studies emphasize the role of inadequate dietary intake and disease-prone environments as immediate drivers of childhood malnutrition [25–29], the evolving understanding of socio-economic determinants of health, as elucidated by The Commission on Social Determinants of Health (CSDH), has prompted a growing body of scholarly work that delves into distal and intermediate risk factors related to childhood CMO [30,31]. These factors encompass elements like poverty, education, employment, sanitation, and community-level environments [32,33].

Specifically, CMO is inextricably tied to the family's availability of nourishing food and healthcare resources. Hence, an increase in per capita household income can facilitate enhanced access to nutritious food, ultimately improving child nutrition [34–37]. One study have demonstrated a direct link between child malnutrition, poverty, and food insecurity, which are influenced by both material circumstances within the household and food systems at macro-level [38]. Food instability remains a notable challenge for children under two years of age, who consume less than the recommended daily caloric intake and lack of essential micronutrients [39]. In addition, socioeconomic status stands as a critical predictor for CMO [40–42]. Furthermore, factors related to household wealth index such as household sanitation environment and access to electrical appliances facilitate the comprehension of the heterogeneity in CMO at the macro-level [42–46].

Moreover, a close link between maternal characteristics and CMO has been experimentally investigated in most studies [6,47]. Drawing upon national surveys [44,47–50], a recurring consensus underscores that maternal attributes, including height, BMI, educational attainment, and employment status, stand as significant determinants of CMO. Globally, studies have produced consistent results revealing that children with shorter mothers are more likely to be stunted. Additionally, the children are more likely to be at risk of malnutrition if a mother is underweight [6,42]. Furthermore, higher maternal education is associated with lower risk of child stunting or wasting, although it is worth noting that also risks associated with higher levels of maternal education due to the mother's lack of dietary knowledge [47,51]. The impact of mothers' employment status and working days on their children's nutrition is controversial, both theoretically and empirically [51–53]. The divergent findings hinge on the debate of whether the positive impact in family income caused by mothers' employment outweighs the negative impact of reduced maternal care time due to longer working hours on children's health [51–54]. In China, marked by rapid urbanization and socioeconomic growth, the female workforce participation rate in China has exceeded 60 % [55], this study specially examines the direct impacts and interaction effects of mothers' employment and average weekly working hours on their children's CMO.

The objective of this study is to investigate the social determinants contributing to CMO under 5. The study seeks to achieve three main contributions. Firstly, the study utilizes data from CHNS to provide evidence that supplements the existing literature on the social determinants of CMO under 5 in China. Furthermore, the study's findings illuminate that the impact of socio-economic factors extends beyond rural, economically disadvantaged regions to include children residing in urban areas in the eastern part of the country. Consequently, there is a compelling need for nutritional intervention policies to encompass the relevant demographic groups within this geographical area. Additionally, the study highlights that the risk factors associated with stunting and wasting differ among various regions and gender groups. Importantly, community urbanization exerts a consistent protective role in ensuring the nutritional well-being of children across all regions, with a particular emphasis on girls in economically underdeveloped rural areas. Thus, achieving sustainable child development necessitates collaborative efforts across multiple sectors, including healthcare, education, social services, and the economy.Simultaneously, the study presents findings that demonstrate the direct and interact impact of maternal employment status and the average weekly working hours on children's CMO. Finally, it aims to draw useful policy implications for developing countries by examining China's comprehensive approach to reducing CMO.

2. Methodology

2.1. Data source

The data for this study are derived from the China Health and Nutrition Survey (CHNS), which was collected by the Chinese Center for Disease Control and Prevention's Institute of Nutrition and Food Safety in collaboration with the Population Center of the University of North Carolina in the United States. The database tracks by employing stratified multi-stage cluster random sampling principles at the individual, household, and community levels, which includes nine provinces or autonomous regions: Heilongjiang, Liaoning, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou in 1991, 1993, 1997, 2000, 2004, 2006, 2009. Since 2011, the following surveys have included two municipalities, Beijing and Chongqing, and also Shanghai, as one of China's most economically developed cities.

In each survey, approximately 4400 households and around 26,000 family members were interviewed. Simultaneously, CHNS assigns varying weights to counties across different levels of provincial development and income during the sampling process. This method is employed to enhance the representativeness of our research analysis. Before conducting interviews with participants for our study on ethical decision-making, the CHNS was ethically reviewed by the National Institute for Nutrition and Health and the Chinese Centre for Disease Control and Prevention (No. 201524) and all subjects signed an informed consent form prior to the survey, ensuring that they understood the purpose of the research, their rights as participants, and the voluntary nature of their involvement.

In this study, children aged 0 to 5 are included to investigate stunting (n = 4,012, chronic malnutrition outcome), and wasting (n = 4229 samples, acute malnutrition outcome). There are some missing individual samples in the data concerning the impact of father characteristics on child stunting (n = 4005). This study employed data from 1991 to 2015, however, the initial wave of the CHNS in 1989 was excluded from this analysis due to a large number missing value.

3. Variables

3.1. Dependent variables

The dependent variables of the CMO are assessed by child stunting (measured by height-for-age z score (HAZ)) and child wasting (measured by weight-for-height z score) based on WHO 2007 Child Growth Standard [56]. The measurements of children's height and weight are administered by professional healthcare staff during the health examination procedure. Z scores were calculated using the function "zanthro" based on height (cm), weight (kg), sex, and age (years) during childhood in STATA 17 version. Higher z-scores for HAZ and WHZ imply a better nutritional status for children, whereas lower z-scores represent a worse nutritional condition for children. Therefore, all z scores are continuous variables, and z scores < -5 or z scores >5 are excluded. In this case, a child with HAZ and WHZ below two standard deviations (HAZ $<$ median -2SD and WHZ $<$ median -2SD) is regarded as to be stunted or wasted.

3.2. Independent variables

The key independent variables are chosen based on the published work by UNICEF [57] and CSDH conceptual frameworks of child malnutrition [32,33]. Proximate determinants include demographic variables such as children's gender, age, ethnicity, parents' height, and body mass index (BMI). Social determinants in this study comprise parents' education levels, parents' employment status, parents' average working days per week, family income per capita, household asset index, whether kid has health insurance, urbanization index level, living regions and areas.

To be specific, parent's education is assessed using the question from the CHNS questionnaire: what is your highest level of education attained? Based on the response, the education level is categorized into six groups: non-educated, primary, low-middle school, upper middle school, vocational school, and college and above. The question about the parents' employment status in the CHNS survey is "Are you presently working?" with response options coded as 1 for "yes" and 0 for "no." The urbanization index is a composite indicator that is calculated based on a community's population density, economic activity, markets, transportation, health, communication, housing, and social services. Then, it is classified into 5 levels: lowest, lower, medium, higher, highest.

The household asset index represents a multifaceted metric constructed through the utilization of principal component analysis (PCA). It combines a range of household attributes and amenities, including domestic appliances like microwaves, electric cookers, pressure cookers, refrigerators, televisions, washing machines and air conditioner. Additionally, it encompasses aspects such as

Table 1
The descriptive analysis and ANOVA analysis between social determinants and children stunting, wasting, respectively.

Variables	HAZ				WHZ			
	N (%)/Mean ± SD	Mean	SD	P value	N (%)/Mean ± SD	Mean	SD	P value
Total sample	4012(100 %)				4229(100 %)			
Child characteristics								
Children's age	3.23 ± 1.42			0	2.99 ± 1.58			0
0	52 (1.30)	2.63	1.66		319 (7.54)	−0.02	1.39	
1	559 (13.93)	1.15	1.83		576 (13.62)	0.41	1.39	
2	726 (18.10)	0.37	1.66		726 (17.17)	0.42	1.33	
3	748 (18.64)	−0.02	1.51		742 (17.55)	0.31	1.23	
4	937 (23.35)	−0.22	1.44		925 (21.87)	0.27	1.32	
5	990 (24.68)	−0.15	1.37		941 (22.25)	0.04	1.29	
Children's Gender				0.8518				0.1658
Boys	2184 (54.44)	0.16	1.62		2326 (55.00)	0.27	1.34	
Girls	1828 (45.56)	0.17	1.64		1903 (45.00)	0.22	1.31	
Children's nationality				0				0.0024
Han	3425 (85.37)	0.23	1.61		3609 (85.34)	0.27	1.41	
Minority	587 (14.63)	−0.22	1.74		620 (14.66)	0.1	1.41	
Medical insurance				0				0.0928
No	2399 (59.80)	−0.09	1.61		2553 (60.37)	0.22	1.32	
Yes	1613 (40.20)	0.56	1.59		1676 (39.63)	0.29	1.33	
3-day Calories consumption	1168.51 ± 459.81	0.17	1.63	0	1128.8 ± 466.04	0.25	1.32	0.1153
3-day Protein intake	36.24 ± 14.60	0.17	1.63	0.3246	35.06 ± 14.69	0.25	1.32	0.0026
3-day Fat intake	36.62 ± 21.18	0.17	1.63	0.3246	35.38 ± 20.79	0.25	1.32	0.0026
Parents' characteristics								
Maternal height	156.51 ± 5.54			0	156.51 ± 5.54			0
≥157	1991 (49.63)	0.58	1.62		2108 (49.85)	0.38	1.35	
<157	2021 (50.37)	−0.24	1.54		2121 (50.15)	0.11	1.29	
Paternal height	167.48 ± 6.17			0	167.46 ± 6.15			0
>=168	1995 (49.73)	0.64	1.61		2091 (49.44)	0.34	1.37	
<168	2017 (50.27)	−0.29	1.52		2138 (50.56)	−0.16	1.27	
Maternal BMI	21.95 ± 2.96			0.0001	21.93 ± 2.95			0
18.5<BMI<24	2832 (70.59)	0.13	1.61		3001 (70.96)	0.24	1.29	
BMI ≥ 24	829 (20.66)	0.38	1.62		861 (20.36)	0.42	1.39	
BMI ≤ 18.5	351 (8.75)	0.02	1.77		367 (8.68)	−0.11	1.36	
Paternal BMI	22.42 ± 3.09			0	22.37 ± 2.98			0
18.5< BMI <24	2790 (69.54)	−0.01	1.6		2962 (70.04)	0.2	1.29	
BMI≥24	1004 (25.02)	0.7	1.61		1031 (24.38)	0.44	1.39	
BMI≤18.5	218 (5.43)	−0.003	1.64		236 (5.58)	0.06	1.37	
Maternal education				0				0.0048
Non-educated	547 (13.63)	−0.63	1.44		577(13.64)	0.2	1.33	
Primary	881 (21.96)	−0.11	1.58		914 (21.61)	0.17	1.33	
Low middle school	1668 (41.58)	0.29	1.57		1778 (42.04)	0.24	1.32	
Upper middle school	465 (11.59)	0.27	1.61		489 (11.56)	0.27	1.3	
Vocational	223 (5.56)	0.91	1.62		227 (5.37)	0.4	1.35	
College and above	228 (5.68)	1.37	1.51		244 (5.77)	0.51	1.3	
Maternal average working days per week	5.68 ± 0.86	0.17	1.63	0	5.67 ± 0.85	0.25	1.32	0.36
Maternal employment status				0				0.0712
Non-worked	754 (18.79)	0.64	1.74		842 (19.91)	0.32	1.36	
Worked	3258 (81.21)	0.06	1.59		3387 (80.09)	0.23	1.31	
Paternal education				0				0.0007
Non-educated	195 (4.86)	−0.49	1.54		204 (4.82)	0.27	1.37	
Primary	659 (16.43)	−0.15	1.58		696 (16.46)	0.09	1.32	
Low middle school	1934 (48.21)	0.1	1.61		2049 (48.45)	0.22	1.34	
Upper middle school	711 (17.72)	0.17	1.54		741 (17.52)	0.33	1.25	
Vocational	244 (6.08)	0.83	1.63		256 (6.05)	0.43	1.32	
College and above	269 (6.70)	1.3	1.53		283 (6.69)	0.4	1.36	
Paternal average working days per week	5.57 ± 0.99	0.17	1.63	0.24	5.25 ± 1.71	0.25	1.32	0.37
Paternal employment status				0.0005				0.083
Non-worked	266(6.64)	0.5	1.76		284 (6.72)	0.38	1.32	
Worked	3739 (93.36)	0.14	1.62		3945 (93.28)	0.24	1.32	
Father's smoking				0.0644				0.9518
Yes	2650 (66.05)	0.24	1.67		2796 (66.11)	0.25	1.33	
No	1362 (33.95)	0.13	1.61		1433 (33.89)	0.25	1.31	
Father's drinking				0.9358				0.2102
Yes	2672 (66.60)	0.17	1.64		2820 (66.68)	0.23	1.33	
No	1340 (33.40)	0.17	1.63		1409 (33.32)	0.28	1.31	
Household characteristics								
Household annual per capita income (ten thousand)	0.66 ± 0.79	0.17	1.63	0	0.65 ± 0.79	0.25	1.32	0
Household asset index	0.76 ± 0.37	0.17	1.63	0	0.74 ± 0.35	0.25	1.32	0.0001

(*continued on next page*)

Table 1 (*continued*)

Variables	HAZ				WHZ			
	N (%)/Mean ± SD	Mean	SD	P value	N (%)/Mean ± SD	Mean	SD	P value
Community characteristics								
Residence				0				0
East coastal area	867 (21.61)	0.62	1.64		909 (21.49)	0.57	1.3	
Central area	1315 (32.78)	0.11	1.58		1379 (32.61)	0.3	1.26	
West area	1272 (31.70)	−0.31	1.54		1354 (32.02)	−0.11	1.26	
North-east area	558 (13.91)	0.72	1.6		587 (13.88)	0.44	1.44	
Area				0				
Urban	1102(27.47)	0.38	1.63		1148 (27.15)	0.32	1.31	0.0371
Rural	2910 (72.53)	0.09	1.63		3081 (72.85)	0.22	1.33	
Urbanization index				0				0.0647
Lowest	825 (20.56)	−0.43	1.53		867 (20.50)	0.19	1.29	
Lower	805 (20.06)	−0.14	1.57		860 (20.34)	0.18	1.27	
Medium	797 (19.87)	0.11	1.61		843 (19.93)	0.29	1.38	
Higher	801 (19.97)	0.46	1.51		835 (19.74)	0.24	1.31	
Highest	784 (19.54)	0.87	1.62		824 (19.48)	0.35	1.35	

household cooking fuels, vehicle ownership, and sanitation and hygiene environments such as access to indoor tap water and the presence of open defecation in the household vicinity, as well as the nature of toilet facilities. This index offers a comprehensive assessment of the socio-economic status and living conditions prevailing within households. In addition, CHNS includes individual dietary information, where it adopts a 24-h personal meal review technique for three days. Meanwhile, information on whether the father smoked or drank was included, but since the proportion of mothers who smoked or drank alcohol in this study group is minimal, hence, it was not controlled. Children's ages, mothers' average number of working days per week, family income per capita are continuous variables, while the rest are categorical variables.

4. Data analysis

Categorical variables are described using frequency and percentage, whereas continuous variables are described using mean and standard deviation (SD). The mean HAZ and WHZ for children under the classification categories determinants are also reported in Table 1. Before fixed effects regressions, the bivariate associations between the CMO and related socio-demographic categorical factors was analyzed using ANOVA analysis. The correlation between continuous independent variables and dependent variables also was analyzed. The results are also reported in Table 1, $p < 0.05$ are considered to be significant. Then, the fixed effect models are used to examine multivariable relationship between social determinants and CMO measured by HAZ and WHZ. In the regression analysis, separate models are constructed to examine the relationships between stunting and wasting, respectively. Within the regression models, to further explore the impact of paternal socio-economic determinants on CMO, an additional regression analysis was performed. Initially, regressions were conducted considering all related socio-economic factors related to mothers. Subsequently, fathers' educational levels, employment status, and average working days per week were introduced into the model for further analysis. Furthermore, heterogeneity analysis in social determinants associated with child stunting and wasting was undertaken, with a specific focus on regional variations, urban-rural divide, and gender disparities. All the analyses employed the STATA 17.0 version.

5. Results

5.1. Descriptive analysis

Table 1 show the mean for HAZ and WHZ associated with the major social determinants of childhood stunting and wasting. Meanwhile, the results of ANOVA analysis are shown in Table 1. At 5 % significance level, $p < 0.05$ shows that the association between the univariate variable and HAZ or WHZ is significant. The mean HAZ of children aged 0–5 years in the sample increased annually from −0.38 in 1991 to 0.92 in 2015. It revealed that child stunting among Chinese children was improving. Meanwhile, WHZ climbed from 0.17 to 0.32, an indication of only a slight improvement in wasting compared to stunting in children.

In the sample, the mean age and SD of the children related to HAZ and WHZ are 3.23 ± 1.42, and 2.99 ± 1.58, respectively. Male children account for about 55 % of all children in the samples, while female children account for about 45 %. Ethnically, majority of the children (over 85 %) are of Han Chinese origin. Around 60 % of the children do not have health insurance. In the context of maternal characteristics, the sample reveals that the mean height and its SD in both samples are consistently observed at 156.5 ± 5.54. Similarly, the mean BMI for mothers is notably similar in both samples. The HAZ sample shows a mean and SD of height 167.48 ± 6.17 and a mean BMI of 22.42 ± 3.09 for fathers, similar to the WHZ sample. Nearly 70 % of parents have normal BMI in the two samples.

The distribution of mothers' and fathers' education levels is dominated by low middle school education, accounting for around 42 % and 48 %, respectively in both samples. In the category of above upper middle school, fathers had a larger percentage of the education compared to mothers who have higher rate of illiteracy. Over 80 % of mothers and 90 % of fathers are employed and they work five to six days per week on average. Approximately above 60 % of fathers reported having a smoking or drinking habit.

About household socioeconomic status, the mean annual per capita income of the family was 0.66 and 0.65 ten thousand yuan

Table 2
The fixed effects of social determinants of child stunting and wasting.

Variables	Model 1	Model 2	Model 3	Model 4
	HAZ	HAZ	WHZ	WHZ
Age	−0.3343***	−0.3351***	−0.0643***	−0.0652***
	(-18.34)	(-18.27)	(-4.35)	(-4.39)
Gender				
Girl	−0.0097	−0.0059	−0.0545	−0.0584
Boy (reference)	(-0.22)	(-0.13)	(-1.36)	(-1.47)
Ethnicity				
Minority	−0.0605	−0.0605	0.1085	0.1076
Han (reference)	(-0.83)	(-0.83)	(1.63)	(1.61)
Health insurance				
Yes	0.2084***	0.2120***	−0.0378	−0.0356
No(reference)	(4.19)	(4.26)	(-0.84)	(-0.79)
Maternal height(cm)				
<157	−0.3104***	−0.3076***	−0.1221***	−0.1221***
≥157(reference)	(-6.59)	(-6.51)	(-2.84)	(-2.84)
Mother's nutrition				
BMI ≥ 24	0.1071*	0.1054*	0.1173**	0.1192**
	(1.86)	(1.82)	(2.19)	(2.22)
BMI≤18.5	−0.1216	−0.1223	−0.3144***	−0.3128***
18.5< BMI <24 (reference)	(-1.51)	(-1.51)	(-4.33)	(-4.30)
Paternal height(cm)				
<168	−0.3869***	−0.3935***	0.0364	0.0374
≥168(reference)	(-8.02)	(-8.13)	(0.81)	(0.83)
Father's nutrition				
Overweight	0.1520***	0.1457**	0.1570***	0.1543***
	(2.69)	(2.58)	(3.01)	(2.96)
Underweight	−0.0796	−0.0874	−0.0808	−0.0810
Normal (reference)	(-0.79)	(-0.86)	(-0.90)	(-0.89)
Maternal' education				
Primary	0.1672**	0.1688**	−0.0157	−0.0087
	(2.20)	(2.19)	(-0.22)	(-0.12)
Low middle school	0.2787***	0.2772***	0.0076	0.0004
	(3.83)	(3.70)	(0.11)	(0.01)
Upper middle school	0.1729*	0.1770*	−0.0034	−0.0132
	(1.88)	(1.84)	(-0.04)	(-0.15)
Vocational	0.4162***	0.3628***	0.0759	0.0595
	(3.27)	(2.76)	(0.68)	(0.51)
College and above	0.4195***	0.3013*	0.0544	0.1291
Illiteracy (reference)	(2.99)	(1.94)	(0.44)	(0.94)
Mother's average working days	−0.4166**	−0.4089**	−0.3085**	−0.3124**
	(-2.43)	(-2.38)	(-2.19)	(-2.24)
Maternal employment status				
Yes	−2.1649**	−2.1013**	−1.9338**	−1.9398**
No (reference)	(-2.23)	(-2.17)	(-2.42)	(-2.44)
Interaction 1	0.3668**	0.3586**	0.3445**	0.3501**
	(2.12)	(2.09)	(2.43)	(2.49)
Paternal' education				
Primary		0.0042		−0.1428
		(0.04)		(-1.32)
Low middle school		−0.0033		−0.0777
		(-0.03)		(-0.76)
Upper middle school		−0.0033		−0.0248
		(-0.03)		(-0.23)
Vocational		0.1487		−0.0069
		(1.04)		(-0.05)
College and above		0.1838		−0.2208
Illiteracy (reference)		(1.15)		(-1.43)
Father's average working days		0.0104		−0.0157
		(0.41)		(-0.70)
Father's employment status				
Yes		−0.0891		−0.0459
No (reference)		(-0.81)		(-0.30)
Household income per capita	0.1519***	0.1468***	0.0053	0.0152
	(3.95)	(3.78)	(0.15)	(0.44)
Household asset index	0.2941***	0.2958***	0.0753	0.0685
	(3.46)	(3.47)	(0.92)	(0.83)
Urbanization index				
Lower	0.0695	0.0745	0.0275	0.0284

(*continued on next page*)

Table 2 (*continued*)

Variables	Model 1	Model 2	Model 3	Model 4
	HAZ	HAZ	WHZ	WHZ
	(1.00)	(1.06)	(0.45)	(0.46)
Medium	0.1596**	0.1681**	0.1097	0.1056
	(2.15)	(2.27)	(1.63)	(1.57)
Higher	0.3097***	0.3107***	−0.0260	−0.0285
	(3.84)	(3.84)	(-0.36)	(-0.40)
Highest	0.3141***	0.2989***	−0.0406	−0.0487
Lowest (reference)	(3.15)	(2.99)	(-0.46)	(-0.54)
Father's smoking				
Yes	0.0224	0.0269	0.0691	0.0692
No (reference)	(0.46)	(0.56)	(1.57)	(1.57)
Father's drinking				
Yes	0.0239	0.0251	−0.0754*	−0.0764*
No (reference)	(0.50)	(0.52)	(-1.72)	(-1.74)
3-day calories intake	−0.0000	−0.0000	0.0002	0.0002
	(-0.30)	(-0.11)	(1.40)	(1.43)
3-day protein intake	0.0042*	0.0039	0.0035	0.0034
	(1.66)	(1.57)	(1.15)	(1.10)
3-day fat intake	0.0013	0.0012	−0.0035**	−0.0035**
	(0.92)	(0.85)	(-2.53)	(-2.51)
Area				
Rural	0.0522	0.0583	−0.1155**	−0.1138**
Urban(reference)	(0.98)	(1.08)	(-2.36)	(-2.32)
Region				
Central	−0.1248*	−0.1230*	−0.2208***	−0.2280***
	(-1.94)	(-1.90)	(-3.76)	(-3.88)
West	−0.3970***	−0.3939***	−0.6270***	−0.6287***
	(-5.73)	(-5.62)	(-9.93)	(-9.91)
North east	0.1939**	0.1854**	−0.1727**	−0.1621**
East(reference)	(2.31)	(2.20)	(-2.17)	(-2.03)
_cons	3.0978***	3.0582***	2.3237***	2.5341***
	(3.14)	(3.11)	(2.88)	(3.15)
N	4012	4005	4229	4229
R^2	0.2841	0.2859	0.0634	0.0656
adj. R^2	0.2781	0.2787	0.0560	0.0567

Note: T statistics in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01. Interaction 1 is the term of mothers' employment status and average working days per week.

inflated in 2015 related to HAZ and WHZ, respectively. Average household asset index ranges from 0.74 to 0.76 in all samples. The urbanization index is classified into five levels; lowest, lower, medium, higher and highest. Geographically, 22 % of the total samples come from the eastern area, 32 % is from the central region, another 32 % of the sample is from the western region, and the balance of 14 % is from the northeast region. Further classified, 72 % of the sample comes from rural regions, whereas 28 % comes from urban areas.

Based on the ANOVA analysis in Tables 1 and it is evident that as children's age increases, there is a noticeable decline in their HAZ ($p < 0.01$). Additionally, the mean WHZ is highest at the age of 2 and relatively lower at ages 0 and 5 ($p < 0.01$). In terms of gender, there is no significant difference observed in either HAZ or WHZ. However, when considering minority groups, it becomes evident that they exhibit lower HAZ ($p < 0.01$) as well as lower WHZ ($p < 0.01$). Notably, children with insurance coverage demonstrate significantly higher HAZ($p < 0.01$) compared to WHZ.

Children whose mother's height is less than 157($p < 0.01$), father's height less than 168($p < 0.01$), and parents' BMI less than 18.5 ($p < 0.01$) have lower HAZ, and WHZ on average. Generally, children whose parents have college education level and above have significant higher HAZ and WHZ. Parents who are unemployed exhibit higher HAZ ($p < 0.01$), WHZ ($p < 0.1$). Maternal average working days per week are significantly correlated with HAZ ($p < 0.01$), while showing significant association with WHZ only at 10 % significance level. In the context of family socio-economic factors, both per capita household income and the household asset index exhibit a significant correlation with both HAZ ($p < 0.01$) and WHZ ($p < 0.01$) as determined by ANOVA analysis. Higher urbanization index level areas have higher HAZ ($p < 0.01$) and WHZ ($p < 0.1$). Furthermore, when considering geographical factors, there are significant differences observed in both HAZ and WHZ among different regions, as well as between rural and urban areas. Specially, there is a huge difference in the mean HAZ between the eastern coastal, northeastern, central and western regions, ranging from −0. 31 to 0.7. The variation in WHZ ranges from −0.11 to 0.57. Urban children have a higher HAZ ($p < 0.01$) and WHZ ($p < 0.05$) than rural children.

5.2. The determinants of child stunting

According to Table 2 below, the risk demographic factors contributing to child stunting are age, parental height, parental's BMI.

Building upon the foundation of Model 1, Model 2 incorporates the regression of paternal socio-economic characteristics. In the two models, it is found that for each additional year of a child's age, HAZ decreases by approximately 0.33–0.34 ($p < 0.01$). While, gender and ethnicity do not show a significant effect on HAZ. Children whose mothers are less than 157 cm and fathers are less than 168 cm have a significantly lower HAZ of 0.31 ($p < 0.01$) and 0.39 ($P < 0.01$), respectively, compared to their counterparts. Children with parents' BMI above 24 have approximately higher HAZ, but only at 10 % significance level.

5.3. The social determinants of child stunting

Based on Table 2 below, the HAZ of children with health insurance is roughly 0.21 higher than that of uninsured children at the 1 % significance level. What is more, higher levels of maternal education significantly reduce children's HAZ. In detail, the HAZ of children whose mother complete compulsory education (low-middle school) in China was 0.28 ($p < 0.01$) higher than that of children whose mothers are illiterate. Also, children whose mothers have vocational education have a greater and significant effect on children's HAZ than children whose mothers have upper middle school education, even though both have the same years of schooling. Mothers with primary education have the relatively small but significant effect by 0.17 on children's HAZ ($p < 0.01$). When the father's level of education, employment status and average working days per week are included in Model 2, whereas, father's education level is not significantly associated with children's HAZ.

In terms of mother's employment, children with mother participating in working have lower HAZ compared to children's mother without a job, and the impact is robust and significant after adjusting other factors ($p < 0.05$). Also, an average increase of one day of work per week for mothers is associated with an approximate 0.41 decrease in the HAZ of children ($p < 0.05$). The interaction term between mother's employment status and average working days shows a positive impact, indicating that increasing the number of mother's working days can lessen the deleterious impact of maternal employment on children's HAZ to some extent. However, this study does not find significant association of father's employment and average working days per week on children's HAZ.

Other social determinants, household per capita income is adjusted for inflation using 2015 as the baseline, and every ten thousand yuan increase, children's HAZ increase by approximately 0.15 ($p < 0.01$). Also, for household asset index, every one additional increase in household asset index, children's HAZ increases 0.29 ($p < 0.01$). The urbanization index has a significant and positive effect on the HAZ of the children. Specially, children residing medium ($p < 0.05$), higher ($p < 0.01$), and the highest levels ($p < 0.01$) of urbanization index tend to experience a significant increase in their HAZ values. Regionally, children living in west area have significantly lower HAZ than east area ($p < 0.01$), while, northeast area shows a higher HAZ in children under 5 ($p < 0.05$).

5.4. The determinants of child wasting

Based on Table 2 above, the demographic factors resulting in child wasting are age, mother's height, parents' BMI. Likewise, extending the analysis from Model 1, Model 2 introduces the inclusion of paternal socio-economic determinants in the regression. Minority and gender do not show a significant effect on WHZ. Children under five whose mother's height is less than 157 cm have a significant reduction in WHZ by 0.12 ($p < 0.01$) compared to their counterparts. Maternal malnutrition ($BMI<18.5$) is the main demographic factor that significantly affect child wasting. The WHZ of children whose mothers' BMI is less than 18.5 was 0.31 ($p < 0.01$) lower than that of children whose mothers' BMI is in the normal range. On the contrary, children with mothers whose BMI is above 24 exhibit a significantly higher WHZ compared to their peers ($p < 0.05$). While, father's height below 168 and father's underweight do not show a significant effect on children's wasting. Children with overweight father have higher average WHZ ($p < 0.01$).

5.5. The social determinants of child wasting

Among the social determinants, maternal employment, and average working days per week, the regional of residence, and whether living in urban area, are significant risk factors of child wasting. To be specific, mother's employment status is a significant risk factors of child wasting. Mothers with a job ($p < 0.05$) and additional working day ($p < 0.05$) make their children have about lower WHZ. However, the interaction term between maternal employment and average working days per week shows a positive impact ($p < 0.05$). Both model 3 controlling just for maternal variables and model 4 controlling for parental variables produced consistent findings. The WHZ of children living in the less developed western ($p < 0.01$) and central regions ($p < 0.01$) are significantly lower than children living in the highly developed eastern region by 0.63 and 0.22, respectively. Children living in the northeastern region is significantly lower than the eastern region at the 5 % significance level. Children living in rural area have lower WHZ compared to children living in urban area ($p < 0.01$).

6. Heterogeneity analysis

6.1. Social determinants of child stunting across regions

To examine heterogeneity, this study estimated the fixed effects models across regions, areas and gender disparities. Table 3 (details in supplementary tables) reports the results of the fixed effects regression of the social determinants of child stunting across regions. The association between social determinants and children's HAZ were virtually same with national level, however, significant social determinants vary across different regions. The protective factor of children's health insurance remains robust in eastern ($p < 0.05$), central ($p < 0.05$), and western regions ($p < 0.05$), while such a relationship is not observed in the northeast. Similarly, a higher maternal education level is a protective factor for children's HAZ in central and northeast area. Nonetheless, maternal education level in the east and the west, no significant associations were found. Similarly, the negative impact of maternal employment on children's HAZ is significantly observed only in the eastern region ($p < 0.05$). Moreover, the average weekly working days of mothers remains robustly significant in the western region ($p < 0.05$).

In both the eastern and western regions, families with higher asset index are associated with higher HAZ for their children, corroborating the consistent results at the national level data ($p < 0.01$). Similarly, the community urbanization index demonstrates significant robustness in the eastern at medium level ($p < 0.01$) as well as high levels ($p < 0.01$), while in the western region, higher level ($p < 0.01$) and highest ($p < 0.05$) levels of urbanization index still show robustness. In summary, in the more developed eastern regions, children's health insurance, maternal employment status, household asset index, and community urbanization index are significantly correlated with children's HAZ. In the less developed central regions, children's health insurance and maternal education level continue to act as protective factors for children's HAZ. In the less developed western regions, children's insurance, maternal average weekly working days, household asset index, and community urbanization index remain protective factors for children's HAZ. In the northeast region, maternal education level remains the most robust protective factor.

6.2. Social determinants of child stunting across areas

Table 4 (details in supplementary tables) reports the results of the fixed effects regression of the social determinants of child stunting across urban area and rural area. Within the urban-rural divide, the presence of children's health insurance remains robustly significant in both urban ($p < 0.05$) and rural areas ($p < 0.01$). Maternal education level in rural areas continues to be significant. Although there is a positive correlation between maternal education levels and children's HAZ in urban areas, it is not statistically significant. Maternal employment status and average weekly working days in rural areas still exhibit a negative correlation with children's HAZ, but only at the 10 % significance level. Per capita household income remains a favorable protective factor for increasing children's HAZ in rural areas ($p < 0.01$), but not significantly so in urban areas. On the other hand, the household asset index remains robustly significant in both urban ($p < 0.05$) and rural areas ($p < 0.01$). The community urbanization index in rural areas maintains a significant positive correlation with children's HAZ. Furthermore, in the western region, rural children have significantly lower HAZ compared to rural children in the eastern region ($p < 0.01$), while no regional disparities are found in urban areas. In summary, significant determinants associated with children's HAZ in urban areas are the presence of children's health insurance and household asset index. In rural areas, significant association of children's HAZ include children's health insurance, per capita household income, household asset index, community urbanization index, and living regions.

6.3. Social determinants of child stunting across gender

Table 4 (details in supplementary tables) also reports the results of the fixed effects regression of the social determinants of child stunting across gender. Within the gender disparities, regarding gender disparities, children's health insurance remains robustly significant for boys ($p < 0.01$), while for girls, it is only significant at the 10 % significance level. Maternal education level remains significant for both male and female children. While, maternal education at or above the level of low middle school can partially mitigate the negative impact of male gender preference within the family on girls' HAZ.

Maternal employment status ($p < 0.01$) and average weekly working days ($p < 0.01$) continue to be significantly negatively correlated with HAZ for female children, which is consistent with the robust results from the national-level data regression. However, no significant correlations are found among male children. Per capita household income, household asset index, the community urbanization development index, and living in a developed region remain favorable protective factors for both male and female children.

In summary, significant determinants associated with HAZ in male children include the presence of children's health insurance, maternal education, per capita household income, household asset index, community urbanization index, and region. For female children, significant correlates of HAZ include maternal education, maternal employment status, average weekly working days, per capita household income, household asset index, community urbanization index, and living regions.

6.4. Social determinants of child wasting across regions

Table 5 (details in supplementary tables) reports the results of the fixed effects regression of the social determinants of child stunting across regions, including east, central, west and north-east area. The association between social determinants and children's WHZ were virtually same with national level, however, significant social determinants vary across different regions.

Maternal education level was not identified as a protective factor for children's WHZ in the national-level data regression. However, when considering regional differences, maternal education at the upper-middle school level exhibits significant effects on children's WHZ in the eastern region ($p < 0.05$) and in the northeast region ($p < 0.01$). Similarly, the negative impact of maternal employment and average weekly working days on children's WHZ is only significantly observed in the western region ($p < 0.05$), while in other regions, no significant correlations between maternal employment and WHZ are found. Likewise, the community urbanization index demonstrates robust and significant correlations with WHZ in the eastern, central, and western regions.

In conclusion, in regions characterized by higher developmental levels in the eastern part, both maternal education level and the community urbanization development index exhibit significant correlations with children's WHZ. In less developed areas in the central region, the community urbanization development index continues to act as a protective factor for children's WHZ. In the more underdeveloped western regions, maternal employment status, average weekly working days, and the community urbanization development index remain significant factors correlated with children's WHZ. In the northeast region, maternal education level remains the most robust protective factor.

6.5. Social determinants of child wasting across areas

Table 6 (details in supplementary tables) reports the results of the fixed effects regression of the social determinants of child wasting across areas, including urban area and rural area. In the context of the urban-rural divide, only maternal employment status ($p < 0.01$) and average weekly working days ($p < 0.05$) were found to be significantly negatively correlated with children's WHZ in urban areas. Moreover, children's WHZ in urban areas of the western region was significantly lower than that of the eastern region ($p < 0.01$). Similarly, regional disparities were also evident in rural areas, with significant differences observed in the central region ($p < 0.01$), western region ($p < 0.01$), and northeast region ($p < 0.01$). In summary, significant factors related to children's WHZ in urban areas include maternal employment status, average weekly working days, and residential region. In rural areas, the significant factors mainly revolve around the residential region.

6.6. Social determinants of child wasting across gender

Table 6 also (details in supplementary tables) presents the outcomes of the fixed effects regression analyzing the impact of social determinants on child wasting across gender. Within the context of gender disparities, maternal employment status ($p < 0.01$) and average weekly working days ($p < 0.01$) were significantly negatively correlated with WHZ in female children, but no significant correlations were found in the case of male. The community urbanization index at a medium level ($p < 0.05$) exhibited a stable and significant correlation with WHZ in females, but no such significant correlations were identified in males. Regionally, both male and female children demonstrated noteworthy associations with their respective geographic areas. In conclusion, significant factors associated with WHZ in male children are linked to the residential region, while WHZ in female children is influenced by maternal employment, average weekly working time, urbanization index, and residential regions.

7. Discussion

7.1. Demographic determinants of child malnutrition outcomes

7.1.1. Age

The significant demographic determinants are the children's age, parent's height, and parental nutritional status. The first 1000 days of life is an important window of growth and development for children [6,50,58]. Once children miss the window of growth and development, the effects of CMO early in life are irreversible [9]. Concurrently, this vulnerable period amplifies their sensitivity to the environment [48]. Inadequate nutrition, together with illness and disease, are both interacting and limiting the children's growth and causing them more prone to be wasted and stunted.

7.1.2. Gender

In this study, the children's gender is not captured in the regression analysis of this study. This is attributed to the study's temporal domain, spanning from 1991 to 2015, a phase marked by the gradual reduction of gender-based disparities in CMO. Predominantly, boys tend to exhibit a heightened susceptibility to stunting and wasting [19,44,59]. This susceptibility is largely influenced by biological factors, with boys necessitating a greater intake of nutrients throughout their growth and developmental phases in contrast to girls [60]. However, because of China's cultural contexts of gender preference where boys are preferred and girls are discriminated, parents tend to advocate a greater portion of limited food supply to their male offspring when faced with family resource scarcity. As a result of this scenario, girls are more likely to be thin or short compared to boys.

7.1.3. Ethnicity

This study does not capture the significant impact of nationality and children's HAZ and WHZ. Most ethnic minority children inhabit in rural and remote mountainous areas where resources, living conditions and health services are relatively deficient. Additionally, mothers from ethnic minority groups tend to have lower levels of literacy [61]. Hence, this study has identified the place of residence to be significant. Moreover, specific ethnic minorities exhibit unique dietary patterns and child-feeding practices [62,63].

7.1.4. Parent's height and BMI

This study also shows consistent findings on the role of mother's height, father's height and parent's BMI in explaining the child malnutrition outcomes [44,46,48]. Genetic factors, notably linked to maternal height, significantly influence children's potential for growth [64]. Moreover, mothers who are underweight accounts for the most variations of children's HAZ and WHZ. Mothers being underweight during pregnancy can impede the child's growth as early as in the womb, causing poor birth outcomes and growth faltering in the following critical period [6]. To be specific, the interplay of growth restrictions, inadequate nutrition, and susceptible environment renders children vulnerable to illness and diseases. The combination of poor nutrition and diseases places children in a state of acute malnutrition, ultimately leading them into severe wasting [49].

7.2. Social determinants of child malnutrition outcomes

7.2.1. Health insurance

This study found that children with health insurance have better nutritional status, which is consistent with the findings of previous study [63]. Early access to health insurance can prevent children from entering a vicious cycle of growth restriction at an early age, as it enhances opportunities for preventive healthcare measures like immunizations and regular checkups, thus diminishing the risk of children contracting diseases [65]. Existing study has provided evidence that early participation in health insurance can have long-lasting effect on children's health, cognitive and school performance [66]. In addition, due to the substantial cost of medical services, the availability of health insurance alleviates the financial burden of on economically disadvantaged families, enabling their children to receive essential medical care [67].

7.2.2. Mother's education

In line with previous studies [19,46,59,64,68], this study reveals that children with mothers who have attained higher levels of education tend to exhibit higher HAZ compared to their counterparts with less educated mothers. The robust positive relationship between maternal education and a child's HAZ is striking, maternal education serves as an indicator of her knowledge in health and nutrition [61,63]. Hence, the higher the mother's education level, the better the child's health development in the family, where the mother is the primary caregiver for children under 5. Furthermore, heightened maternal education directly enhances family economic income, thereby fostering the growth and development of children. Also, educated mothers, equipped with health knowledge, are more inclined to utilize the available healthcare services [42]. Therefore, disparities in mothers' education levels significantly impact the extent to which healthcare resources contributes to children's health [61].

7.2.3. Mother's employment status

This study finds strong negative associations of maternal occupation status with children's HAZ and WHZ, respectively. Maternal employment contributes to augmented household income motivating mothers to allocate more resources toward products related to children's health [69]. Conversely, maternal employment can affect the amount of time spent caring for children, by reducing the time spent preparing food or allowing children to consume non-nutritious fast food [51,52]. It is worth noting that grandparents are more involved in child care in the context of the specific Chinese culture [70]. The influence of maternal employment on child health exhibits regional and country-specific variability. Meanwhile, the coefficient of the interaction term between mothers' working days and employment status is positive, suggesting that the negative effect of mothers having a job on children HAZ, and WHZ is significantly attenuated by the longer average weekly working days of mothers. This positive relationship is in line with previous studies [69,71].

7.2.4. Household per capita income

Children living in higher levels of household income have a higher HAZ. This finding is parallel with the previous studies [34–36, 40–42]. Additionally, the relationship between household income and children's HAZ exhibits regional variation, with the increase in household income in poor rural areas having the most pronounced improvement on improving children's HAZ. The augmented household income empowers families to allocate more financial resources to purchasing nutritious food items [61]. Additionally, it contributes to an enhancement in overall living conditions, encompassing the utilization of cleaner energy sources for cooking, upgrades in household appliances for better food storage and preservation, and the enhancement of sanitation facilities to prevent the incidence of infectious diseases.

7.2.5. Household asset index

The household asset index is mainly assessed by sanitation environment and household possessions. Environmental factors associated with children's CMO mainly include unimproved water supply, sanitation infrastructure, and the type of cooking fuel [58,72]. Inadequate sanitation has been reviewed as the second leading risk factor in East Asia and the Pacific area [73,74]. Research suggests that the effect of water quality on children's height is not significant, but there is a relationship between children's infections with intestinal diseases and water quality [75]. On contrary, it has been proven that exposure to indoors tap water has long-lasting effects on children [75,76]. Wasting in children is mainly caused by a combination of nutritional deficiencies and infection diseases [44]. Drinking clean and safe water directly reduces the risk of children contracting infectious diseases such as diarrhea and intestinal diseases [13,75–77]. Furthermore, adopting clean cooking methods, such as electricity, liquefied gas, and natural gas rather than coal can significantly reduce the indoor air pollution. Notably, indoors air pollution can cause respiratory infections and impair the development of growth, and increase the risks of cardiovascular disease and all-cause mortality. Household durables or properties have been shown to have a positive impact on children's health [78–80]. The presence of essential appliances in households serves to lower the risk of foodborne illnesses, which can partially contribute to child acute malnutrition. Additionally, other household fixed assets, such as air conditioning systems and vehicles, to some extent, serve as indicators of the family's income level.

7.2.6. Community determinants

The community urbanization index and the place of residence are among the protective factors for children's long-term nutritional health. Living in eastern region or urban area can be understood as the representative factors of elevated living standards, enhanced access to healthcare resources and more economically developed activities in their living environments, which are all beneficial for children's nutritional status.

8. Conclusion

This study investigates the social determinants of child nutritional status, with a particular focus on child stunting and wasting. This study employs the national representative panel data from CHNS 1991 to 2015, the period which witnessed the remarkable development of China's economy. There are over 4000 children included in this study. The results showed the risk factors of child stunting and wasting are robust in the all models. Genetic factors inherited from parents are the basic demographic determinants of CMO. The maternal social determinants such as, mother's education level and employment status are found to be the strongest and significant factors in influencing child stunting. It is concluded that the maternal employment status is a significant factor that influence child wasting except the demographic factors. However, this study discovers that the income effect of mothers' labor force involvement is significantly lower than the negative effect of decreasing child care time for children's stunting and wasting. On the contrary, there is no significant association between paternal social determinants with child stunting and wasting. Also, household characteristics are crucial to children's growth and development. The increase in per capita household income, and higher household asset index have significant impact on the long-term development of children. Geographically, living in the west areas contributes the same risk factor for child stunting and wasting. This study also finds that child living in urban areas and communities with higher urbanization index are the protective factors for child stunting.

From a microscopic perspective, children's proximal environment has a substantial influence on growth and development. The negative impact of mother employment on the health of children under the age of five is particularly severe. Work opportunities in China, particularly for mothers in disadvantaged areas, can only be acquired by migrating to major cities. Moreover, mothers who migrated to work are frequently denied official maternity insurance or benefits. The fierce labor market competitiveness and cultural context in China drive women to work as much as they can, lowering the amount of time available for childcare especially for those mothers working in local urban regions. The government of China might enact legislation to provide mothers who work outside with the same maternity benefits as those who are working in the cities. Government childcare facilities should be established near enterprises to make it simpler for working women to manage employment and childcare thus, enhancing feasibility. Simultaneously, the government should decrease the working hours of parents with young children.

The impact of children's distal environmental variables on nutrition cannot be overlooked from a macro perspective. China's widespread access to both electricity and water in rural regions, as well as the nine-year compulsory education program that has enhanced gender equality access to school, have had a profound impact on child wasting and stunting which other developing nations should emulate. To attain sustainable development goals, the Chinese government should prioritize lowering malnutrition and wasting among 5-year-old in the western region, particularly in impoverished regions. Despite the fact that the Chinese government has implemented several nutrition enhancement initiatives for students in compulsory education, the legal school entry age in China is six years old. Children under the age of five are facing their critical stage of growth and development, and therefore, the nutritional improvement for children under the age of five cannot be overlooked.

Data availability Statement

The datasets produced and analyzed during the present study can be accessed on the designated website provided: https://www.cpc.unc.edu/projects/china/.

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CRediT authorship contribution statement

Sa Li: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Norashidah Mohamed Nor:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Shivee Ranjanee Kaliappan:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

[1] J.K. Das, R.A. Salam, M. Saeed, F.A. Kazmi, Z.A. Bhutta, Effectiveness of interventions for managing acute malnutrition in children under five years of age in low-income and middle-income countries: a systematic review and meta-analysis, Nutrients 12 (1) (2020 Jan 1) 116.
[2] World health organization. Malnutrition [internet]. Who.int. World health organization: WHO, Available from: https://www.who.int/news-room/fact-sheets/detail/malnutrition, 2021.
[3] M. de Onis, F. Branca, Childhood stunting: a global perspective, Matern. Child Nutr. 12 (1) (2016 May) 12–26.
[4] H. Alderman, Long term consequences of early childhood malnutrition, Oxf. Econ. Pap. 58 (3) (2006 Apr 3) 450–474.
[5] J.J. Heckman, The economics, technology, and neuroscience of human capability formation, Proc. Natl. Acad. Sci. USA 104 (33) (2007 Aug 8) 13250–13255.
[6] R.E. Black, L.H. Allen, Z.A. Bhutta, L.E. Caulfield, M. de Onis, M. Ezzati, et al., Maternal and child undernutrition: global and regional exposures and health consequences, Lancet 371 (9608) (2008 Jan) 243–260.
[7] C.G. Victora, L. Adair, C. Fall, P.C. Hallal, R. Martorell, L. Richter, et al., Maternal and child undernutrition: consequences for adult health and human capital, Lancet 371 (9609) (2008 Jan) 340–357.
[8] A. Case, C. Paxson, Causes and consequences of early-life health, Demography 47 (S) (2010) S65–S85.
[9] K.G. Dewey, K. Begum, Long-term consequences of stunting in early life, Matern. Child Nutr. 7 (3) (2011 Sep 19) 5–18.
[10] J.M. Perkins, R. Kim, A. Krishna, M. McGovern, V.M. Aguayo, S.V. Subramanian, Understanding the association between stunting and child development in low- and middle-income countries: next steps for research and intervention, Soc. Sci. Med. 193 (101–109) (2017 Nov) 101–109.
[11] J.C. Wells, A.L. Sawaya, R. Wibaek, M. Mwangome, M.S. Poullas, C.S. Yajnik, et al., The double burden of malnutrition: aetiological pathways and consequences for health, Lancet 395 (10217) (2020 Jan) 75–88.
[12] C.G. Victora, F.P. Hartwig, L.P. Vidaletti, R. Martorell, C. Osmond, L.M. Richter, et al., Effects of early-life poverty on health and human capital in children and adolescents: analyses of national surveys and birth cohort studies in LMICs, The Lancet [Internet] 399 (10336) (2022 Apr 30), 1741–52. Available from: https://www.sciencedirect.com/science/article/pii/S0140673621027161.
[13] G. Fink, E. Peet, G. Danaei, K. Andrews, D.C. McCoy, C.R. Sudfeld, et al., Schooling and wage income losses due to early-childhood growth faltering in developing countries: national, regional, and global estimates, The American Journal of Clinical Nutrition [Internet] (2016). Jun 29[cited 2020 Oct 16];104(1): 104–112. Available from: https://academic.oup.com/ajcn/article, 104/1/104/4633919.
[14] M.E. McGovern, A. Krishna, V.M. Aguayo, S. Subramanian, A review of the evidence linking child stunting to economic outcomes, Int. J. Epidemiol. 46 (4) (2017 Mar 30) 1171–1191.
[15] Women and children's working committee of the state council. Programme for the development of Chinese women and Children_Women and children working committee of the state council [internet]. www.nwccw.gov.cn, 2021. https://www.nwccw.gov.cn/node_2439.htm [cited 2023 May 12]. Available from:.
[16] United nations children's fund, world health organization, world bank group. UNICEF/WHO/The world bank group joint child malnutrition estimates: levels and trends in child malnutrition: key findings of the 2021 edition [internet]. www.who.int.2021. https://www.who.int/publications/i/item/9789240025257. Available from:.
[17] United Nations Children's Fund. Improving child nutrition: the achievable imperative for global progress - world, ReliefWeb [Internet]. reliefweb.int. 2013 [cited 2023 Mar 17]. Available from: https://reliefweb.int/report/world/improving-child-nutrition-achievable-imperative-global-progress?gclid=Cj0KCQjwn9CgBhDjARIsAD15h0BSb9qzV3WRMRFHtsHDhP1b7SAOx72f_KFA-B7QzkMzQ_21JQH-igaAkCKEALw_wcB.
[18] B. Yang, X. Huang, Q. Liu, S. Tang, M. Story, Y. Chen, et al., Child nutrition trends over the past two decades and challenges for achieving nutrition SDGs and national targets in China, Int. J. Environ. Res. Publ. Health 17 (4) (2020 Feb 11) 1129.
[19] L. Pei, L. Ren, H. Yan, A survey of undernutrition in children under three years of age in rural Western China, BMC Publ. Health 14 (1) (2014 Feb 5).
[20] D.M. Yu, L.Y. Zhao, Z.Y. Yang, S.Y. Chang, W.T. Yu, H.Y. Fang, et al., Comparison of undernutrition prevalence of children under 5 Years in China between 2002 and 2013. Biomedical and environmental sciences: BES [internet], Mar 1 [cited 2023 Mar 27];29(3):165–76. Available from: https://pubmed.ncbi.nlm.nih.gov/27109127/#:~:text=Results%3A%20The%20results%20indicated%20the, 2016.
[21] K. Chen, C. Liu, X. Liu, Z. Wang, R. Luo, S. Li, et al., Nutrition, cognition, and social emotion among preschoolers in poor, rural areas of south Central China: status and correlates, Nutrients 13 (4) (2021 Apr 16) 1322.
[22] China's state council. Notice of the general office of the state council on the issuance of the national nutrition plan (2017-2030) (guo ban fa [2017] No. 60) _Government information disclosure column [internet]. www.gov.cn, 2017. http://www.gov.cn/zhengce/content/2017-07/13/content_5210134.htm. Available from:.
[23] X. Huang, B. Yang, Q. Liu, R. Zhang, S. Tang, M. Story, Improving maternal and child nutrition in China: an analysis of nutrition policies and programs initiated during the 2000–2015 Millennium Development Goals era and implications for achieving the Sustainable Development Goals, J. Health Popul. Nutr. 39 (1) (2020 Dec).
[24] M.M. Black, C.K. Lutter, A.C.B. Trude, All children surviving and thriving: re-envisioning UNICEF's conceptual framework of malnutrition, Lancet Global Health 8 (6) (2020 Jun) e766–e767.
[25] L. Ban, S. Guo, R.W. Scherpbier, X. Wang, H. Zhou, L.J. Tata, Child feeding and stunting prevalence in left-behind children: a descriptive analysis of data from a central and western Chinese population, Int. J. Publ. Health 62 (1) (2016 Jun 18) 143–151.
[26] A. Wang, R.W. Scherpbier, X. Huang, S. Guo, Y. Yang, J. Josephs-Spaulding, et al., The dietary diversity and stunting prevalence in minority children under 3 years old: a cross-sectional study in forty-two counties of Western China, Br. J. Nutr. 118 (10) (2017 Nov 28) 840–848.
[27] D. Tang, T. Bu, Y. Liu, X. Dong, The impact of mothers' dietary patterns on children's nutritional status in China, Am. J. Health Behav. 44 (5) (2020 Sep 1) 719–731.
[28] G. Fink, I. Günther, K. Hill, The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007, Int. J. Epidemiol. 40 (5) (2011 Jun 30) 1196–1204.
[29] K.R. Smith, J.P. McCracken, M.W. Weber, A. Hubbard, A. Jenny, L.M. Thompson, et al., Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial, Lancet 378 (9804) (2011 Nov) 1717–1726.
[30] P. Braveman, L. Gottlieb, The social determinants of health: it's time to consider the causes of the causes. Public health reports [internet], Jan 1;129(2):19–31. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3863696/, 2014.
[31] N. Bharmal, Kathryn Pitkin Derose, M. Felician, M.M. Weden, Rand health. Understanding the upstream social determinants of health [internet], Available from: https://www.rand.org/content/dam/rand/pubs/working_papers/WR1000/WR1096/RAND_WR1096.pdf, , 2015.

[32] M. Marmot, S. Friel, R. Bell, T.A. Houweling, S. Taylor, Closing the gap in a generation: health equity through action on the social determinants of health, Lancet 372 (9650) (2008 Nov) 1661–1669.
[33] M. Marmot, J. Allen, R. Bell, E. Bloomer, P. Goldblatt, WHO European review of social determinants of health and the health divide, Lancet 380 (9846) (2012 Sep) 1011–1029.
[34] H.J. Wong, F.M. Moy, S. Nair, Risk factors of malnutrition among preschool children in Terengganu, Malaysia: a case control study, BMC Public Health [Internet] (1) (2014 Aug 3) 14. Available from: https://bmcpublichealth.biomedcentral.com/articles, 10.1186/1471-2458-14-785.
[35] L. Wu, Z. Yang, S.A. Yin, M. Bs, H. Gao, The relationship between socioeconomic development and malnutrition in children younger than 5 years in China during the period 1990 to 2010. Asia Pac J Clin Nutr [Internet] [cited 2020 Aug 15];24(4):665–73. Available from: http://apjcn.nhri.org.tw/server/APJCN/24/4/665.pdf, 2015.
[36] Y. Chen, X. Lei, L.A. Zhou, Does raising family income cause better child health? Evidence from China, Econ. Dev. Cult. Change 65 (3) (2017 Apr) 495–520.
[37] H.Y. Berhane, M. Jirström, S. Abdelmenan, Y. Berhane, B. Alsanius, J. Trenholm, et al., Social stratification, diet diversity and malnutrition among preschoolers: a survey of addis ababa, Ethiopia. Nutrients [internet], Mar 1[cited 2020 Nov 28];12(3):712. Available from: https://www.mdpi.com/2072-6643/12/3/712, 2020.
[38] J. Karpati, C. Neubourg, A. Laillou, E. Poirot, Improving children's nutritional status in Cambodia: multidimensional poverty and early integrated interventions, Matern. Child Nutr. 16 (S2) (2020 Jul 4).
[39] S. Kureishy, G.N. Khan, S. Arrif, K. Ashraf, A. Cespedes, M.A. Habib, et al., A mixed methods study to assess the effectiveness of food-based interventions to prevent stunting among children under-five years in Districts Thatta and Sujawal, Sindh Province, Pakistan: study protocol, BMC Publ. Health 17 (1) (2017 Jan 5).
[40] C.Y. Wong, M.S. Zalilah, E.Y. Chua, S. Norhasmah, Y.S. Chin, A. Siti Nur'Asyura, Double-burden of malnutrition among the indigenous peoples (Orang Asli) of Peninsular Malaysia, BMC Publ. Health 15 (1) (2015 Jul 21).
[41] V.D. Kien, H.Y. Lee, Y.S. Nam, J. Oh, K.B. Giang, H.V. Minh, Trends in socioeconomic inequalities in child malnutrition in vietnam: findings from the multiple indicator cluster surveys, 2000–2011, Glob. Health Action 9 (1) (2016 Mar), 29263.
[42] A.M. Asif, M. Akbar, On the decomposition of rank-dependent indicator of socio-economic inequalities in child malnutrition: some empirical findings, Socio-Economic Planning Sciences. 2021 Jan 77 (2021), 101025, 1-7(0038-0121, ZDB-ID 208905-1.).
[43] H. Ameye, J. De Weerdt, Child health across the rural–urban spectrum, World Dev. 130 (104950) (2020 Jun), 104950.
[44] J.L. Blankenship, J. Cashin, T.T. Nguyen, H. Ip, Childhood stunting and wasting in Myanmar: key drivers and implications for policies and programmes, Matern. Child Nutr. 16 (S2) (2020 Aug 24), e12710.
[45] M. Yao, L. Li, M. Yang, Y. Wu, F. Cheng, Household air pollution and childhood stunting in China: a prospective cohort study, Frontiers in Public Health [Internet] (2022). Oct 21[cited 2022 Dec 13];10 (6):e1001455. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/. PMC9650942IF: 5.2 Q1 B3IF: 5.2 Q1 B3/.
[46] F. Habyarimana, Key determinants of malnutrition of children under five years of age in Rwanda: simultaneous measurement of three anthropometric indices, Afr. Popul. Stud. 30 (2) (2016 May).
[47] N. Joshi, B. Bolorhon, I. Narula, S. Zhu, S. Manaseki-Hollan, Social and environmental determinants of child health in Mongolia across years of rapid economic growth: 2000-2010, Int. J. Equity Health 16 (1) (2017 Oct 30).
[48] A.A. Yirga, H.G. Mwambi, D.G. Ayele, S.F. Melesse, Factors affecting child malnutrition in Ethiopia, African Health Sciences [Internet] 19 (2) (2019 Jun 1) 1897.–909. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6794502/.
[49] W. Khatun, S. Rasheed, A. Alam, T.M. Huda, M.J. Dibley, Assessing the intergenerational linkage between short maternal stature and under-five stunting and wasting in Bangladesh, Nutrients 11 (8) (2019 Aug 7) 1818.
[50] H. Kismul, P. Acharya, M.A. Mapatano, A. Hatløy, Determinants of childhood stunting in the democratic republic of Congo: further analysis of demographic and health survey 2013–14, BMC Publ. Health 18 (1) (2017 Aug 1).
[51] A.S. Rashad, M.F. Sharaf, Does maternal employment affect child nutrition status? New evidence from Egypt, Oxf. Dev. Stud. 47 (1) (2018 Jul 23) 48–62.
[52] M.Z. Hosen, M.H. Pulok, M. Hajizadeh, Effects of maternal employment on child malnutrition in South Asia: an instrumental variable approach, Nutrition 105 (2023 Jan), 111851.
[53] P. Nie, A. Sousa-Poza, Maternal employment and childhood obesity in China: evidence from the China Health and Nutrition Survey, Appl. Econ. 46 (20) (2014 Mar 27) 2418–2428.
[54] N. Zozaya, J. Oliva-Moreno, L. Vallejo-Torres, Association between maternal and paternal employment and their children's weight status and unhealthy behaviours: does it matter who the working parent is? BMC Publ. Health 22 (1) (2022 Jul 12).
[55] The World Bank. Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate) - China | Data [Internet]. data.worldbank.org, Available from: https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS?locations=CN, 2022.
[56] World Health Organization. WHO child growth standards : head circumference-for-age, arm circumference-for-age, triceps skinfold-for-age and subscapular skinfold-for-age : methods and development [Internet]. apps.who.int, Available from: https://apps.who.int/iris/handle/10665/43706, , 2007.
[57] U. Jonsson, Nutrition and the united nations convention on the rights of the child [internet]. UNICEF-IRC [cited 2023 May 12]. Available from: https://www.unicef-irc.org/publications/130-nutrition-and-the-united-nations-convention-on-the-rights-of-the-child.html#:~:text=Nutrition%20is%20mentioned%20specifically%20only, 1993.
[58] M. Hossain, N. Choudhury, K. Adib Binte Abdullah, P. Mondal, A.A. Jackson, J. Walson, et al., Evidence-based approaches to childhood stunting in low and middle income countries: a systematic review, Arch. Dis. Child. 102 (10) (2017 May 3) 903–909.
[59] S.H. Quamme, P.O. Iversen, Prevalence of child stunting in Sub-Saharan Africa and its risk factors, Clinical Nutrition Open Science 42 (2022 Apr) 49–61.
[60] T. Khara, M. Mwangome, M. Ngari, C. Dolan, Children concurrently wasted and stunted: a meta-analysis of prevalence data of children 6–59 months from 84 countries, Matern. Child Nutr. (2) (2017 Sep 25) 14.
[61] H. Li, S. Yuan, H. Fang, G. Huang, Q. Huang, H. Wang, et al., Prevalence and associated factors for stunting, underweight and wasting among children under 6 years of age in rural Hunan Province, China: a community-based cross-sectional study, BMC Publ. Health (1) (2022 Mar 11) 22.
[62] A. Wang, R.W. Scherpbier, X. Huang, S. Guo, Y. Yang, J. Josephs-Spaulding, et al., The dietary diversity and stunting prevalence in minority children under 3 years old: a cross-sectional study in forty-two counties of Western China, Br. J. Nutr. 118 (10) (2017 Nov 28) 840–848.
[63] Y. Zhang, X. Huang, Y. Yang, X. Liu, C. Yang, A. Wang, et al., Double burden of malnutrition among children under 5 in poor areas of China. Sartorius B, editor, PLoS One 13 (9) (2018 Sep 17), e0204142.
[64] Y. Wu, Z. Guo, An analysis of the nutritional status of left-behind children in rural China and the impact mechanisms of child malnutrition, Child. Youth Serv. Rev. 119 (2020 Dec), 105598.
[65] A. Finkelstein, S. Taubman, B. Wright, M. Bernstein, J. Gruber, J.P. Newhouse, et al., The Oregon health insurance experiment: evidence from the first year, The Quarterly Journal of Economics [Internet] 127 (3) (2012 Jul 14) 1057–1106. Available from: https://academic.oup.com/qje/article/127/3/1057/1923446.
[66] W. Huang, H. Liu, Early childhood exposure to health insurance and adolescent outcomes: evidence from rural China, J. Dev. Econ. 160 (2023 Jan), 102925.
[67] X. Peng, D. Conley, The implication of health insurance for child development and maternal nutrition: evidence from China, Eur. J. Health Econ. 17 (5) (2015 May 30) 521–534.
[68] T.R. Chowdhury, S. Chakrabarty, M. Rakib, S. Saltmarsh, K.A. Davis, Socio-economic risk factors for early childhood underweight in Bangladesh, Globalization and Health [Internet] 14 (1) (2018 May 30). Available from: https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-018-0372-7.
[69] T.W. Morrissey, R.E. Dunifon, A. Kalil, Maternal employment, work schedules, and children's body mass index, Child Dev. 82 (1) (2011 Jan) 66–81.
[70] J. Yu, Z. Zhang, Does living with grandparents affect children's and adolescents' health? Evidence from China, Int. J. Environ. Res. Publ. Health 18 (22) (2021 Nov 13), 11948.
[71] K.M. Ziol-Guest, R.E. Dunifon, A. Kalil, Parental employment and children's body weight: mothers, others, and mechanisms, Soc. Sci. Med. 95 (2013 Oct) 52–59.

[72] J.H. Rah, S. Sukotjo, N. Badgaiyan, A.A. Cronin, H. Torlesse, Improved sanitation is associated with reduced child stunting amongst Indonesian children under 3 years of age, Matern. Child Nutr. 16 (S2) (2020 Aug 24), e12741.
[73] W.J. Martin, R.I. Glass, H. Araj, J. Balbus, F.S. Collins, S. Curtis, et al., Household air pollution in low- and middle-income countries: health risks and research priorities, PLoS Medicine [Internet] 10 (6) (2013 Jun 4), e1001455. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3672215/.
[74] G. Danaei, K.G. Andrews, C.R. Sudfeld, G. Fink, D.C. McCoy, E. Peet, et al., Risk factors for childhood stunting in 137 developing countries: a comparative risk assessment analysis at global, regional, and country levels, 11, in: J.K. Tumwine (Ed.), PLOS Medicine [Internet], vol. 13, 2016 Nov 1, e1002164. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5089547/.
[75] T. Wu, H. Shi, J. Niu, X. Yin, X. Wang, Y. Shen, Distance to water source in early childhood affects growth: a cohort study, Publ. Health 193 (2021 Apr) 139–145.
[76] M. Harris, M.L. Alzua, N. Osbert, A. Pickering, Community-level sanitation coverage more strongly associated with child growth and household drinking water quality than access to a private toilet in rural Mali, Environmental Science & Technology 51 (12) (2017 Jun) 7219–7227.
[77] V.M. Aguayo, P. Menon, Stop stunting: improving child feeding, women's nutrition and household sanitation in South Asia, Matern. Child Nutr. 12 (2016 May) 3–11.
[78] I. Tewari, Y. Wang, Durable ownership, time allocation and female labor force participation: evidence from China's "home appliances to the countryside" rebate, Econ. Dev. Cult. Change 70 (1) (2019 Oct 11).
[79] O. Karlsson, R. Kim, W. Joe, S.V. Subramanian, The relationship of household assets and amenities with child health outcomes: an exploratory cross-sectional study in India 2015–2016, SSM - Population Health 10 (2020 Apr), 100513.
[80] J. Shi, F. Wang, H. Wang, The effect of household technology on child health: evidence from China's "home appliances going to the countryside" policy, Int. J. Environ. Res. Publ. Health 19 (19) (2022 Sep 22), 11976.