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Association of childhood disadvantage with malnutrition in older ages in India

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Abstract

Introduction Much research on the association between childhood status and adult health has been focussed on high income countries and, hence, these findings cannot be generalised for all developing economies. Therefore, this study is an attempt to systematically examine the impact of multiple domains of early disadvantage on nutrition status during old age in India, while testing for potential mediation by adult health, socio-economic status and lifestyle.

Methods The study uses data from the first wave of the Longitudinal Ageing Study in India (LASI), 2017-18. Binary logistic regression was used to assess the adjusted association of childhood and adulthood conditions with nutrition status. Two separate models were run for underweight and overweight. We used the structural equation modelling (SEM) approach to construct latent variables and structural models to test our hypothetical model.

Results The SEM explained 78% of the variance in underweight. The direct effect of education and childhood conditions on underweight was significant. The SEM explained 68% of the variance in overweight. Results shows that the direct effect of education and working status on overweight was significant. The indirect and total effect of childhood conditions on overweight was significant.

Conclusion The study underscores the importance of considering both direct and indirect effects in understanding the pathways through which early life experiences influence nutritional status in old age. The unexpected finding regarding the direct effect of childhood conditions on overweight in the Indian context raises important questions about the complexities of nutrition and health in this population.

Keywords BMI, Older adults, Early life, Childhood, Adulthood, Mediation, India

Introduction

With 139.6 million population aged 60 years and above (10.1% of the total population), India has the second largest older adult population globally. It is also expected to reach double its current size to 290 million (17.3% of the total population) in the next three decades [1]. Malnutrition among older adults is a major health concern that needs to be tackled if healthy and productive ageing is to be achieved [2]. India is witnessing a steady increase in the prevalence of overweight and obesity among older adults [3]. This is being accompanied by the highest prevalence of underweight among older adults globally [4].

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Consequently, identifying older adults at risk at both ends of the spectrum is crucial to tackle this burgeoning public health challenge in India [5]. Life Course Epidemiology (LCE) has emerged as a theoretical framework to examine the impact of early life events on health outcomes in later life [6]. Seconded with an evolutionary perspective, LCE acknowledges that an individual's weight is not simply the summed up impacts of contemporary influences on behaviour, it is rather a consequence of evolutionary and individual developmental histories [7]. There are two mutually exclusive approaches within LCE that connect early life experiences with later life events within the development history of an individual- the critical period theory and the accumulation of risk model or the cumulative inequality theory. The critical period theory states that early life exposures to negative events results in biological changes that increase vulnerability to diseases or health problems in later life. While these exposures can take place over the life course, there has been increased focus on early life exposures [8]. The cumulative inequality theory, a derivative of the cumulative advantage theory, states that negative life events and experiences place people at an increased risk while positive experiences create opportunities and the structure of both can modify life chances for individuals or groups [9, 10]. This theory amplifies the importance of childhood as a life stage, where early appearance of differences or experiences lead to inequality. There is a large body of literature that establishes the link between early life experiences and problems in adult life. What remains unaddressed is the mechanism through which this happens. For instance, given the considerable amount of time between childhood and adulthood, do early life conditions have temporary or enduring effects on health in later life? Are these effects direct or mediated through intervening experiences and exposures? These are the questions that this study seeks to answer. For the study of life course, it is crucial to observe not only early exposures that generate chains of risk, but also midlife resources that mediate early disadvantage. This facilitates the need to consider other life course risks and resources in tandem with early life conditions [11].

Previous studies have attempted to study different stages of life and their inter-connectedness and found them to have an impact on educational attainment [12], occupational status [13], criminal offenses [14] and mental health [15]. It is well established that childhood problems such as low birth weight and economic deprivation have a marked impact on both physical and mental health of individuals during the life course [11]. In addition to the above, findings from previous studies state that those from disadvantaged backgrounds have more health related risk factors [16], increased risk of chronic diseases including depression [17], cardiovascular diseases [18, 19] and stroke [20]. Such individuals also tend to have worse self-rated health [21] and higher mortality rates [22]. Adult weight is reported to be influenced by a gamut of factors including genetic, environmental and behavioural factors, taking into account both past and present circumstances [23, 24].

Studies suggest that there are several pathways in the life course that affect overweight and obesity among individuals. For example, childhood circumstances may affect educational attainment and psycho-social traits, which in turn may have an impact on socio-economic position and health behaviour in later life [6]. Additionally, childhood environment may have a more direct impact on overweight and obesity in adulthood through nutrition in infancy [25], psychological factors [26] and social and cultural norms [27]. Certain studies state that paternal occupation is one of the most important childhood marker of adult weight, along with other factors such as maternal body mass index, childhood obesity and childhood growth patterns [28]. Childhood socio-economic indicators may have an impact on adult weight through a number of mechanisms, including parental modelling of daily weight related behaviours such as consumption of energy dense foods and sedentary lifestyles [29]. Moreover, much research on the association between childhood status and adult health has been focussed on high income countries and, hence, these findings cannot be generalised for all developing economies [30]. Developing countries have experienced nutrition and epidemiology transition, followed by rapid economic development. This makes the population growing in such social transitions have differential impact on health [31]. Thus, life course analysis for developing countries like India may help to identify the mechanisms through which early life adversities may affect health during later life.

Childhood socio-economic disadvantage can lead to pathways that increase clinical and social risks, such as substance use, social isolation, and mental distress, which may worsen cognitive function in later life [32]. According to the brain reserve hypothesis, environmental factors significantly influence brain plasticity, affecting intelligence, education, and occupation, which in turn shape cognitive functioning [33]. However, some studies suggest that cognitive decline in older age is not determined by any single life stage but rather by exposure to reserve-related factors and the cumulative effect of multiple traumas over the life course [34]. Given that early life factors for late-onset diseases are well-documented in epidemiological research, understanding the independent association between early life factors and late-life cognition could help in designing interventions that enhance cognitive function, potentially benefiting individuals regardless of their genetic susceptibility [6].

Association between childhood disadvantage and adult weight suggest a 'long arm' of early life-course experiences and their impact on adult weight [35, 36]. However, a limited number of studies have investigated the association between childhood health and adult health using large scale population-based surveys. None of the studies have looked at the association between childhood socio-economic status and nutrition status among older adults. Therefore, this study is an attempt to systematically examine the impact of multiple domains of early disadvantage on nutrition status during old age, while testing for potential mediation by adult health, socio-economic status and lifestyle. Through this study, we seek to answer the following research questions: Is childhood disadvantage associated with malnutrition in older ages i.e. 60 and above? Do adult socio-economic conditions mediate the association between childhood disadvantage and malnutrition in older ages?

Data and methods

Data

The data for this study was taken from the first wave of a prospective cohort study "Longitudinal Ageing Study of India (LASI)-Wave-1. This is a nationally representative survey of adults aged 60 and above across all states and union territories of India which collects information on disease, health and healthcare and socio and economic well-being of older adults. The data was collected between April 2017 and December 2018.

The LASI survey utilized a multistage, stratified, area-probability cluster sampling design to identify its target population: adults aged 45 and older, along with their spouses, regardless of age. In rural areas, a three-stage sampling approach was used, while in urban areas, a four-stage approach was implemented. The first stage in each state or Union Territory involved selecting Primary Sampling Units (PSUs), which are sub-districts (Tehsils/Talukas). In the second stage, villages were chosen in rural areas, and wards in urban areas, from the selected PSUs. For rural regions, households were selected from the chosen villages in the third stage. In urban settings, however, an additional step was added: in the third stage, a Census Enumeration Block (CEB) was randomly selected, and in the fourth stage, households were picked from this CEB. Data on socio-demographic and health-related aspects of respondents were collected through face-to-face interviews using computer-assisted personal interviewing (CAPI).

The final sample size of the survey was 72,250 with individual and household response rates of 87.3 and 95.8 respectively. More information about the methods and procedures for data collection can be found elsewhere [37].

For this study, we first merged individual files and biomarker files using one-to-one matching to assess the information on anthropometry measures such as height and weight. We applied relevant sampling weights so that each state was represented in proportion to its population size. There were about 3413 individuals whose weight and height measurements were missing. These cases were dropped to obtain a representative sample of older adult Indian population aged 60 years and above. The final analysis was then conducted on a sample size of 31,464 individuals. Figure 1 shows the flowchart for sample study selection.

Childhood conditions

This section elaborates on the variables that were used to define childhood conditions for the purpose of the study.

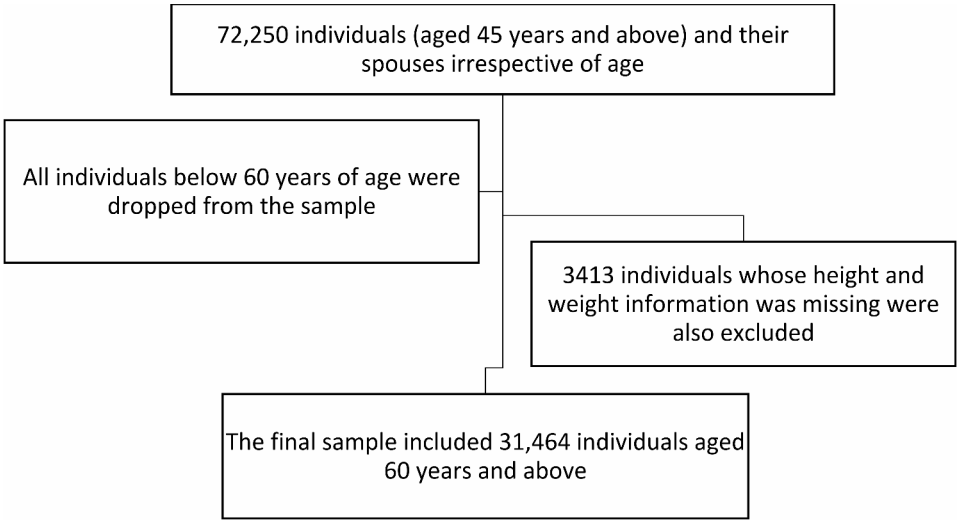

Fig. 1 Flowchart for the study sample selection

Father's education

Two questions were asked in the individual module of LASI: *"Did he ever attend school?"* and *"What is (was) the highest level of education that he completed?"*. Based on these two questions, father's education was classified into four categories, namely, "not educated", "primary", "secondary", and "graduate and above".

Mother's education

As mentioned above, two questions pertaining to mother's education were also asked in the individual module in LASI: "*Did she ever attend school?"* and *"What is (was) the highest level of education that he completed?"* Based on these two questions, mother's education was classified into four categories, namely, "not educated", "primary", "secondary", and "graduate and above".

Status of childhood wealth

In LASI, the financial status of the family during childhood was assessed by asking the question *"Now think about your family when you were growing up, from birth to age 16. Compared to other families in your community, would you say your family during that time was pretty well off financially, about average, or poor?"* The response was coded in three categories, namely, "pretty well off financially", "average", and "poor".

Status of childhood health

In LASI, the status of self-rated health during childhood was assessed by asking the question *"Now I want to ask you about your overall childhood health up to age 16. In general, would you say your childhood health was very good, good, fair, poor or very poor on the basis of what you remember, or what you heard or perceived from your parents?"* Based on the response given by the respondents, "very good", "good", "fair", "poor", "very poor", a dichotomous variable for childhood self-rated health was created and the responses were categorized as "good" and, "otherwise".

Adulthood conditions

Education

Educational status of the respondents was assessed using two questions in LASI: *"Have you ever attended school?" and "What is the highest level of education that you completed?"* Using these two questions, educational attainment of the respondents was made into a categorical variable with four categories, namely, "not educated", "primary", "secondary", and "graduate and above".

Working status

Working status was assessed in LASI using two questions, *"Now, I am going to ask you some questions about your work and employment. Have you ever worked for at least 3 months during your lifetime? Work includes agricultural work, wage work, self-employed activities, and unpaid family business work. Work also includes all kinds of labor, excluding doing your own housework, whether you earn wages or not."* And *"At what age (or which year) did you start working (or farming), excluding working after school or during school breaks while you were a primary or middle school student?"* These two questions were combined to create a working status variable with three categories "never worked", "started work in childhood" for those respondents who started working before the age of 14 and "started work in adulthood" for those respondents who started working after the age of 14 [38].

Nutrition status

Nutrition status of the respondents was assessed using the weight and height information collected by LASI in the biomarker module. Body mass index (BMI) was calculated as the ratio of weight (in kilograms) and squared height (metres) of the participants. Using the cut-off recommended by the World Health Organization (WHO), BMI was categorized into "underweight" (less than 18.5 kg/m^2), "normal" (18.5 to 24.9 kg/m^2), "overweight/obese" (greater than 25.0 kg/m^2) [39].

Covariates

The study controlled for potential confounders by including other potentially related covariates, namely, age group (60–74 and 75 and above), sex (male and female), lifestyle factors (smoking, alcohol consumption and level of physical activity), presence of any chronic diseases, presence of any form of ill-treatment/abuse (yes and no), and monthly per capita expenditure (MPCE) (yes and no). These have been considered risk factors for poor health and nutrition in old age [40, 41].

Methods

We used descriptive statistics to illustrate the sample characteristics and study variables of childhood conditions, adulthood conditions and nutrition status of 60 and above population.

Binary logistic regression was used to assess the adjusted association of childhood and adulthood conditions with nutrition status. We ran two models- the outcome variable in Model 1 was underweight and the outcome variable in Model 2 was overweight.

We used the structural equation modelling (SEM) approach, a combination of measurement models, to construct latent variables and structural models to test our hypothetical model. SEM enables the testing of direct and indirect (mediating) effects via path analysis and its combination with measurement models for SES to reduce measurement error [42]. This is crucial while employing complex structural equation modelling to reduce the

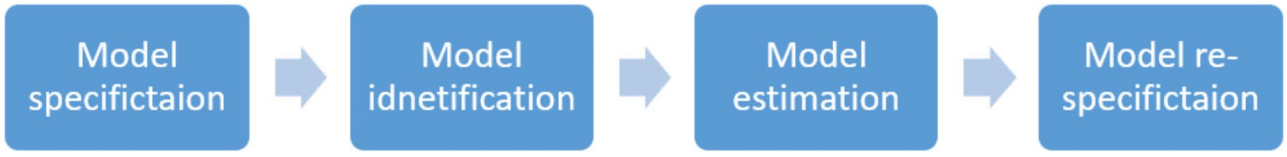

Fig. 2 A four-step approach for conducting SEM analysis

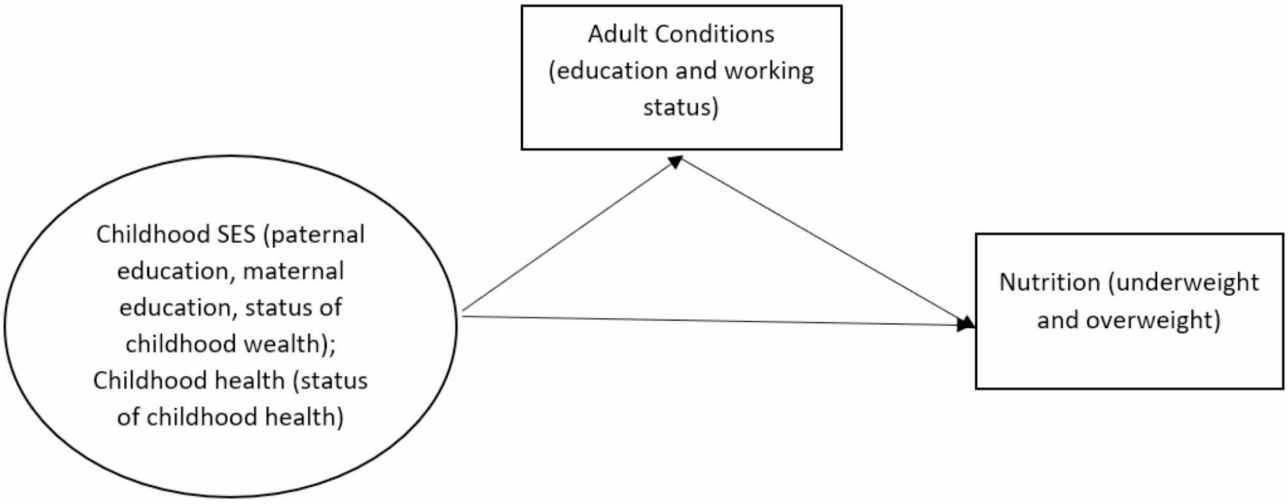

Fig. 3 Hypothetical conceptual model for the mediating effect of adult conditions on nutrition in old age. *Note: Childhood conditions (represented by an ellipse) is a latent variable and adult conditions and nutrition (represented by rectangles) are observed variables. The model also includes other control variables: age group, sex, lifestyle factors (smoking, alcohol consumption and level of physical activity), presence of any chronic diseases, presence of any form of ill-treatment/abuse, and monthly per capita expenditure*

bias due to measurement error [42]. SEM is an advanced statistical analysis that allows for the analysis of multiple independent and dependent variables. Using SEM, we tested the direct and indirect effect of childhood conditions on nutrition status in old age and the mediating effect of adulthood conditions on the above association. The p-value less than 0.05 was considered statistically significant. All the analyses were conducted using Stata 16.1 (SE) software.

SEM was carried out as per the four-step approach as suggested by Kline [43]. Figure 2 shows the four-step approach for conducting SEM analysis.

Model specification

A hypothetical model for the mediating effect of adult conditions on the association between childhood conditions and nutrition status was developed following literature review as shown in Fig. 3. A manifest or observed variable (represented by rectangles) is a variable which can be measured directly. On the other hand, a latent variable (represented by ellipses) is one which can neither be measured directly nor observed but can be inferred from observed variables. For our analysis, we constructed one latent variable (childhood conditions) which was defined by four observed variables- father's education, mother's education, status of childhood wealth and status of childhood health.

Model identification

Model identification was utilized to test the internal consistency of the model and uniqueness of the model parameters. Three rules have been put forth for model identification: (1) the t-rule (df ≥ 0); and (2) three (or two) indicator rule.

- *The t-rule*: The t in t-rule indicates the number of free parameters specified in the model. It is used to test the degree of freedom (d.f.) which is calculated by subtracting the unique elements in the variance covariance matrix from the number of parameters. In other words, the value of t is equal to or less than half the number of manifest variables multiplied by the number of manifest variables plus 1 [$t \leq (1/2)*p*(p+1)$]. For the model to be identified, the degree of freedom should be greater than or equal to zero. It is a necessary but not sufficient condition for model identification.
- *Three indicator rule*: This rule depicts the minimum number of indicators to be used for determining factors in the model, which varies based on the number of factors to be determined. For instance,

at least three manifest variables are needed to determine a single factor in the model. The latent variable in our study (childhood conditions) was determined by four manifest variables (father's education, mother's education, status of childhood wealth and status of childhood health).

Model estimation

The factor loadings in the measurement model are a representation of the relationship between the observable variables and latent variable. Each observable variable's ability to accurately reflect the underlying latent variable is demonstrated by the factor loadings. Standardised factor loadings must typically be over 0.30 to be deemed an acceptable indicator, although values above 0.5 are preferred [41]. In our model, estimating direct, indirect, and overall effects illustrates the two ways that early life influences later-life health. The total impact is the sum of the direct and indirect effects (i.e., those mediated by at least one intermediate variable), where the direct effect is the degree to which childhood conditions affect old age nutrition directly, i.e., unmediated by any other variables. The word "effect" is employed in a technical meaning and does not indicate a causal relationship in the sense of the framework for probable outcomes [42].

Table 1 Socio-economic profile of older adults in India, ($n = 31,464$)

Background factors	Sample	Percentage
Childhood SES		
Paternal education		
Not educated	22,544	71.7
Educated	8919	28.3
Maternal education		
Not educated	29,386	93.4
Educated	2078	6.6
Financial status during childhood		
Good	2633	8.4
Average	15,009	47.7
Poor	13,822	43.9
Childhood Health		
Status of childhood health		
Poor	1160	3.7
Good	30,304	96.3
Adult SES		
Education		
No education	21,382	68
Primary	3520	11.2
Secondary	4371	13.9
Graduate and above	2191	7
Working status		
Never worked	8315	26.4
Started work during childhood	12,867	40.9
Started work during adulthood	10,282	32.7

Evaluation of the overall model was done using six goodness-of-fit indices, including (1) chi-square test of model fit; (2) root mean square error of approximation (RMSEA); (3) comparative fit index (CFI); (4) Tucker-Lewis index (TLI); (5) chi-square test of baseline model; (6) standardized root mean square residual (SRMR). These six indices determine how well the defined model fits the data. The model is considered fit when (1) p-value determined by chi-square test is not significant ($p > 0.05$; however, since this indicator is affected by the sample size and distributional misspecification, it is relatively unimportant); (2) RMSEA is less than 0.05; (3) CFI is greater than 0.95; (4) TLI is greater than 0.95; (5) the p-value associated with chi-square test of baseline model is less than 0.05; and (6) SRMR is less than 0.08 [43]. The mediation effects are estimated with 95% confidence intervals.

Model re-specification

The last step, model re-specification includes the modification of the indices of the model, to improve the goodness-of-fit values and to minimize the complexity of the model by removing the unknown parameters [43].

Results

Table 1 provides a detailed socio-economic profile of older adults in India ($n = 31,464$), divided into childhood socio-economic status (SES) and adult SES. A significant portion of older adults had uneducated parents, with 71.7% reporting no paternal education and an even higher 93.4% reporting no maternal education. About 43.9% of respondents reported poor financial conditions in childhood, while 47.7% described their financial status as average. The vast majority, 96.3%, reported good childhood health, while 3.7% reported poor health during childhood.

In adulthood, 68% of older adults remained without formal education, indicating low educational attainment. 11.2% completed primary education, while 13.9% completed secondary education. A small minority, 7%, attained graduate-level education or above. Regarding employment, 26.4% of older adults never worked, while 40.9% started working during childhood, which may suggest early entry into labor force due to economic necessity. 32.7% started working during adulthood, showing delayed entry into the workforce for a sizable portion of the population.

In order to assess whether the missing cases had any effect on the sample, a socio-economic profile was done for the entire sample and the results obtained were compared from Table 1. Since no notable differences were found between the two, it was decided to drop the missing cases and proceed with the analysis.

Table 2 shows the percentage distribution of malnutrition among older adults based on childhood and adult

Table 2 Percentage distribution of malnutrition among older adults as per childhood and adult characteristics

	Underweight (%)	Overweight (%)
Childhood SES		
Paternal education		
Not educated	29.3	18.4
Educated	15.7	37.7
Maternal education		
Not educated	27.5	20.9
Educated	19.6	32.5
Financial status during childhood		
Good	18.8	37.1
Average	23.4	24.6
Poor	32.4	15.7
Childhood Health		
Status of childhood health		
Poor	31.8	19.7
Good	26.3	22.1
Adult SES		
Education		
No education	32.2	16.5
Primary	20.8	26.9
Secondary	10.7	38.7
Graduate and above	5.6	46.7
Working status		
Never worked	22.6	30.4
Started work during childhood	32.4	14.7
Started work during adulthood	27.5	19.6

characteristics, specifically for being underweight and overweight.

Among 60 + individuals whose fathers were not educated, 29.3% were underweight. This percentage decreased to 15.7% among individuals whose fathers were educated. Similarly, among individuals whose mothers were not educated, 27.5% were underweight, whereas among those with educated mothers, the percentage was lower at 19.6%. Among 60 + individuals who had good financial status during childhood, 18.8% were underweight, whereas this percentage was higher among those with an average (23.4%) or poor (32.4%) financial status.

A higher proportion of older adults who had poor childhood health were underweight, with 31.8% falling into this category. In contrast, among those who had good childhood health, 26.3% were underweight. Among those with no education, 32.2% were underweight, whereas only 5.6% of those with graduate and above education were underweight. A higher proportion of individuals who started working during childhood (32.4% underweight) or during adulthood (27.5% underweight) were underweight as compared to those who never worked (22.6% underweight).

Table 3 Logistic regression analysis of childhood SES and childhood health as predictors of old age nutrition

	Underweight		Overweight	
	AOR	95% CI	AOR	95% CI
Childhood SES				
Paternal education				
Not educated (ref.)				
Educated	0.85*	(0.77, 0.94)	1.21*	(1.12, 1.32)
Maternal education				
Not educated (ref.)				
Educated	1.06	(0.93, 1.21)	0.96	(0.86, 1.08)
Financial status during childhood				
Good (ref.)				
Average	0.98	(0.87, 1.12)	0.97	(0.88, 1.08)
Poor	1.24*	(1.09, 1.42)	0.74*	(0.66, 0.83)
Childhood Health				
Status of childhood health				
not good (ref.)				
Good	0.86*	(0.80, 0.95)	1.06	(0.97, 1.17)
Adult SES				
Education				
No education (ref.)				
Primary	0.62*	(0.57, 0.68)	1.70*	(1.57, 1.84)
Secondary	0.39*	(0.34, 0.45)	2.29*	(2.07, 2.53)
Graduate and above	0.23*	(0.18, 0.32)	2.43*	(2.11, 2.81)
Working status				
Never worked (ref.)				
Started work during childhood	1.26*	(1.15, 1.39)	0.68*	(0.61, 0.75)
Started work during adulthood	1.22*	(1.13, 1.32)	0.77*	(0.71, 0.82)

Note: CI- Confidence Interval; AOR: Adjusted odds ratio; Models are controlled for relevant background characteristics; *$p < 0.01$; **$p < 0.05$

Among 60 + individuals whose fathers were not educated, 18.4% were overweight. This percentage increased to 37.7% among those with educated fathers. A higher proportion of individuals who had a good financial status during childhood (37.1% overweight) were overweight compared to those with an average (24.6% overweight) or poor (15.7% overweight) financial status during childhood.

The first part of Table 3 shows the results of a logistic regression analysis investigating the association between childhood socioeconomic status (SES), childhood health and the likelihood of being underweight. The table contains the Adjusted Odds Ratios (AOR) and their corresponding 95% Confidence Intervals (CI) for different factors.

Individuals whose fathers were educated have an AOR of 0.85 (95% CI: 0.77–0.94) for being underweight. This suggests that having an educated father is associated with a lower likelihood of being underweight during old age. Maternal education doesn't have a statistically significant

impact on the likelihood of being underweight. Individuals with poor financial status during childhood have an AOR of 1.24 (95% CI: 1.09–1.42), indicating that experiencing poor financial status during childhood is associated with a higher likelihood of being underweight in old age. Individuals who had good childhood health have an AOR of 0.86 (95% CI: 0.80–0.95) for being underweight. This suggests that having good childhood health is associated with a lower likelihood of being underweight in old age. In terms of education, individuals with "Primary," "Secondary," and "Graduate and above" education levels have significantly lower AORs (0.62 (95% CI: 0.57, 0.68), 0.39 (95% CI: 0.34, 0.45), and 0.23 (95% CI: 0.18, 0.32), respectively) compared to those with no education (the reference category). This implies that higher levels of education are associated with a significantly reduced likelihood of being underweight in old age. Individuals who started working during childhood and adulthood have AORs of 1.26 (95% CI: 1.15, 1.39) and 1.22 (95% CI: 1.13, 1.32), respectively, compared to those who never worked. This suggests that starting work during childhood and adulthood is associated with a higher likelihood of being underweight in old age.

Table 3 shows the results of a logistic regression analysis investigating the association between childhood socioeconomic status (SES), childhood health and the likelihood of being overweight. Individuals whose fathers were educated have an AOR of 1.21 (95% CI: 1.12–1.32) for being overweight, compared to those with uneducated fathers. This suggests that having an educated father is associated with a higher likelihood of being overweight in old age. In contrast, maternal education doesn't show a significant association with being overweight. Interestingly, individuals who had poor financial status during childhood have a significantly lower AOR of 0.74 (95% CI: 0.66–0.83) for being overweight in adulthood. This implies that having a poor financial status during childhood is associated with a reduced likelihood of being overweight. While individuals with good childhood health have an AOR of 1.06 (95% CI: 0.97–1.17) for being overweight compared to the reference category (those who had poor childhood health), this result is not statistically significant. It suggests that childhood health status might not be a significant predictor of adult overweight. Higher levels of education are associated with a significantly increased likelihood of being overweight. AORs increase as education levels rise. For example, individuals with primary education have an AOR of 1.70 (95% CI: 1.57, 1.84), those with secondary education have an AOR of 2.29 (95% CI: 2.07, 2.53), and those with graduate and above education had the highest AOR of 2.43 (95% CI: 2.11, 2.81) for being overweight, all compared to individuals with no education. Individuals who started working during childhood and adulthood have lower AORs for being overweight compared to those who never worked. This suggests that working during childhood or adulthood is associated with a reduced likelihood of being overweight.

Table 4 Factor loadings of latent variables

Childhood conditions	Factor loadings
Father's education	0.77
Mother's education	0.50
Status of childhood wealth	0.52
Status of childhood health	0.69

Table 4 presents the factor loadings of latent variables related to childhood conditions. Factor loadings represent the strength and direction of the relationship between the observed variables (in this case, father's education, mother's education, status of childhood wealth, and status of childhood health) and the underlying latent variable The values in this table indicate how strongly each observed variable contributes to or loads onto the latent variable. Factor loading for father's education is 0.77, meaning father's education has a strong positive relationship with the underlying latent variable. In the context of this study, a higher level of father's education contributes significantly to the measurement of the latent variable related to childhood conditions. Factor loading for father's education is 0.50, suggesting that mother's education also contributes to the measurement of the latent variable but with a somewhat weaker positive relationship. A factor loading of 0.52 suggests that childhood wealth status plays a moderate role in measuring the latent variable related to childhood conditions. Status of childhood health has a relatively strong positive relationship with the latent variable (with a factor loading: 0.69).

The unstandardized adjusted direct, indirect and total effect of childhood conditions and adult conditions on underweight is shown in Fig. 4; Table 1 (Appendix). The SEM explained 78% of the variance in underweight. Results shows that the direct effect of education on underweight was significant (β= -0.08; 95% CI: -0.09, -0.07). For each unit increase in adult education, there is a decrease of 0.08 units in the likelihood of being underweight in old age. The direct effect of working status on underweight was also significant (β = 0.03; 95% CI: 0.02, 0.04). A one-unit increase in working status is associated with an increase of 0.03 units in the likelihood of being underweight in old age. Additionally, the direct effect of childhood conditions on underweight was also significant (β= -0.07; 95% CI: -0.10, -0.05). For each unit increase in childhood conditions, there is a decrease of 0.07 units in the likelihood of being underweight. This effect suggests that better childhood conditions are associated with a reduced likelihood of being underweight in old age. The indirect (β= -0.12; 95% CI: -0.13, -0.10) and total (β= -0.19; 95% CI: -0.21, -0.17) effect of childhood

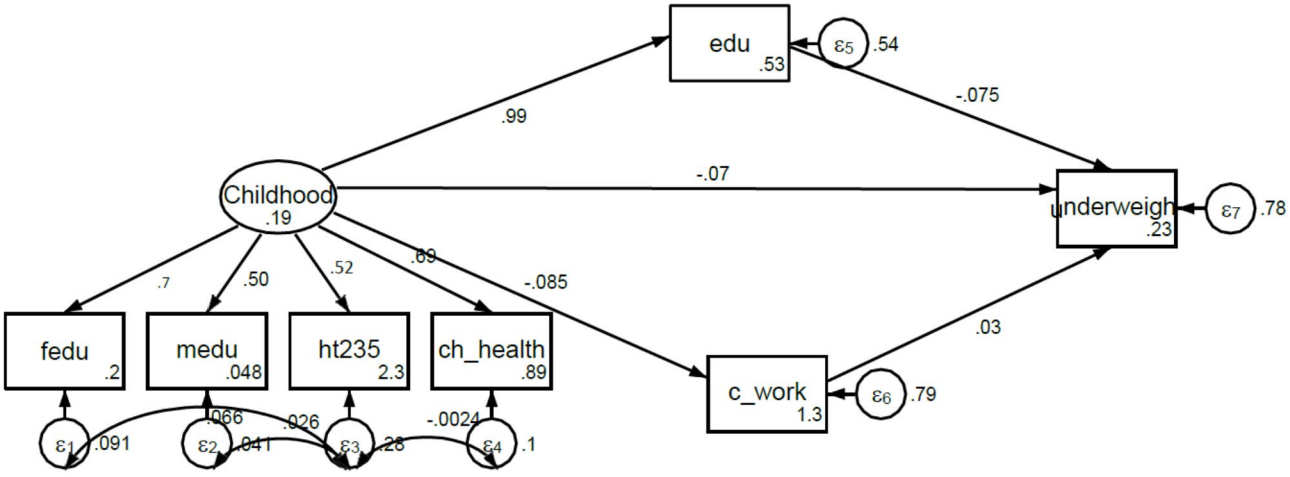

Fig. 4 Structural equation model for underweight with path coefficients.
Note: fedu- Father's education; medu- Mother's education; ht235- Status of childhood wealth; ch_health- Status of childhood health; edu- Education; c_work- Working status

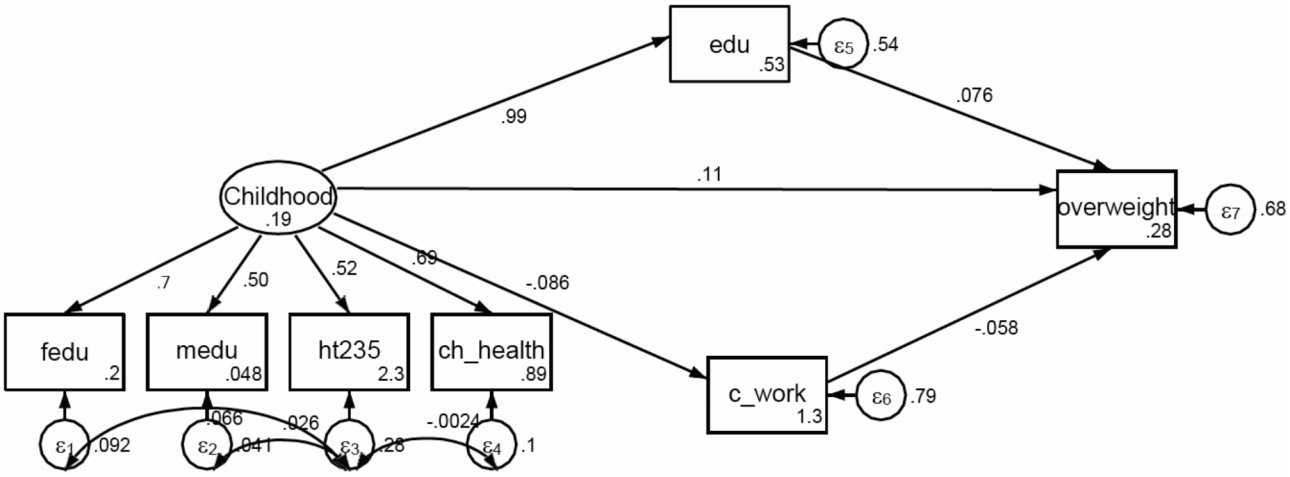

Fig. 5 Structural equation model for overweight with path coefficients.
Note: fedu- Father's education; medu- Mother's education; ht235- Status of childhood wealth; ch_health- Status of childhood health; edu- Education; c_work- Working status

conditions on underweight was significant. The indirect effect is -0.12, indicating that the effect of childhood conditions on underweight is partly mediated by education and working status. The total effect combines both the direct and indirect effects. For each unit increase in childhood conditions, there is a total decrease of 0.19 units in the likelihood of being underweight in old age. This suggests that better childhood conditions are associated with a reduced likelihood of being underweight, and this effect is statistically significant (p-value = 0.00).

Regarding model fit, although p-values for both the chi-square tests are significant, we ignore it since it is sensitive to sample size and distributional misspecification. The other goodness-of-fit indices indicate good fit with an RMSEA value of 0.04, comparative fit index (CFI) of 0.98, Tucker-Lewis index (TLI) of 0.94 and standardized root mean square residual value of 0.04.

The unstandardized adjusted direct, indirect and total effects of childhood conditions and adult conditions on overweight is shown in Fig. 5; Table 2 (Appendix). The SEM explained 68% of the variance in overweight. Results shows that the direct effect of education on overweight was significant (β = 0.08; 95% CI: 0.07, 0.09), implying that for each unit increase in adult education, there is a 0.08 unit increase in the likelihood of being overweight in old age. The direct effect of working status on overweight was also significant (β= -0.06; 95% CI: -0.07, -0.05), suggesting that a one-unit increase in working status is associated with a decrease of 0.06 units in the likelihood of being overweight in old age. Additionally, the direct effect of childhood conditions on overweight was also

significant (β = 0.11; 95% 95% CI: 0.11, 0.16). This represents the direct effect of childhood conditions on being overweight in old age, without considering the mediators (education and working status). A one-unit increase in childhood conditions leads to a 0.11 unit increase in the likelihood of being overweight in old age. The indirect (β = 0.12; 95% CI: 0.11, 0.13) and total (β = 0.25; 95% CI: 0.23, 0.28) effect of childhood conditions on overweight was significant.

Regarding model fit, although p-values for both the chi-square tests are significant, we ignore it since it is sensitive to sample size and distributional misspecification. The other goodness-of-fit indices indicate good fit with an RMSEA value of 0.05, comparative fit index (CFI) of 0.91, Tucker-Lewis index (TLI) of 0.98 and standardized root mean square residual value of 0.03. Thus, the results suggest that childhood conditions have both direct and indirect effects on being overweight in old age, with the model fitting the data reasonably well based on various fit indices.

Discussion

There is a growing body of evidence that suggests that childhood disadvantage can have a long-term impact on adult health and well-being, including nutrition status. However, there is a lack of research on this topic in India, particularly among older adults. Understanding the association between childhood disadvantage and malnutrition in older ages and the factors that contribute to malnutrition in older adults could have important implications for the prevention and management of malnutrition in older adults in India. The research aims to systematically examine the impact of multiple domains of early disadvantage on nutrition status during old age, while testing for potential mediation by adult health, socio-economic status, and lifestyle.

The results provide valuable insights into the complex relationship between early life factors i.e. childhood socio-economic status and later-life health outcomes i.e. malnutrition in older ages. The findings show that both childhood factors such as SES, parental education, and financial conditions significantly influence the late-life nutritional status. Moreover, in the adulthood, educational attainment, employment status and working conditions as a mediator also showed a significant association between childhood SES and nutritional status. The study highlights that adult education and working status mediate the relationship between childhood conditions and nutrition in old age.

These findings are consistent with previous research conducted in European countries, which has shown that childhood conditions, such as parental education, financial status, and health, have a significant impact on adult health outcomes occurrences [44]. Evidence shows that individuals with higher parental education tend to experience better health and lower mortality rates in old age [41]. Finding that poor childhood financial status is associated with a reduced likelihood of being overweight in old age is intriguing and requires careful consideration. While this result might seem counterintuitive given the prevailing understanding of the association between socioeconomic disadvantage and obesity [45], it could be indicative of complex interactions between socioeconomic factors and lifestyle choices that influence weight status. Less access to processed foods and sugary drinks, which are major contributors to overweight and obesity may reduce the risk of overweight among them. This finding is in line with a study that reported that children who experienced poverty during childhood were more likely to be underweight in adulthood [46]. Poor SES being a multi-faceted construct [47] deprives individuals of basic needs and negatively impacts educational outcomes [48]. Additionally, some found that individuals who experienced poverty during childhood were more likely to have chronic health conditions, such as heart disease, stroke, and diabetes, in adulthood studies [49, 50]; which can also lead to obesity [49, 51]. A recent meta-analysis highlighted the complex interplay between early life stressors, socio-economic disadvantage, and long-term health consequences, underscoring the need for comprehensive public health strategies to promote early intervention and preventive measures [52].

The effect of childhood conditions on overweight was significant suggesting that better childhood conditions are associated with a higher risk of being overweight in old age. This result contradicts some previous research, which has often highlighted the protective role of early-life advantages against the risk of being overweight [53, 54]. A study by Hertzman [55] highlights the concept of the "biological embedding" of early experiences, suggesting that early adversity, including inadequate nutrition and socio-economic disadvantage, can have enduring effects on health and development. Braveman and Gottlieb [56] discuss how socio-economic factors, including parental education and wealth, influence health disparities and underscore the need for policies aimed at reducing health inequalities across the life course. In contrast, an inverse association is reported between low socioeconomic status during childhood and adulthood obesity/overweight [57, 58]. This is likely due to several factors, including the impact of childhood conditions on physical development, cognitive function, and health behaviours.

Results show that adult education and working status impact nutritional status at adult ages. For example, individuals with higher levels of education are more likely to have jobs that provide access to healthy food and opportunities for physical activity. Additionally, individuals who are employed are more likely to have access to health

insurance, which can help them manage chronic diseases and other health conditions that can lead to malnutrition. A meta-analysis underscores the link between employment status and health outcomes, indicating that working conditions and job security can influence nutritional patterns [59]. Findings that working during adulthood had a higher likelihood of being underweight underscores the need to explore the working conditions, job types, and socioeconomic factors that may contribute to this relationship. Previous studies have established that adult smoking is inversely correlated with socioeconomic disadvantage throughout childhood [60, 61]. Since smoking protects against a higher body mass index, this inverse gradient tends to offset the gradient in obesity; instead, smoking is predictive of central obesity [62, 63].

Similar to previous studies [44], the addition of the mediator variable i.e. adulthood education and employment status decreased the coefficients although the effect remained positive. Higher levels of education reduced the likelihood of being underweight. This finding aligns with previous research highlighting the protective role of education in promoting better health outcomes in later life [53] with implications for both overweight and underweight [54]. Comparatively, a positive relationship between education and overweight or obesity is observed in low- and middle-income countries [62]. Additionally, the mediating role of education between childhood SES and health at older age (CVD, self-rated health, and impaired mobility) has been well documented [63]. An examination into the effects of early-life socio-economic adversity on nutritional status highlights the intricate interplay between poverty, work, and nutritional deficiencies [64]. This relationship between working status and malnutrition warrants further exploration, as it diverges from some previous research that often associates employment with better access to resources and better health outcomes [59]. The work of Marmot [65] on the social gradient in health emphasizes how socioeconomic disadvantage, including early engagement in labour, can perpetuate health disparities across the life course.

Recent data suggests that socioeconomic disparities in obesity may be narrowing, indicating that the obesity pandemic is becoming more prevalent [66]. We acknowledge the ongoing discussion about the optimal time to intervene; for instance, Heckman [67] argues that investing is best done during childhood. Specifically, the explains that investing as early as possible—between birth and age five—results in the highest rate of return in early childhood development. However, to yield the intended results, any investment made during childhood must be followed up on later [68]. The study's unexpected result regarding the direct effect of childhood conditions on overweight warrants further exploration by considering the "nutrition transition" framework [69].

Conclusion

In conclusion, this study adds to the body of literature on the relationship between childhood conditions and later-life health outcomes. It underscores the importance of considering both direct and indirect effects in understanding the pathways through which early life experiences influence nutritional status in old age. The unexpected finding regarding the direct effect of childhood conditions on overweight in the Indian context raises important questions about the complexities of nutrition and health in this population. The study's findings highlight the need for context-specific research to better understand the factors contributing to overweight and obesity in diverse populations. Further research is needed to explore the cultural and contextual factors that may contribute to this unexpected relationship.

Recommendations

The findings of this study have important implications for the prevention of malnutrition in old age. It is important to invest in programs that promote early childhood development and ensure that all children have access to healthy food and quality education which could help to reduce the risk of being underweight and other health problems in old age. Additionally, it is important to support programs that help older adults to maintain a healthy weight and manage chronic diseases. Interventions that aim to improve childhood conditions, such as early childhood education programs and programs that provide financial assistance to low-income families.

Limitations

Due to the limited availability of the mediator factors and direct factors, we cannot address some factors that may also explain old age health, such as birth weight, diseases such as pneumonia, size at birth, and more behavioural risk in adulthood. Owing to the retrospective nature of these responses, these variables may be prone to recall bias. This analysis, being a cross-sectional one (i.e. BMI was measured at one point in time), limits causality. Causality cannot be attributed to the observed associations between childhood SES and adulthood obesity solely. Measuring childhood SES during childhood instead of retroactively recalling it during adulthood may allow for a more precise estimation of associations. It should be noted that BMI is influenced by lifestyle factors like exercise and food, which might have an impact on weight growth. However, since these factors were measured concurrently, we were unable to develop a model that examines how these health behaviours can moderate BMI. Notwithstanding these drawbacks, the study's unique

design made it possible to thoroughly evaluate the relationships between pertinent childhood and adult variables and nutrition in later life.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05727-w.

Supplementary Material 1

Author contributions

Conceptualization- AS and AC, Data curation and analysis- AS, Writing (original draft)- AS and NS, Writing (revised draft)- AS, AC and NS, Supervision- AC.

Data availability

Data is publicly available on request from the IIPS website using the following link https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf.

Declarations

Consent for publication

Since the study was based on secondary data, consent for publication was not applicable.

Competing interests

The authors declare no competing interests.

Ethical approval and consent to participate

Since the study was based on secondary data, ethical approval and consent to participate was not applicable.

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