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Research article

Do maternal socioeconomic status influence child overweight?

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ABSTRACT

The prevalence of overweight among Chinese children under 5 years of age has been increasing steadily. Using data from China Health and Nutrition Survey (CHNS) spanning from 1991 to 2015, this study investigates the relationship between maternal employment status, maternal education level, and the prevalence of child overweight among Chinese children under 5 years old. The findings indicate that having mothers with low middle school education significantly reduces their children's body mass index z-scores (BMIZ) ($p < 0.05$). However, no significant association is observed between maternal education level and childhood overweight in urban areas. In rural areas, only when the maternal education level is college or above, there is a significant increase in BMIZ ($p < 0.01$). The impact of maternal education level on childhood obesity is influenced by household per capita income, and when household per capita income reaches a certain level, higher maternal education is negatively associated with child BMIZ. The study also reveals a significant negative association between maternal employment ($p < 0.01$) , average weekly working days ($p < 0.01$), and the BMIZ of children under 5 years of age, while the interaction effect between them is positive and significant. This study has recommended some policy interventions, by promoting parental education on child feeding and parenting, providing professional child care, and offering financial subsidies to families with children under 5.

1. Introduction

Childhood overweight was once considered a public issue in developed countries, but now it has emerged as a health threat in low and middle-income countries [1–6]. Despite its frequent association with excessive energy intake, this surplus of energy is not beneficial for the children potential growth. Instead, it signifies hidden malnutrition or dietary imbalances among children [4,7,8]. Drawing upon the life course model employed in the longitudinal studies [9], childhood overweight has multifaceted effects that extend beyond the immediate years, which influence health, academic performance and psychological welfare in the child life cycle. Consequently, it poses a long-term risk for premature mortality and non-communicable chronic diseases such as cardiovascular ailments in adulthood [3–6,10]. Guided by the principles outlined in Sustainable Development Goal 3 (SDG 3) which seeks to attain a state of good health and well-being for the whole population, the Chinese government initiated the Program for the Development of Chinese Children 2017–2030. This strategic initiative is formulated to overcome the escalating concern of childhood overweight and obesity, which potentially can prevent future non-communicable diseases [11]. In light of the accelerated aging issue of the Chinese population and the decreasing birth rates, there is a compelling need to prioritize the current health status of children. This is crucial as the contemporary health status of individuals carries profound ramifications for the accumulation of future human capital and the

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Abbreviations

CHNS	China Health and Nutrition Survey
BMI	body mass index
BMIZ	BMI-for-age z score
SDG3	Sustainable Development Goal 3
WHO	World Health Organization
SD	Standard Deviation
PCA	Principal component analysis
FCT	China Food Composition Table

overall economic progress of the nation [5,8,12–15].

A global estimate of 38.2 million children under 5 are classified as overweight or obese [5]. China has taken a prominent position in the global landscape of childhood overweight and obesity, which heighten its concern. Reported statistics highlight the severity of the issue, with childhood overweight cases surging by approximately 88.9 %, accompanied by more than twofold increase in obesity rates [16]. Among children under the age of six, the overweight rate rose from 6.5 % to 8.4 % between 2002 and 2012, while the obesity rate increased from 2.7 % to 3.1 % during the same period [17]. It is projected that without effective control measures, the prevalence of obesity on children under the age of 7 will reach 6 %, accounting for approximately 6.64 million children [18]. Regionally, the increase in the rates of overweight among suburban children is worrying as it surpassed the rate observed among urban children [19]. China's ongoing economic development has yielded significant improvements across various socio-economic dimensions. Per capita disposable income has risen from 9000 yuan per capita in 1990 to 36,900 yuan in 2022 [20]. According to World Bank development indicators, although China's female labor force participation rate has gradually decreased from 73.2 % in the 1990s to 61 % in 2021, it still exceeds the global average [21]. However, the enrollment rate of female in higher education exhibited a remarkable upward trajectory, surging from 14 % in 2003 to 69 % in 2021, marginally exceeding the male enrollment rate of 59 % [22]. When delving into the study of child health, the significance of maternal education and employment as the foremost socioeconomic determinants is justifiable. The existing body of research has shown that the prevalence of childhood overweight and obesity is rising and spreading across various strata of social standing, with notably steeper increments in segments of higher socioeconomic status in contrast to their counterparts in lower socioeconomic status [23].

A substantial population of obese children has become a pressing public health threat in China. Research on the socioeconomics determinants of obesity have gained attention but most of the studies are confined to certain regions, specific provinces or individual municipalities [24–28]. The research done has mostly concentrated on obesity among school-aged children and adolescents, which leave a glaring gap in the examination of early intervention phase for children under the age of 5. Parallel to the remarkable educational achievements and sustained labor force engagement of Chinese women on a global scale, it is imperative to recognize the dual roles of mothers as working professional and higher educational achievements, and the cultural expectation imposed on them to execute domestic chores and childcare. For contemporary young mothers, they are not only expected to serve as one of the family's economic providers but they also have to coordinate their children's daily routines and educational management, extending beyond the realm of childrearing [29]. In light of these cultural dynamics, this study places its focus on the relationship between the socioeconomic status of mothers' education and their occupation on the impact of overweight in Chinese children under 5 years of age. In this study, the association between mothers' education levels and employment status on the child overweight problem is investigated, which is then moderated by key household economic status characteristics such as: per capita household income and average number of days worked per week.

There has been a considerable amount of international research on the socioeconomic determinants of childhood overweight but majority lacks conclusive findings. Until now, empirical studies on childhood overweight in China are still limited, particularly related to children under 5. Due to the scarcity of such studies, this research offers crucial evidence on the interaction effects of maternal education level and household per capita income, as well as maternal employment status and their average workdays per week. The results of this research would provide valuable insights which are relevant to other developing nations facing nutritional challenges and for the Chinese government, this study offers policy implications in mitigating childhood overweight problems.

2. Literature review

Currently, many developed nations have been actively conducting research which are grounded in the ecosystem theory of childhood overweight or obesity. These investigations primarily seek to elucidate the interplay between socio-economic stratification in the environments where children reside and the prevalence of obesity [3,9,30–37]. The theoretical framework of this study emphasizes that childhood overweight is the outcome of intricate interactions among multiple factors. Apart from the genetic impacts arising from the child's prenatal and early-life development, this study looks into a range of ecological environmental elements affecting children. These environmental elements incorporate micro-level household-related factors within the domains of parental [38,39] and community influence [24], all of which exhibit social gradients. Having said that, the family environment plays a pivotal role in shaping health behaviors related to childhood obesity, starting from the early stages of the child's life and until they attain adulthood [9,15,34]. The family constitutes the most immediate being in supplying resources to children, especially for those under

the age of five. Families with higher incomes tend to adopt healthier behaviors such as; making healthier food choices, allocating more time for physical activity and having greater access to better healthcare, all of which contribute to lower BMI in children [36,37]. Within this familial context, mothers as the primary caregivers in a family setting tend to exert a direct influence on their children's dietary choices, physical activity, screen time, sleep patterns, and other health-related habits that contribute to the risk of childhood obesity [40–44]. It is reported that in majority countries, mothers predominantly assume the key role of establishing a conducive family dietary environment and shaping behaviors which exerts a certain influence over their children's food preferences and consumption practice [44]. Thus, maternal education has a crucial impact in caregiving because mothers with higher education levels tend to have better health knowledge and possess greater access to healthcare services [45]. On the contrary, if mothers have lower nutritional knowledge, their children are more likely to be exposed to the consumption of energy-dense foods and sugary beverages, which can lead to excess intake of total energy and fat. This in turn, contributes towards a diminished preference for healthy dietary choices and promotes unhealthy lifestyles [43].

Based on the discussion above, it is evident that maternal feeding knowledge and lifestyle tend to be significantly affected by socioeconomic factors. This is supported by prior investigations which have established a connection between childhood overweight and socioeconomic determinants [23,24,45–50]. The literature review has thoroughly explored the correlation between socioeconomic status and overweight, uncovering diverse patterns of influence across distinct levels of national income [51–55]. Specifically, children in high-income countries with low maternal education and low household income are at higher risk of overweight [45,56–59]. However, the impact of socioeconomic status on childhood obesity in developed countries may not be directly applicable to developing nations that are currently undergoing nutritional transition. Research conducted in other middle-to low-income countries suggests a different trend, where children with mothers having higher levels of education and greater family incomes might exhibit increased body weight and a higher likelihood of overweight [48,60]. In economically disadvantaged nations, although increased maternal education and higher household income have been identified as factors associated with a decreased likelihood of childhood undernutrition, but their influence on diminishing the potential for overnutrition is not uniformly observed [61]. Given the interdependency between maternal education and family income, the impact of these factors on childhood overweight cannot be assumed to be independent. Higher wealth status is a risk factor for childhood overweight, especially when children have mothers with lower levels of education [31].

The mechanism between maternal employment and child overweight has been extensively studied in developed countries [62–68] but results are inconsistent. In theory, the impact of maternal employment on childhood overweight is primarily constrained by the interaction of family resources and time allocation. Present studies mostly revolve around variations stemming from how the association between maternal employment's financial implications and temporal effects intersects with childhood obesity, mainly across different income levels in various countries. Maternal employment not only has the potential to bolster family income, but it also empowers mothers to afford higher-quality nutritious food for their children [64]. As a result, working mothers are more inclined to invest in their children's health, for example, by obtaining insurance coverage that enhances their access to healthcare services [44]. However, in developing countries, the extent to which maternal income growth influences child overweight can vary. In situations where mothers are engaged in informal employment or physically demanding agricultural work, modest salary increments restrict their capacity to acquire energy-dense foods, thus partially fostering a healthier trajectory for child development. Yet, when wage growth exceeds a certain threshold, mothers are more prone to opt for easily accessible processed foods, thereby elevating the risk of child overweight [44].

Employed mothers face challenges in terms of dedicating time to child care and preparing nutritious meals [65], particularly for younger infants who rely on breastfeeding and need close attention. The adverse impact of maternal employment on children depends on the mothers' working hours. In other words, the risk of childhood obesity associated with prolonged maternal working hours could potentially be offset if high-quality childcare from other caregivers or institutions is available. Empirical evidence has demonstrated that regardless of whether mothers are working full-time, part-time, or non-standard work schedules, there is a positive correlation between longer maternal working hours and the increased risk of childhood obesity [15,40,64].

In some developed countries, children with mothers engaged in longer working hours tend to rely more on childcare facilities. However, lower childcare quality can easily expose children to high-calorie and nutritionally poor food options [40]. As a result of mothers who are obliged to work and are unable to supervise the children's diet, this situation will lead to increased exposure to fast food, sugary beverages, and prepared (instant) foods. Maternal employment can also influence the children's weight through the modification of their dietary habits and lifestyle, which includes infrequent or irregular family meals, late bedtimes, and increased engagement in prolonged sedentary activities, such as extended screen time [63,65,68]. The challenging full-time employment can limit the time available for physical activity among working women, hence, indirectly contributing to childhood obesity. Children of physically active mothers are more likely to engage in moderate-intensity exercise and have a lower probability of being overweight. However, in European countries like Denmark, there is little evidence available to support any link between maternal employment and childhood obesity, dietary habits, physical activity or screen time [66,69,70]. The availability of high-quality formal childcare services and adequate paid parental leave in European countries, can mitigate the risk of child obesity resulting from reduced maternal care time. Nonetheless, the effects of maternal employment on childhood obesity vary across nations as discovered in many studies.

3. Materials and methods

3.1. Data source

Data for this study were collected from China Health and Nutrition Survey (CHNS) which was conducted by Chinese Center for

Disease Control and Prevention's Institute of Nutrition and Food Safety in collaboration with the State of North Carolina Population Center in the United States. They utilized a multi-stage stratified sampling approach for a span of 26 years with ten rounds of data collection. CHNS has captured the changing landscape of China's economic development and the prevalence of childhood overweight rates, thus, making it a representative and valuable national health study. It covered a wide geographical range, including economically developed eastern provinces as well as central and western provinces with varying levels of development. The provinces were categorized into high, medium, and low economic growth groups and counties were weighted based on income levels. CHNS database provides comprehensive data that allows the examination of socioeconomic determinants of childhood obesity at community-level, family-level and individual-level. The database covers various aspects such as demographic information, socioeconomic factors, dietary consumption, and anthropometric measurements.

CHNS launched its initial survey in 1989 and thereafter, continued with nine subsequent waves, conducted at an average interval of approximately three years with the latest data released in 2015. Initially, the survey included nine provinces across the eastern, central, and western regions of China. Starting from 2011 onwards, three municipalities, Beijing, Shanghai, and Chongqing, were also included in CHNS sampling. The number of individuals and households in the samples exhibited slight variations in each survey round. In the most recent survey wave, CHNS expanded its scope to encompass 7200 households and over 30,000 individuals. This study specifically focuses on the critical developmental phase of children aged 0 to 5. Nevertheless, the 1989 survey round is excluded from this study due to missing data, thereby, limiting the investigation to the years from 1991 to 2015. After removing missing values for certain variables, the study sample size comprises 4429.

3.2. Dependent variable

The dependent variable in this study is child overweight, which is measured using the BMI-for-age z score (BMIZ) based on WHO 2007 Child Growth Standard [71]. The weight and height of children under 5 years of age were measured by the professional staff during the health examination procedure. BMIZ score was calculated using "zanthro" function in STATA version 17.0 based on height in centimeters, weight in kilogram, gender and age in years. To ensure data quality, missing key information and extreme BMIZ values ($<$-5 or $>$5) were excluded from the analysis. BMIZ is a continuous variable for children with BMI-for-age z score over one standard deviation (BMIZ $>$ median 1SD) are considered as at the risk of overweight.

3.3. Independent variables

The primary independent variables in this study are the maternal education level and employment status. Maternal education level is assessed based on a specific question asked in CHNS questionnaires: "the highest level of education you have attained". The education level is categorized into six groups: non-educated, primary, low-middle school, upper middle school, vocational school, and college and above. In this study, vocational school level is considered equivalent to upper middle school. Due to the small number of individuals with master's degrees or higher in the sample, the categories of college degree and master's degree or higher are consolidated into one category denoted as "college and above". Additionally, the study also examined the interaction effect between the mother's education level and household per capita income level. The household per capita income was adjusted to account for inflation using 2015 as the reference year and the income levels were then classified into five tiers: lowest, lower, medium, higher, and highest. The mother's employment status in CHNS survey is retrieved through the question; "Are you presently working?" with response options coded as: 1 for "yes" and 0 for "no." In addition, the study investigates the interaction effect between the mother's employment status and the number of days worked per week. The question related to the mother's working days asks about the average number of days worked in a week and is measured as a continuous variable.

Table 1
The main variables' definition between maternal socioeconomic status and child overweight.

Determinants	Variables	Definitions
Household determinants	Maternal education level	Categorized as non-educated, primary school, low middle school, upper middle school, vocational, college and above.
	Maternal employment	Whether she is currently employed.
	Household per capita income	Categorized into 5 quintiles: lowest, lower, medium, higher, highest, and they are adjusted to account for inflation using the reference year 2015.
	Household asset index	The physical assets of the household, such as the presence of a vehicle, refrigerator, air conditioner and other sanitary equipment: whether the household's drinking water is indoor or not; and the presence of feces in the vicinity of the household, which are synthesized into a single indicator using PCA.
Community determinants	Region	Classification of areas of residence into eastern; central region; western region; north-eastern region.
	Living area	Classification of areas of residence into urban and rural area.
	Urbanization index	Including population density, economic engagement, market accessibility, transportation availability, healthcare provisions, communication infrastructure, housing quality, and social service availability within a community, calculated by CHNS.

Note: Variables are selected from the database of CHNS's questionnaires. PCA means principal component analysis.

Table 2
Descriptive Data and ANOVA analysis: determinants of child overweight.

Variables		BMIZ		
	N (%)/Mean ± SD	Mean	SD	P value
Total sample	4429 (100 %)			
Child characteristics				
Children's age	2.91 ± 1.65			0
0	467 (10.54)	2.64	1.39	
1	582 (13.14)	0.38	1.48	
2	724 (16.5)	0.42	1.43	
3	742 (16.75)	0.32	1.3	
4	929 (20.98)	0.3	1.34	
5	985 (22.24)	0.12	1.25	
Children's Gender				0.022
Boys	2427 (54.80)	0.58	1.56	
Girls	2002 (45.20)	0.48	1.51	
Children's nationality				0.576
Han	3771 (85.14)	0.54	1.52	
Minority	658 (14.86)	0.51	1.63	
Health insurance				0.041
No	2691 (60.75)	0.58	1.56	
Yes	1738 (39.25)	0.48	1.5	
3-day Calories consumption	1115.2 ± 470.44	0.54	1.54	0
3-day Protein intake	34.70 ± 14.82	0.54	1.54	0
3-day Fat intake	35.12 ± 20.79	0.54	1.54	0
Parents' characteristics				
Maternal height	157 ± 5.57			0
≥157	2234 (50.44)	0.66	1.6	
<157	2200 (49.56)	0.41	1.47	
Paternal height	168 ± 6.17			0.004
>=168	2208 (49.85)	0.6	1.59	
<168	2221 (50.15)	0.47	1.48	
Maternal BMI	21.95 ± 2.94			0
18.5<BMI<24	3138 (70.85)	0.53	1.51	
BMI ≥ 24	913 (20.61)	0.72	1.55	
BMI ≤ 18.5	378 (8.53)	0.17	1.64	
Paternal BMI	22.34 ± 3.01			0.001
18.5< BMI <24	3070 (69.32)	0.49	1.5	
BMI≥24	1107 (24.99)	0.69	1.59	
BMI≤18.5	252 (5.69)	0.47	1.7	
Maternal education level				0.001
Non-educated	591 (13.34)	0.47	1.47	
Primary	965 (21.79)	0.48	1.55	
Low middle school	1848 (41.72)	0.53	1.54	
Upper middle school	505 (11.40)	0.49	1.54	
Vocational	251 (5.67)	0.76	1.65	
College and above	269 (6.07)	0.87	1.52	
Maternal average working days per week	5.67 ± 0.86	0.54	1.54	0.5822
Maternal employment				0
Non-worked	900 (20.32)	0.8	1.67	
Worked	3529 (79.68)	0.47	1.5	
Paternal education level				0.0175
Non-educated	211 (4.76)	0.55	1.57	
Primary	724 (16.35)	0.39	1.53	
Low middle school	2141 (48.34)	0.53	1.56	
Upper middle school	768 (17.34)	0.57	1.45	
Vocational	276 (6.23)	0.68	1.55	
College and above	309 (6.98)	0.72	1.59	
Paternal average working days per week	5.24 ± 1.73	0.54	1.54	0.0914
Paternal employment				0.0068
Non-worked	310 (7)	0.77	1.64	
Worked	4119 (93)	0.52	1.53	
Father's smoking				0.861
Yes	2662 (60.10)	0.49	1.49	
No	1767 (39.90)	0.61	1.6	
Father's drinking				0.035
Yes	2942 (66.43)	0.5	1.52	
No	1487 (33.57)	0.61	1.57	
Father's health insurance				0.044
Yes	1944 (43.89)	0.59	1.59	
No	2485 (56.11)	0.5	1.49	

(*continued on next page*)

Table 2 (*continued*)

Variables		BMIZ		
	N (%)/Mean ± SD	Mean	SD	P value
Mother's health insurance				0.008
Yes	2662 (60.10)	0.49	1.49	
No	1767 (39.90)	0.61	1.6	
Household characteristics				
Household per capita income				0.001
Lowest	892 (20.14)	0.56	1.51	
Lower	887 (20.03)	0.51	1.46	
Medium	892 (20.14)	0.48	1.49	
Higher	885 (19.98)	0.42	1.59	
Highest	873 (19.71)	0.72	1.63	
Household asset index	0.74 ± 0.35	0.54	1.54	0.0005
Community characteristics				
Region				0
East coastal area	962 (21.69)	0.78	1.5	
Central area	1439 (32.44)	0.59	1.51	
West area	1424 (32.1)	0.29	1.53	
North-east area	611 (13.77)	0.63	1.6	
Area				0.891
Urban	1204 (27.18)	0.54	1.5	
Rural	3225 (72.82)	0.54	1.55	
Urbanization index				0.106
Lowest	899 (20.30)	0.5	1.48	
Lower	887 (20.03)	0.47	1.52	
Medium	878 (19.82)	0.59	1.59	
Higher	882 (19.91)	0.5	1.53	
Highest	883 (19.94)	0.64	1.57	

Note: The data above is from CHNS. The results above are summarized by STATA.

3.4. Covariates

This study incorporates various demographic characteristics, including the children's gender and age, ethnicity, as well as the height and body mass index (BMI) of their parents. Other social determinants that are associated with child overweight are also included. These social determinants comprise father's employment status, father's average working days, household asset index, whether the child has health insurance, whether the parents have health insurance, community urbanization index, place of residence, and dietary factors such as; 3-day caloric intake, 3-day protein intake, and 3-day fat intake. To be specific, the household asset index is a composite metric created by applying principal component analysis (PCA) which combines material assets and sanitation indicators within the household. The urbanization index is a comprehensive metric derived from a combination of factors calculated by CHNS. Nutritional values were derived from 24-h dietary recall data of individuals or households using China Food Composition Table (FCT) introduced in 1991 and its subsequent revisions. The study also took into account the father's smoking and drinking habits, while the limited prevalence of mothers' smoking and consuming alcohol within the study sample in China precludes them as control variables. The detailed definitions of the main variables linked to child overweight are listed in Table 1 below.

3.5. Statistical analysis

To investigate whether maternal education and employment influence child overweight, this study first employs descriptive analysis to examine pattern and trend of data distribution. In the descriptive analysis, categorical variables are reported in frequencies and percentages, while continuous variables are reported in means and standard deviations (SD). Before proceeding with the formal regression analyses, ANOVA was performed to determine the presence of statistically significant variations within the subgroups, including demographic factor and socioeconomic factors. The reported p-values, where $p < 0.05$, indicate significant differences in group means at 5 % level of significance for the categorical variable.

Following this, the panel data was utilized and the attributes of the outcome variables were taken into account in the application of the two-way fixed effects models (regional fixed effects and time fixed effects) to investigate the association between maternal employment and maternal education level on childhood overweight, while controlling for other covariates. Model 1 was utilized to incorporate the main independent variables and other covariates. However, recognizing the potential influence of household income per capita on the relationship between maternal education and children's BMIZ, the interaction term was introduced into Model 1. The inclusion of maternal working days as a moderating effect in clarifying the association between maternal employment and children's BMIZ are guided by both theoretical and empirical framework of this study. Therefore, interaction term involving maternal working status and average weekly working hours were respectively included in Model 1. Expanding on the framework established in Model 1, the incorporation of the father's level of education and employment status was carried out with the aim of conducting a more comprehensive investigation of their impact on children's BMIZ in Model 2. Due to the uneven development between urban and rural areas and gender disparities in China, separate regressions for urban and rural subsamples (Model 3 and Model 4) and male and female

Table 3
The fixed effect regression between maternal socioeconomic status and child overweight.

Variable	Model 1	Model 2
	BMIZ	BMIZ
Age	−0.3057***	−0.3068***
	(-19.45)	(-19.45)
Gender		
Girl	−0.1071**	−0.1103**
Boy (reference)	(-2.48)	(-2.56)
Ethnicity		
Minority	0.1594**	0.1583**
Han (reference)	(2.21)	(2.20)
Health insurance		
Yes	−0.1861***	−0.1856***
No (reference)	(-3.27)	(-3.26)
Maternal height(cm)		
<157	−0.1218***	−0.1228***
≥157 (reference)	(-2.59)	(-2.61)
Mother's nutrition		
Overweight	0.1833***	0.1838***
	(3.22)	(3.21)
Underweight	−0.3682***	−0.3657***
Normal (reference)	(-4.50)	(-4.46)
Paternal height(cm)		
<168	0.0322	0.0305
≥168	(0.66)	(0.63)
Father's nutrition		
Overweight	0.1492***	0.1459**
	(2.58)	(2.53)
Underweight	−0.0980	−0.0984
Normal (reference)	(-1.01)	(-1.01)
Household per capita income		
Lower	−0.2291*	−0.2222*
	(-1.77)	(-1.71)
Medium	−0.2775*	−0.2795*
	(-1.72)	(-1.73)
Higher	−0.7073**	−0.7200**
	(-2.35)	(-2.42)
Highest	0.2471	0.2770
Lowest (reference)	(0.65)	(0.73)
Mother' education level		
Primary	−0.1185	−0.1028
	(-1.00)	(-0.87)
Low middle school	−0.2834**	−0.2779**
	(-2.21)	(-2.14)
Upper middle school	−0.1464	−0.1410
	(-0.84)	(-0.79)
Vocational	0.2204	0.2230
	(0.50)	(0.50)
College and above	0.0909	0.1340
Illiteracy (reference)	(0.21)	(0.30)
Interaction 1		
Lower*Low middle school	0.3689**	0.3675**
	(2.13)	(2.12)
Medium* Low middle school	0.4050**	0.4191**
	(2.06)	(2.13)
Mother's average working days	−0.5245***	−0.5334***
	(-3.28)	(-3.37)
Mother's employment		
Yes	−3.2233***	−3.2363***
No (reference)	(-3.59)	(-3.64)
Interaction 2	0.5617***	0.5687***
	(3.53)	(3.60)
Father' education level		
Primary		−0.2099*
		(-1.80)
Low middle school		−0.1499
		(-1.34)
Upper middle school		−0.1368
		(-1.15)
Vocational		−0.1657

(*continued on next page*)

Table 3 (*continued*)

Variable	Model 1	Model 2
	BMIZ	BMIZ
		(-1.12)
College and above		−0.2959*
Illiteracy (reference)		(-1.74)
Father's average working days		−0.0007
Father's employment		(-0.03)
Yes		−0.1394
No (reference)		(-0.83)
Household asset index	0.0792	0.0762
	(0.86)	(0.82)
Urbanization index		
Lower	0.0300	0.0329
	(0.43)	(0.47)
Medium	0.1147	0.1096
	(1.54)	(1.47)
Higher	−0.0480	−0.0539
	(-0.59)	(-0.66)
Highest	−0.0209	−0.0285
Lowest (reference)	(-0.22)	(-0.29)
Mother's health insurance		
Yes	0.2233**	0.2113**
No (reference)	(2.45)	(2.31)
Father's health insurance		
Yes	−0.0737	−0.0542
No (reference)	(-0.89)	(-0.65)
Father's smoking		
Yes	0.0824*	0.0812*
No (reference)	(1.73)	(1.70)
Father's drinking		
Yes	−0.0771	−0.0759
No (reference)	(-1.63)	(-1.60)
3-day calories intake	−0.0000	−0.0000
	(-0.05)	(-0.00)
3-day protein intake	0.0006	0.0005
	(0.21)	(0.17)
3-day fat intake	−0.0007	−0.0007
	(-0.47)	(-0.49)
Region		
Central	−0.1384**	−0.1380**
	(-2.14)	(-2.13)
West	−0.4865***	−0.4829***
	(-6.91)	(-6.84)
North east	−0.1961**	−0.1855**
East (reference)	(-2.32)	(-2.18)
Fixed effects	Yes	
_cons	4.7812***	5.0890***
	(5.23)	(5.56)
N	4429	4429
R^2	0.1593	0.1608
adj. R^2	0.1468	0.1469

Note: The data above is from CHNS. T statistics in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01. Interaction 1 is the term between mother's education level and household per capita income levels. Interaction 2 is the term between mother's employment status and average working days per week. The results above are regressed by STATA.

subsamples (Model 5 and Model 6) were also incorporated. All data analyses were conducted using STATA version 17.0. Significance level is defined at the $p < 0.05$ level.

4. Results

4.1. Descriptive analysis

In this study, the prevalence of overweight among children under the age of five is 16.35 %. The average BMIZ of children in the study increased gradually from 0.39 to 0.57 per year between 1991 and 2015. Table 2 presents the mean age and standard deviation (SD) of the children in the sample as 2.91 ± 1.65, revealing a trend of declining BMIZ with increasing age. The sample consists of slightly higher proportion of male children (54.8 %) compared to female children. The majority of children belong to the Han nationality (85.14 %) and the results of this study reveals that, both male gender and Han nationality are associated with significantly

higher BMIZ. Concerning dietary intake and its impact on children's BMIZ, the mean and SD of caloric intake was recorded at 1115.2 ± 470.44, with protein intake quantified at 34.70 ± 14.82 and fat intake at 35.12 ± 20.79. Pertaining to parents' characteristics, the proportion of mothers' height over 157 and fathers' height over 168 are around 50 %, respectively. Based on their nutritional status, approximately 20.61 % of mothers and 24.99 % of fathers in the sample are classified as obese. A striking result from this study is that, children whose mothers' height are less than 157, fathers' height less than 168, and parents' BMI less than 18.5 have lower BMIZ on average.

An examination of the main independent variables in the study reveals that the maternal mother's education level is distributed as follows: the majority (41.72 %) have completed a low middle school education, followed by primary education (21.79 %), non-educated (13.34 %), upper middle school (11.4 %), college and above (6.07 %), and vocational education level (5.67 %). Approximately four out of five mothers are employed, and the average number of working days per week is 5.68 with a standard deviation of 0.86. Household per capita income is categorized into five levels, ranging from lowest to highest. Children from both end of the income range, the lowest and highest income groups tend to have higher BMIZ scores.

In terms of other covariates, more than half of the children (60 %) possess health insurance, while approximately 56.11 % of fathers and fewer than half of mothers (39.90 %) are covered by health insurance. The mean and SD of household asset index is calculated as 0.74 ± 0.35. Geographically, the sample comprises 21.69 % from the eastern region, 32.44 % from the central region, 32.1 % from the western region, and 13.77 % from the northeast region. There are significant differences in mean BMIZ among these regions, with the highest BMIZ observed in the eastern coastal area and the lowest BMIZ in the western area.

Regarding the urban-rural divide, majority of the sample (72.82 %) comes from rural areas. However, there is no significant disparity in BMIZ between urban and rural areas. The urbanization index highlights that children from areas with highest urbanization index have the highest BMIZ. Building upon initial ANOVA analysis, significant variations were observed ($p < 0.05$) among subgroups in terms of: children's age, gender, insurance, 3-day calories consumption, 3-day protein intake, 3-day fat intake, parental height, parental BMI, parental education level, parental employment, household per capita income, household asset index, parental health insurance, fathers' drinking and place of residence.

4.2. Main results: the association of maternal socioeconomic status and child overweight

The results of the two models (1 & 2) are reported in Table 3 below. First, the study looks at the association between maternal education level and children's BMIZ in Model 1, and the result showed that the BMIZ of children with junior middle school level's mothers is significantly lower about 0.28 than those children with uneducated mothers. In Model 2, the impact of mothers with junior high school education on children's BMIZ remains statistically significant and robust ($p < 0.05$), even when accounting for the fathers' educational levels and employment status as covariates. Following this, children born to mothers with primary and upper high school education tend to have lower average BMIZ values compared to those with uneducated mothers, although this difference does not reach statistical significance. On the contrary, mothers with education above the vocational level exhibits a positive association with children's BMIZ, but this association does not show statistical significance. In this study, the schooling of mothers who have completed upper middle school education is deemed equivalent with mothers at vocational education levels.

Household with higher level per capita income has shown a substantial negative influence on children's BMIZ, with the significance and sign essentially similar across the two models. After adjusting for other variables in Model 1 and Model 2, families with higher income level significantly reduce BMIZ by approximately 0.71 ($p < 0.01$) and 0.72 ($p < 0.01$), respectively. When the average per capita household income reaches its highest level, the average BMIZ of children exceeds that of children from households with the lowest income ($p > 0.1$). Turning to the moderating effect between maternal education level and household per capita income, the interaction term of maternal education level (junior middle school level) and household per capita income level (lower and middle level) is positive and significant at 5 % in Model 1 and Model 2. This signifies that the reduction in BMIZ associated with a mother's junior high school education is weakening in the presence of lower to middle family income level. Precisely, at lower and middle household income level, children whose mothers have low middle education level have higher BMIZ than those who have uneducated mothers and are from the lowest family income groups.

Next, moving to the association between maternal employment and children's BMIZ, in Model 1, the BMIZ of children with employed mothers is at 3.22 lower than children whose mothers are not in employment, controlling for other variables ($p < 0.01$). It is evident that the average weekly working hours of the mother also have a significant and negative effect on the children's BMIZ. An increase in the average weekly working days of mothers significantly reduce the BMIZ of children by 0.52 ($p < 0.01$). However, the interaction term between maternal employment status and number of working days per week is positively significant. It is therefore crucial to highlight the presence of a positively significant interaction effect between maternal employment status and the number of working days per week. This suggests that the influence of maternal employment in decreasing children's BMIZ is subject to moderation by the average number of days a mother works each week. Put simply, as the number of days a mother works per week increases, children tend to exhibit higher BMIZ scores. This result is consistently shown in Model 2.

On other socioeconomics determinants, children's health insurance significantly reduced BMIZ by approximately 0.19 ($p < 0.01$) in both models. Mothers with health insurance significantly increases their children's BMIZ ($p < 0.05$). Geographically, children living in the developed eastern region have a significantly higher BMIZ than those living in the central ($p < 0.05$), western ($p < 0.01$) and northeastern regions ($p < 0.05$). The urbanization index and household asset index cannot explain the disparities in children's BMIZ in all models. Model 2 revealed that no significant effects of father's employment and weekly working hours on children's BMIZ are found.

Various demographic factors exhibit statistically significant differences, and for each additional year in a child's age, there is a

substantial reduction of 0.31 in the child's BMIZ ($p < 0.01$). Female children exhibit an average BMIZ 0.11 lower than their male counterparts at 5 % significance level. Children from ethnic minority backgrounds demonstrate an average BMIZ approximately 0.16 higher than Han Chinese children ($p < 0.05$).

Factors such as mothers' height and obesity significantly contribute to a better understanding of child obesity problem. Children born to mothers who are shorter than 157 cm have an average BMIZ significantly lower by approximately 0.12 compared to others in their same-aged peers ($p < 0.01$). Children of obese mothers have significantly higher BMIZ, approximately 0.18, compared to children of mothers with normal body mass index ($p < 0.01$). In contrast, children born to underweight mothers are profoundly influenced by genetic factors, displaying a significantly lower BMIZ of 0.37 compared to their counterparts ($p < 0.01$). Father's height and underweight status do not exhibit a statistically significant relationship with a child's BMIZ. Similar to maternal obesity, children of obese fathers have significantly higher BMIZ, approximately 0.15, compared to children of fathers with normal body mass index ($p < 0.01$).

4.3. Urban-rural disparities

Childhood overweight disparities between urban and rural areas were conducted in Model 3 and Model 4 (detailed in the supplementary material). The outcomes showed that no significant effect of mothers' education level on children's BMIZ was found in urban areas. In rural areas, children whose mothers' education level are in the category of college and above have higher BMIZ of 1.18 ($p < 0.01$) compared to children whose mothers have no education. When controlling for other variables, no significant differences in child BMIZ were observed based on family income levels in urban areas. However, in rural regions, a notable distinction in child BMIZ emerged only when family income reached at medium level. Specifically, children from households with medium income level exhibited a significantly lower BMIZ by 0.40 compared to those from households with the lowest income level. In terms of the impact of maternal employment on children's BMIZ, the regression results showed that employed mother and their additional working days can significantly reduce children's BMIZ, which are consistent with the findings of the previous national-level data.

The coefficient for urban and rural working mothers exhibited significant differences in their impact on children's BMIZ. In urban areas, the mean BMIZ of children under 5 years old with employed mothers is significantly lower by 5.14 ($p < 0.01$) compared to those without employed mothers. While, in rural areas, the mean BMIZ of children under 5 years old with employed mothers is significantly lower by 2.41 compared to those without employed mothers ($p < 0.05$). Related to maternal average working days in urban areas, children with mothers who work on average one extra day per week have 0.67 ($p < 0.01$) reduction in their children's BMIZ. While in rural areas, this coefficient is 0.44 ($p < 0.05$). The interaction terms between maternal employment and average weekly working days are positive in both urban and rural areas, which is consistent with the national data, suggesting that the negative effect of maternal employment on children's BMIZ is attenuated by an average of one more day of maternal work per week. Both Model 3 and Model 4 integrate paternal socioeconomic status, measured by educational and occupational indicators. The results align consistently with national data, indicating no significant association with children's BMIZ.

4.4. Gender disparities

Gender disparities are examined in Model 5 and Model 6 (seen in the supplementary material). Maternal education level continues to exhibit significance for both male and female children, albeit with distinct patterns. Notably, for boys, a negative correlation with BMIZ remains significant at 5 % level ($p < 0.05$) with mothers having upper middle school education. Conversely, for girls, the adverse impact of having mothers with junior high middle school education and college and above, their BMIZ becomes statistically significant at 10 % level. After adjusting other variables, household per capita income remains a protective factor for reducing BMIZ in both male and female children. A lower household income level significantly reduces BMIZ in boys ($p < 0.05$), while for girls, a decrease in BMIZ is beneficial only when household income reaches a higher level ($p < 0.01$). Maternal employment status ($p < 0.05$) and average weekly working days ($p < 0.05$) exhibit a significant negative correlation with BMIZ in male children, which is consistent with the robustness of the national-level regression outcomes. However, for female children, the significant association between maternal employment and BMIZ is only found at 10 % significance level. The average number of days per week that mothers work has a negative impact on both male and female children, with statistical significance observed only for male children at 5 % level. Household per capita income at the lower level significantly decreases children's BMIZ, while at the highest level, it shows a positive but statistically non-significant correlation with BMIZ in male children. On the other hand, at higher household per capita income levels, female children experience a significant BMIZ reduction of 1.23 ($p < 0.01$). Models 5 and 6, which include paternal socioeconomic status, do not reveal any associations with children's BMIZ.

5. Discussion

China's rapid economic growth and remarkable rise in per capita disposable income have led to a concerning public health issue of overweight affecting all segments of society [17,23,72]. This study primarily utilized longitudinal data from CHNS spanning the years 1991–2015 to investigate the impact of maternal education level and employment on childhood overweight. These factors are widely utilized indicators for assessing socioeconomic disparities in the study of child overweight [14,31,73]. The findings of this study have shown a social gradient in early childhood overweight which is consistent with the development of current research. However, specific associations observed differ due to the complex interplay of socioeconomic factors among contexts [[23,45,47,48,74]].

The primary contribution of this study lies in its focused examination of the association between maternal socioeconomic factors and overweight in children under the age of 5. It distinguishes itself by utilizing BMIZ as a measure of childhood overweight, calculated

according to the WHO growth standard of 2007. Other similar studies conducted in China have largely focused on school-aged children in specific provinces or regions [26,27,28,48,51], but this study extends its scope encompassing preschool-aged children, thus, covering the entire crucial growth period of early childhood in China. This study departs from other studies that have employed limited criteria for assessing overweight and relying solely on children's BMI, which lacks adjustments for age and gender, hence, resulting in inaccurate overweight or obesity evaluations [27,39,47]. Primarily, this study captures the protective effect of mothers with only junior high school education against childhood overweight under 5. In the context of heterogeneity analysis, it is imperative to recognize that children residing in rural areas tend to display elevated BMIZ, particularly those with mothers who have attained college-level education and above. This observation aligns with previous similar studies, wherein it has been theorized that children born to parents with higher educational attainment are more susceptible to experiencing increased body weight, BMI, or a heightened risk of overweight status [25,39]. Cross-sectional study conducted among CHNS sample of school-age children aged 7–18 found that, at each level of maternal education attainment, which is at or above junior high school, the children are more prone to be overweight or obese compared to their counterparts with relatively lower maternal education levels [75]. On the contrary, studies in developed countries such as the United States, Australia, Spain, and Germany consistently identify lower maternal education levels as a risk factor for childhood obesity [74,76]. In these countries, families with higher maternal education levels tend to have children who are less likely to be obese. This finding is entirely opposite to what is observed in other developing countries.

Generally, in the literature, mothers with junior high school education level are consistently regarded as having the potential to improve child development and reduce the prevalence of stunting when compared to mothers with only primary education or those who are illiterate [61,72]. This is attributed to the fact that mothers with junior high school education possess foundational knowledge about nutrition and have the ability to access basic healthcare services. In addition, given the extended time span of this study, the average maternal education level in the sample stands at junior high school highlights the advantages of China's nine-year compulsory education in enhancing children's nutritional health [59,77,78]. In the context of China, junior high school education corresponds to a comparatively modest level of educational attainment. Within this educational stratum, mothers typically have access to limited financial resources, which in turn restricts their capacity to allocate excessive quantities of high-energy foods for their children. The result of this study showed that the impact of maternal junior high school education on the child BMIZ is positively moderated by low family income within the household. This suggests that higher parental education levels contribute to the reduction of childhood overweight only when the family income surpasses a certain threshold [47,79].

Upon further investigation, it is clear that irrespective of whether composite or single dimensions are employed to assess children's socioeconomic status, still children of higher social status face a heightened risk of obesity. Likewise, the gender-specific differences in obesity outcomes exhibit variability among studies. In the context of this study's analysis of heterogeneity, distinctions between genders came to light, particularly with maternal education at the upper middle school level exhibiting a more prominent influence on male children. The gender disparity in childhood overweight observed in this study is consistent with findings in similar research [25, 47,48]. An investigation carried out using data from China Education Panel Survey, where the average age of the subjects was 13.3, and the measurement criteria were based on the Chinese national BMI cutoff points, elucidate that within higher socioeconomic strata, obesity is more prevalent among boys than girls [80]. Similarly, studies on the socio-economic factors influencing obesity among 7-year-old children in Shanghai and 5–12 primary students in Guangzhou revealed the presence of social gradient in obesity among boys, which is in line with patterns observed in developing countries. Boys from higher-income and higher-education backgrounds are more likely to be obese [48,51]. On contrary, a survey conducted on childhood obesity among children aged 9–17 in coastal provinces of the Yangtze River Delta region, uncovered a positive relationship between higher socioeconomic status and overweight in girls. This effect was particularly pronounced when mothers had completed high school education or higher [27]. An investigation into obesity inequality among children aged 9–12 in the northeastern region found that at both extremes of socioeconomic status, children from the lowest-educated parents and the highest-educated parents experienced a lower risk of obesity. In contrast, girls from moderately affluent self-employed families were the most susceptible to the influence of community environments leading to an increased risk of obesity [24]. The inconsistency in these research findings is likely attributed to variations in the study populations and areas covered. It is vital to acknowledge that disparities in the assessment criteria for overweight and obesity, along with variations in the classification standards for socioeconomic status, have the potential to yield divergent results. Majority of these studies heavily relied on cross-sectional data. It becomes evident that the socio-economic determinants of childhood overweight exhibit complex interactions and influences that differ across distinct age groups or geographical regions.

This study also highlights a significant and inverse relationship between maternal employment status, average working time, and children's BMIZ. These findings contrast with research conducted in the developed countries, which have invariably demonstrated that maternal employment increases the risk of childhood obesity [56,62–68], or no association between maternal employment and child overweight [45,66]. This particular negative association is distinctively observed in the urban-rural and gender contexts within China. The findings of this study are consistent with other similar research [81,82], primarily attributed to the fact that non-working mothers can dedicate more time to cooking, resulting in increased calorie intake for their children. With respect to traditional Chinese culture, caregivers are encouraged to fulfill every need of their children, and childhood overweight is often seen as a symbol of effective nurturing. Nevertheless, this cultural trait illustrates a deficiency in their understanding of expert health-related information, and they tend to underestimate the lifelong consequences of early childhood overweight. Hence, maternal employment acts as a protective factor against childhood obesity.

The inconsistent findings on the relationship between maternal employment and children's overweight in developed countries largely depend on the level of support and intensity of national childcare policies for families with children. For China, due to the prevalence of specific cultural norms and formal childcare facilities for children under 5 are scarce, grandparents play prominent role in co-parenting and providing childcare [25]. However, this study demonstrates a consistent finding with developed countries, where

prolonged working hours carry a certain risk of increasing child BMIZ [40,50]. These results suggest that the disparity in research findings may be attributed to the presence or absence of formal childcare settings or alternative caregiving arrangements that offer high-quality companionship for children. These factors may moderate the adverse effects of maternal work hours and intensity on the risk of childhood overweight.

Hence, this study holds substantial significance. Drawing from nationwide longitudinal data, it furnishes evidence regarding the socioeconomic impact of maternal education and employment on obesity in children under the age of five in China. This expansion of the existing literature diversifies the prevailing emphasis on the relationship between childhood obesity and socioeconomic status in developed countries. The anthropometric measurements of height and weight for children under five were conducted by professional health examiners in each survey round of CHNS, thus circumventing potential biases arising from self-reported weight and height data. To date, much of the research concerning China has centered around school-age children or adolescents, with insufficient attention paid to the critical early stages of childhood obesity. Therefore, the interactive effects of maternal education levels and household income remain under-explored in the literature.

This study's limitations stem from the constraints of available data. It did not extensively explore the underlying mechanisms through mechanistic analyses of individual health behaviors contributing to elevated obesity risk in children under five years old. These behaviors include aspects like family dietary patterns, physical activity levels, screen time engagement, and sleep duration. In the availability of abundant data, future research could focus on the mechanistic analysis of the relationship between maternal socioeconomic status and childhood obesity. Issues on reverse causation biases arising from the selection bias associated with some mothers' employment were not fully addressed. But, in this sample, the majority of mothers were employed, mitigating this bias to a certain extent.

6. Conclusion

This study underscores the preventive role of mothers with low middle school education in curbing childhood overweight. Maternal education levels exhibit varying socio-economic gradients across urban and rural areas, as well as gender differences. Interactions between maternal education levels and household per capita income have been observed closely in this study. The negative association between maternal employment and children's overweight as well as the impact of working days per week, tend to differ from the findings in developed nations. However, there is an alignment in the observation that longer working days for mothers pose an increased risk of childhood overweight.

The significant impact of maternal education on child overweight underscores the need for comprehensive interventions and policies. Merely having higher education does not guarantee greater health consciousness or appropriate feeding practices among mothers. Therefore, it is crucial for the government to implement measures that promote and provide parental education on child feeding and parenting during pregnancy, through the utilization of healthcare professionals experts and maintaining comprehensive hospital records. Furthermore, with the rise in per capita income, the government should actively raise awareness regarding unhealthy dietary patterns, such as the fast-food culture and consumption of sugary beverages. This can be achieved through effective communication channels and campaigns. The government should work towards facilitating consumer awareness of healthier food choices by advocating for strict regulation of food labeling practices to ensure accurate information about the ingredients is provided. The main negative impact of maternal employment on childhood overweight depends on the reduction of quality child care and health management due to the increase of mothers' working hours. Although to a certain degree the grandparents of the children compensate this negative effect, as China's population ages, there is a need for district-based government child care institutions to provide professional care to alleviate the burden of both young and dual-earner parents. To lessen the burden, government can provide financial subsidies for families with children under the age of 5 to some extent and encourage all companies to give parents 1 h of childcare time per day.

Ethics statement

Before conducting interviews with participants for our study on ethical decision-making, the China Health and Nutrition Survey was ethically reviewed by the Institute of Nutrition and Health of the Chinese Centre for Disease Control and Prevention 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.

Data availability statement

The data relevant to this research have been archived in the openly accessible database of the China Health and Nutrition Survey. For more detailed information, please consult the provided link: 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, Investigation, 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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