Health Empirics

HEALTH EMPIRICS

Journal of the Indian Health Economics and Policy Association
Volume 1, Issue 2, June 2026

IHEPA
Indian Health Economics and Policy Association

ISSN-

Health Empirics

Volume 1 | Issue 2 | June 2026

ISSN:

PUBLISHER

Health Empirics is published by the Indian Health Economics and Policy Association (IHEPA).
Registered Office: Centre for Multi-Disciplinary Development Research (C.M.D.R)
Dr. B.R. Ambedkar Nagar, Lakamanahalli, Dharwad, Karnataka – 580 004, India.
Secretariat & Editorial Office: Department of Economics, Tripura University, Suryamaninagar, West Tripura, Tripura, India, PIn- 799022.

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Email: secretary.ihepa@gmail.com | editor@healthempirics.org

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(Form IV — See Rule 8)

Place of Publication: Department of Economics, Tripura University (A Central University), Suryamaninagar, Agartlala, Tripura - 799 022, India

Periodicity of Publication: Quarterly

Publisher's Name: Secretary, Indian Health Economics and Policy Association (IHEPA)

Editor's Name: Udaya Shankar Mishra, International Institute for Population Sciences (IIPS), Mumbai, India

Owner: Indian Health Economics and Policy Association (IHEPA)

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Editorial Note

Udaya Shankar Mishra*
Editor-in-Chief, Health Empirics

The second issue of Health Empirics furthers its commitment to evidence-based research into the interconnected forces contributing to health and welfare. Its contributions encompasses a range of health concerns of life including childhood nutrition, management of chronic illnesses, financial vulnerability and longevity into older ages. Evaluation of household, institutional and policy environments together reveal that good health is a derivative of public-sector initiatives, socioeconomic conditions, migration, food conditions, healthcare systems and distribution of risk.

The issue opens with Singh's assessment of Supplementary Nutrition Programme under the Integrated Child Development Services resulting in improvement in minimum dietary diversity among children aged 6-23 months. The study observes that regular supplementation is associated with greater dietary diversity, particularly among rural, poorer, and nutritionally disadvantaged populations. Rinju explores the relationship between household mobility and child nutrition. It offers a differentiated account, demonstrating that child nutritional outcomes are shaped by migration streams as well as household wealth, parental education, and regional living environment.

Kumar and Joe build on the discussion on changing food environments by evaluating the potential effects of front-of-package warning labels on overweight and obesity among Indian adolescents. The warning labels are identified as a potentially low-cost, high-impact intervention, while the projected effects depend on behavioural assumptions and limited cost evidence.

Kulkarni et al. address chronic disease management through an innovative reconstruction of a diabetes cohort from electronic medical records and enabling analysis of diabetes incidence, transitions between glycaemic states, excess morbidity, and seasonal variation. The paper also illustrates the potential of electronic medical records to strengthen long-term community-based research where prospective cohorts are costly and difficult to sustain.

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Dasgupta and Mukherjee assessed the exposure of risk to poor resulting from health shocks in consecutive National Sample Surveys. The analysis transcends diseases and household financial stability to reveal consistently greater risk among households headed by women, households with inadequate sanitation access, less educated, rural, and the uninsured. The unanticipated observation that households included under public insurance schemes being more susceptible highlights the need to reassess the scope, structure and adequate protection offered by the insurance schemes.

John et al.'s study offers fresh evidence on account of the socioeconomic inequality in survival to older age. The study records shorter life expectancy among poorer households with Scheduled Tribes and Scheduled Castes documenting significant differences in longevity among economic and social groups. It conveys that ageing is shaped by social inequalities.

The issue concludes with Sethy and Das's review of the book entitled 'Paradigm Shifts in Population and Health in India: An In-depth Analysis of SDGs' edited by Sanghmitra S. Acharya, Sampurna Kundu, Sampurna Singh. The review notes the comprehensive analytical approach and emphasis laid on caste, gender, migration, spatial inequality, digital health and marginalised communities along with calling for a more robust theoretical foundation and clearer policy direction.

A shared theme highlighted across the studies relates to health disparities developing at the earliest stages of life, often altered through education, migration, wealth, government intervention, are manifested in chronic health conditions, economic vulnerability and has a ultimate bearing on individual longevity. The studies also underscore the broadening scope of research methodologies in healthcare, ranging from large-scale national surveys to electronic health records and microsimulation.

The mandate of Health Empirics is served by providing a platform for systematic evaluation, innovative research methods and policy relevant health research. We hope these studies foster continued investigation into institutional and social conditions that provide sustainable, equitable, and inclusive health and welfare. I extend my sincere appreciation to the authors, reviewers, Editorial Board, Associate and Managing Editors along with the Indian Health Economics and Policy Association, and the journal support team whose collective efforts made this issue possible.

Targeting Nutrition in Early Life: Evidence on ICDS and Minimum Dietary Diversity in India

Swati Singh[#]

Despite sustained public investment in child nutrition, dietary diversity among young children in India remains inadequate. This study evaluates whether the Supplementary Nutrition Programme (SNP) under the Integrated Child Development Services (ICDS) improves Minimum Dietary Diversity (MDD) among children aged 6–23 months. Using NFHS-5 data covering 64,725 children, we estimate the association between the frequency of SNP receipt and MDD using logistic regression. Further, propensity score matching (PSM) is employed to address observable selection bias. Regular SNP supplementation (daily/weekly) significantly increases the likelihood of achieving MDD at the national level (OR 1.8; 95% CI 1.6, 2). However, interstate variation exists. In states with less diversified ICDS food menus (Bihar, Rajasthan, Chhattisgarh, Haryana), regular supplementation is positively associated with MDD (OR 1.5; 95% CI 1.2–1.8), but not in states with more diversified menus (Kerala, Telangana, Gujarat, Odisha). It significantly increases dietary diversity among rural and poorer households, with stronger effects also observed in Empowered Action Group (EAG) states (OR = 1.30; 95% CI: 1.13–1.48). ICDS supplementary nutrition improves dietary diversity among vulnerable child populations, especially in poorer and nutritionally disadvantaged regions, though broader nutritional gains remain limited.

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Dietary diversity serves as a key indicator of food consumption patterns, reflecting both household access to a variety of foods and the adequacy of nutrient intake. In this context, the World Health Organization's (WHO) indicator of Minimum Dietary Diversity (MDD) for children aged 6–23 months is widely used as a proxy for the micronutrient quality of a child's diet. Adequate dietary diversity is particularly important for child health, as insufficient intake of essential nutrients can adversely affect survival, physical growth, and cognitive development (UNICEF, 2019). Examining patterns of dietary diversity also helps identify specific food groups that are under-consumed in children's diets. Recent evidence suggests that children in India who do not meet MDD standards are less likely to consume fresh foods, including vitamin A-rich fruits and vegetables (Beckerman et al., 2020).

Malnutrition is a global health concern with diverse causes, including inadequate dietary patterns, socio-economic conditions, and health disparities. The literature has primarily focused on anthropometric measures (such as height-for-age, weight-for-age, or weight-for-height) to combat child malnutrition (Corsi et al.,2011; Maternal, L., 2013). However, dietary patterns have been overlooked even though a lack of a diversified diet is one of the leading causes of child malnutrition (UNICEF, 2020). While anthropometric measurements capture genetics, environment, and illness exposure (Perkins et al., 2016), they do not necessarily exhibit nutritional inadequacies. Estimating the MDD among children is also important to aid youngsters with nutritional deficiencies (Moursi et al., 2008), even in the absence of any anthropometric failure. For instance, 36% of children in India were estimated to be stunted in 2021, but 78% of children were unable to attain MDD (Fanzo et al., 2019). Furthermore, vitamin A deficiency is 30 percentage points more common than stunting among children under five (Black et al., 2013).

A child aged 6–23 months was considered to have achieved MDD if he or she consumed foods from at least four out of seven specified food groups, typically including fruits or vegetables, animal-source foods, and staple items (WHO, 2008; 2010). In 2017, the WHO–UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM) revised this indicator by adding breast milk as an eighth food group and increasing the threshold to five out of eight food groups (WHO, 2021). The Infant and Young Child Feeding (IYCF) guidelines similarly stress the importance of consuming foods from multiple food groups to ensure adequate nutrient intake among children aged 6–23 months. More broadly, regular consumption of a diverse range of foods is widely recognised as a useful proxy for dietary quality in early childhood (Mishra & Ray, 2009; Ruel et al., 2010).

In India, the Integrated Child Development Services (ICDS) scheme was introduced on October 2, 1975, as a national initiative to improve the health, nutrition, and development of young children and mothers. The ICDS targets vulnerable populations, particularly children under three years and pregnant or lactating women, providing

a crucial window for nutritional support. Services include immunization, health check-ups, supplementary feeding, and nutrition education, along with preschool education for children aged three to six years. Under the Supplementary Nutrition Programme (SNP), Take-Home Rations (THR) are distributed to bridge the gap between actual intake and Recommended Dietary Allowances, aiming to improve nutritional status (Talati et al., 2016).

Previous research has found limited evidence that ICDS programs have a substantial causal impact on reducing chronic child malnutrition (Kumar et al., 2006; Bhutta et al., 2008; Onis et al., 2013; Dixit et al., 2018). Some recent studies observed a positive impact of the ICSD program on children's height (Kandpal, 2011; Jain, 2015). When infants are introduced to a wider variety of food in addition to breast milk, it has been associated with lower rates of stunted growth, being underweight, and experiencing wasting (Chandrasekhar et al., 2017; Meshram et al., 2019). Understanding whether the provision of food supplements in the program increases dietary diversity among children is crucial as it might later contribute to the reduction in stunting, wasting, and underweight.

This paper focuses on delineating the impact of services under the ICDs program on dietary diversity among children. The key contribution of this study lies in its detailed exploration of the links between children's MDD and the ICDS services, particularly the receipt and frequency of food supplementation from Anganwadi/ICDS centres , across different contexts—states with more versus less diversified ICDS food menus, poor versus rich households, rural versus urban areas, and Empowered Action Group (EAG) versus non-EAG states. We used the multivariable logistic regression to estimate the odds ratio (ORs) of ICDS services and other personal and socioeconomic characteristics on MDD of children aged 6-23 months. Further, the paper compares the MDD of children aged 6-23 months who received supplementary food from Anganwadi (Treatment group) with those who didn't receive any supplements (Control group). Investigating the effect of supplementary food on diet diversity is challenging because individuals self-select themselves to receive supplementary food. There is a possibility that those who receive supplementary food are more educated, more motivated, or more aware. To establish the causal relation between supplements taken and diet diversity the individuals receiving supplements must be randomly selected. Therefore, we used propensity score matching (PSM) to address potential endogeneity arising from self-selection, under the assumption that differences influencing both the likelihood of receiving treatment and the outcome can be accounted for by observable pre-treatment characteristics.

The following sections of this paper are structured as follows: Section 2 presents details about the data, sample size, and the key variables employed in the study. Section 3 delves into the statistical methodologies that have been applied in the

analysis. Section 4 discusses the empirical results. Finally, Section 5, concludes and engage in a comprehensive discussion of the results.

Data

- **Study Population And Sample Size**

The study uses data from NFHS-5 (2019–21), a nationally representative survey covering all Indian states and union territories. It surveyed 7,24,115 women (15–49 years), providing information on 2,32,920 children under five. This analysis focuses on 64,725 children aged 6–23 months, consistent with WHO/UNICEF IYCF guidelines for assessing nutrient adequacy during the complementary feeding period (WHO, 2010).

- **Outcome - Food Consumption And Dietary Diversity**

In NFHS-5, mothers reported all foods consumed by their child in the previous 24 hours. Information on 16 food items was collected and aggregated into seven food groups following WHO IYCF guidelines (2008, 2010, 2021): (1) dairy products; (2) grains, roots and tubers; (3) vitamin A–rich fruits and vegetables; (4) other fruits and vegetables; (5) eggs; (6) flesh foods; and (7) legumes and nuts.

In 2017, WHO and UNICEF added an eighth group, breast milk, updating the MDD definition from consuming at least four of seven groups to at least five of eight groups (WHO, 2021). A dietary diversity score was created for each child, ranging from 0 to 8, where 0 indicates no consumption of any food item and 8 indicates consumption from all eight groups. Using this score, a binary variable for MDD was created, coded as 1 if a child consumed foods from five or more groups, and 0 if the score was four or less, indicating inadequate dietary diversity.

- **Primary Correlates**

To assess the impact of ICDS on MDD, the key explanatory variable captures whether a child received food supplements from an Anganwadi/ICDS centre. Mothers were asked how often the child received food in the past 12 months (not at all, almost daily, at least once a week, at least once a month, or less often). A binary variable was constructed, coded 1 if the child received food regularly (almost daily or at least once a week) and 0 if the child did not receive any food supplements.

- **Secondary Correlates**

The analysis controlled for a set of child, maternal, and household characteristics commonly associated with child dietary outcomes. These included child's sex, birth order, maternal education, maternal employment and dietary diversity, household

wealth, access to mass media, religion, caste, and region of residence. Maternal dietary diversity was measured using a score based on consumption from multiple food groups, with a binary indicator created for adequate diversity following FAO guidelines (FAO, 2021; Rajpal et al., 2021). Household wealth was derived from a standard asset-based index and categorized into quintiles. Region and other sociodemographic controls were included to account for contextual variation in dietary practices.

Methodology

To estimate the effect of supplementary food from Anganwadi centres on children's dietary diversity, we first employed a logistic regression model controlling for key sociodemographic characteristics:

$$Y_{ids} = \alpha_0 + \alpha_1 F_{ids} + X'_{ids}\alpha_2 + \epsilon_{ids}$$

Where Y_{ids} is a binary variable and takes the value 1 if MDD exits for child i from district d and state s, else it's 0. The frequency of receiving food supplements (F_{ids}) is a categorical variable. It has five categories: not at all, almost daily, at least once a week, at least once a month, and less often. X vector includes all the explanatory variables children's gender, birth order, child current illness, household wealth, mother's education, mother's employment status, mother's diet diversity, mass media, religion, caste, urban, improved sanitation, improved drinking water and regions. Further, the model is enhanced by incorporating state fixed effects (S) and district fixed effects (D) in equation (1) to strengthen the robustness of the logistic regression results. Lastly, to compare outcomes between EAG and non-EAG states, we add an interaction term between F_{ids} and EAG states in Equation (1). In other specification, regional controls are excluded from X to avoid multicollinearity.

Estimating the causal effect of supplementary food on children's dietary diversity is challenging due to self-selection, as participation in Anganwadi services is not random. Mothers who access these services may differ in education, awareness, and practices, which can bias results. To address this, we use propensity score matching (PSM) to estimate the average treatment effect on the treated (ATET), comparing children who received supplements with those who did not. The matching is based on observed characteristics such as child, maternal, and household factors, assuming selection depends only on these variables. Robustness checks are also conducted across subsamples.

Results

Figure 1 shows the prevalence of MDD among children aged 6–23 months across frequency of supplementation food. The x-axis represents the prevalence of MDD,

measured as the proportion of children meeting the MDD threshold, while the different bars on y-axis indicate program frequency of receiving supplementary food. Results show that breastfeeding children benefit most from regular supplementation, whereas non-breastfeeding children gain limited advantage, indicating that SNP alone may not be sufficient for this group. Over time, a modest increase in MDD prevalence is observed from NFHS-4 to NFHS-5 for all children, however, among non-breastfed children MDD prevalence has declined.

Figure 1: . Prevalence of MDD among children (6-23 months) by ICDS Food Supplementation and its Frequency, India, NFHS 4 & 5; S.F-Supplementary Food; Less- Less Often.

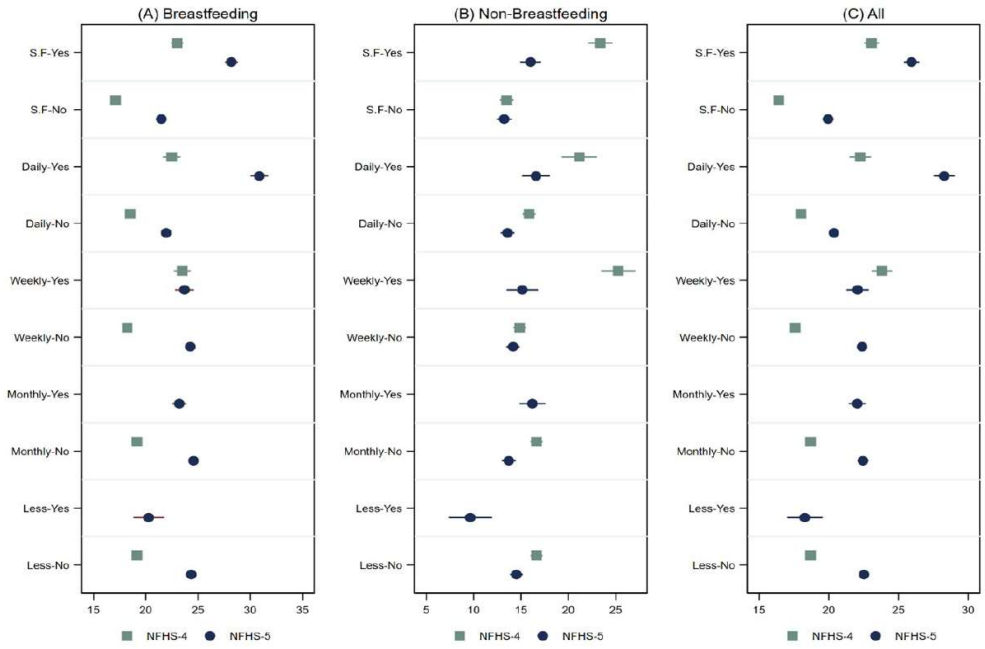

Table 1 presents summary statistics for children aged 6–23 months using NFHS-4 and NFHS-5. The share of children achieving MDD increased from 19% to 22%, while the proportion of breastfeeding children remained steady at 81%. Intake increased for most food groups, except grains, roots, and tubers (Group 2). ICDS services (supplementary nutrition, health check-ups, immunization, and early childhood care) aim to support child and maternal development. Between 2015–16 and 2019–21, children receiving any benefits rose from 51% to 77%, with supplementary nutrition coverage increasing from 34% to 71%. Although stunting, wasting, and underweight decreased, anaemia among children rose from 64% to 71%. Health check-ups and immunization improved, but early childhood care/

preschool participation fell sharply from 57% to 26%. Maternal characteristics show rising education levels, with more mothers attaining secondary or higher education, yet employment rates remained unchanged. Adequate maternal diet diversity increased from 48% to 53%, but anaemia also rose slightly from 56% to 60%.

Table 1. Descriptive Statistics for children aged 6–23 months (NFHS-5 and NFHS-4)

	NFHS 5 (2019-21) N=64,725		**NFHS 4 (2015-16) N=74,132**	
Variable	Mean	SD	Mean	SD
Infant & young child feeding				
Weaned (fed semisolid food in last 24 h)	0.24	0.43	0.21	0.41
Minimum dietary frequency[a]	0.32	0.46	0.31	0.46
Minimum dietary diversity	0.22	0.42	0.19	0.39
Breastfed (currently)	0.81	0.39	0.81	0.39
Consumed in last 24 h				
Dairy products	0.52	0.50	0.51	0.50
Grains, roots, and tubers	0.66	0.47	0.69	0.46
Vitamin A rich fruits and vegetables	0.41	0.49	0.39	0.49
Other fruits and vegetables	0.28	0.45	0.24	0.43
Eggs	0.17	0.38	0.14	0.35
Flesh foods	0.09	0.29	0.08	0.27
Legumes and nuts	0.17	0.38	0.13	0.34
ICDS services in past 12 months				
Received any benefits	0.77	0.42	0.51	0.50
Received food supplements	0.71	0.45	0.34	0.47
Never received food supplements	0.06	0.24	0.29	0.45
Received food supplements daily	0.25	0.43	0.16	0.37
Received food supp. At least once a week	0.15	0.36	0.18	0.38
Received food supp. At least once a month	0.27	0.44	NA	NA
Received food supp. Less often	0.04	0.20	NA	NA
Received health checkup regularly	0.51	0.50	0.28	0.45
Received immunization	0.65	0.48	0.31	0.46
Go to anganwadi for early childhood care	0.26	0.44	0.57	0.49
Child characteristics				
Female child	0.48	0.50	0.48	0.50
Birth order[b]	1.97	0.99	2.04	1.03
Nutrition outcomes[c]				
Stunting	0.32	0.47	0.33	0.47
Underweight	0.28	0.45	0.30	0.46
Wasting	0.19	0.39	0.22	0.41
Anaemic	0.71	0.45	0.64	0.48

	NFHS 5 (2019-21) N=64,725		NFHS 4 (2015-16) N=74,132	
Variable	Mean	SD	Mean	SD
Mother characteristics				
Mother not educated	0.19	0.39	0.27	0.45
Mothers completed primary education	0.11	0.31	0.14	0.34
Mothers completed secondary education	0.52	0.50	0.47	0.50
Mothers completed higher education	0.18	0.38	0.12	0.32
Mother anaemic	0.60	0.49	0.56	0.50
Mother's diet diversity[d]	0.53	0.50	0.48	0.50
Wealth index				
Lowest	0.24	0.43	0.24	0.43
Lower middle	0.21	0.41	0.22	0.41
Middle	0.20	0.40	0.20	0.40
Upper middle	0.19	0.39	0.19	0.39
Highest	0.16	0.37	0.15	0.36
Caste				
SC	0.23	0.42	0.22	0.41
ST	0.10	0.30	0.10	0.31
OBC	0.44	0.50	0.44	0.50
No caste	0.19	0.39	0.20	0.40
Religion				
Hindu	0.79	0.40	0.79	0.41
Muslim	0.16	0.37	0.16	0.37
Christian	0.02	0.14	0.02	0.14
others/no religione	0.02	0.15	0.03	0.16
Urban	0.27	0.44	0.28	0.45
Rural	0.73	0.44	0.72	0.45
Regions				
North Region	0.12	0.32	0.08	0.28
Northeast Region	0.04	0.19	0.13	0.33
West Region	0.13	0.33	0.01	0.12
East Region	0.27	0.44	0.27	0.44
Central Region	0.28	0.45	0.13	0.34
South Region	0.17	0.38	0.34	0.48

[a]Minimum meal frequency refers to two meals for breastfed infants aged 6–8 months, three meals for breastfed children aged 9–23 months, and four meals for non-breastfed children aged 6–23 months; [b]Birth order has 4 categories: 1, 2, 3 4+; [c]Stunting, wasting, and underweight are defined as height-for-age, weight-for-height, and weight-for-age Z-scores below -2 SD, respectively. Anaemia refers to haemoglobin levels below the WHO threshold for children; [d]Mothers were considered to have minimum dietary diversity if they are consuming food items daily or weekly from at least five of the nine food groups i.e., (Group 1) "milk/or curd"; (Group 2) "pulses or beans"; (Group 3) "dark green leafy vegetables"; (Group 4) "fruits"; (Group 5) "eggs"; (Group 6) "fish", (Group 7) "chicken or meat", (Group 8) "fried food", (Group 9) "aerated drinks"; eOthers include Sikh, Buddhist, Jain, Jewish, Zoroastrian; SD is Standard Deviation

Consistent with existing literature, ICDS, particularly SNP, has little effect on stunting, wasting, and underweight (Table A1, Supplementary Material S1). This study focuses on the association between children's MDD and ICDS food implementation programmes. Table 2 shows that children receiving food supplements daily or weekly have higher odds of achieving MDD compared to those who never receive them, with odds decreasing as frequency declines. Regular health check-ups are also positively linked to MDD.

Maternal education and diet diversity are positively associated with children's MDD (OR: 1.5, % CI: 1.48, 1.6). Maternal employment is linked to higher MDD (OR: 1.29, 95% CI: 1.24–1.34), and children who were recently ill show higher odds (OR: 1.40, 95% CI: 1.25–1.56). Households with mass media access (OR: 1.3, 95% CI: 1.18–1.44), improved sanitation (OR: 1.09, 95% CI: 1.04–1.15), and improved drinking water (OR: 1.13, 95% CI: 1.08–1.18) also have higher MDD. No significant rural–urban differences are observed nationally, and compared to the south, other regions have lower odds except the east. Findings remain consistent with state and district fixed effects (Table A2, S1).

Table 2. Adjusted Odds Ratios (OR) of MDD and ICDS Services, Children Aged 6–23 Months, India (NFHS-5)

	MDD-Child		MDD-Child		MDD-Child	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Received any benefits from ICDS						
No®						
Yes	1.22***	[1.14 1.30]				
Received food supplementation from ICDS						
No®						
Yes			1.33***	[1.24 1.43]		
Frequency of food supplementation from ICDS						
Never®					1.00	-
Daily Food Supplementation					1.78***	[1.59 1.98]
Weekly Food Supplementation					1.67***	[1.49 1.86]
Monthly Food Supplementation					1.55***	[1.39 1.72]
Less Often Food Supplementation					1.43***	[1.26 1.63]
Health Checkup	1.28***	[1.22 1.35]	1.20***	[1.14 1.26]	1.19***	[1.13 1.25]
Immunizations	0.86***	[0.81 0.91]	0.85***	[0.81 0.90]	0.86***	[0.82 0.92]
Early Childhood Care	1.00	[0.96 1.05]	0.99	[0.94 1.04]	0.96	[0.91 1.01]
Child Sex						
Male®						
Female	1.00	[0.96 1.04]	0.99	[0.95 1.03]	0.99	[0.95 1.03]

	MDD-Child		MDD-Child		MDD-Child	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Birth Order						
Birth Order-1®						
Birth Order-2	1.27***	[1.21 1.33]	1.26***	[1.20 1.32]	1.26***	[1.19 1.32]
Birth Order-3	1.12***	[1.05 1.19]	1.08*	[1.01 1.15]	1.08*	[1.01 1.15]
Birth Order-4	1.23***	[1.15 1.31]	1.22***	[1.13 1.32]	1.23***	[1.14 1.32]
Child Illness						
No®						
Yes	1.29***	[1.24 1.34]	1.28***	[1.23 1.34]	1.29***	[1.23 1.35]
Child Illness						
Weekly Food Supplementation					1.67***	[1.49 1.86]
Mother's Education						
No Education®						
Primary	1.09*	[1.02 1.17]	1.09*	[1.00 1.18]	1.08	[1.00 1.17]
Secondary education	1.17***	[1.11 1.24]	1.19***	[1.11 1.27]	1.18***	[1.11 1.26]
Higher education	1.27***	[1.17 1.37]	1.29***	[1.18 1.40]	1.28***	[1.18 1.40]
Mother's Currently Working						
No®						
Yes	1.40***	[1.25 1.56]	1.43***	[1.26 1.61]	1.42***	[1.26 1.61]
Mother's Dietary Diversity						
No®						
Yes	1.54***	[1.48 1.61]	1.52***	[1.45 1.59]	1.51***	[1.44 1.58]
Mother's Anemia Status						
No®						
Yes	1.01	[0.97 1.05]	1.00	[0.96 1.04]	1.00	[0.95 1.04]
Mass Media						
No®						
Yes	1.34***	[1.23 1.45]	1.32***	[1.20 1.45]	1.31***	[1.18 1.44]
Wealth Quintile						
Poorest®						
Poorer	1.00	[0.94 1.06]	1.02	[0.96 1.09]	1.02	[0.96 1.09]
Middle	1.07*	[1.00 1.14]	1.10**	[1.02 1.18]	1.10**	[1.02 1.18]
Richer	1.14***	[1.06 1.22]	1.18***	[1.09 1.28]	1.19***	[1.10 1.29]
Richest	1.23***	[1.13 1.34]	1.28***	[1.16 1.41]	1.30***	[1.18 1.43]
Social Category						
Schedule Castes®						
Schedule Tribes	1.18***	[1.11 1.25]	1.21***	[1.13 1.30]	1.21***	[1.13 1.29]
Other Backward Class	0.88***	[0.84 0.92]	0.89***	[0.85 0.94]	0.90***	[0.85 0.95]
Others	1.00	[0.94 1.06]	1.00	[0.93 1.07]	1.00	[0.93 1.07]

	MDD-Child		MDD-Child		MDD-Child	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Religion						
Hindu®						
Muslim	1.15***	[1.09 1.21]	1.14***	[1.07 1.22]	1.14***	[1.07 1.21]
Christian	1.49***	[1.37 1.63]	1.44***	[1.31 1.60]	1.42***	[1.29 1.58]
Others	1.26***	[1.14 1.39]	1.25***	[1.11 1.40]	1.23***	[1.10 1.39]
Improved Sanitation						
No®						
Yes	1.09***	[1.04 1.15]	1.09***	[1.04 1.15]	1.09**	[1.03 1.15]
Improved Drinking Water						
No®						
Yes	1.13***	[1.08 1.18]	1.11***	[1.06 1.17]	1.11***	[1.06 1.16]
Sector						
Rural®						
Urban	0.99	[0.94 1.04]	0.95	[0.90 1.02]	0.96	[0.90 1.02]
NFHS Regions						
South®						
North	0.87***	[0.81 0.94]	0.89**	[0.82 0.97]	0.90*	[0.83 0.98]
North-East	1.07	[0.99 1.16]	1.08	[0.98 1.19]	1.08	[0.98 1.19]
West	0.66***	[0.60 0.72]	0.66***	[0.60 0.72]	0.66***	[0.60 0.73]
East	1.19***	[1.11 1.27]	1.32***	[1.22 1.42]	1.36***	[1.26 1.47]
Central	0.66***	[0.62 0.71]	0.68***	[0.63 0.73]	0.68***	[0.64 0.74]
Observations	64,725		50,281		50,281	

OR- Adjusted Odds Ratios based on logistic regression; 95% CI – 95% Confidence interval. ® denotes the reference category for the correlates. *** p<0.01, ** p<0.05, * p<0.1

The ATET estimated using PSM indicates that children aged 6–23 months receiving any ICDS benefits are 5 percentage points (pp) more likely to meet MDD compared to non-beneficiaries (Table 3, column 1).

PSM reveal that children in the treatment group, who received food supplements regularly from ICDS, were 7 pp (column 2) more likely to attain MDD compared to those in the control group who never received food supplements from ICDS. Further, PSM was employed on distinct sub-samples, maintaining a consistent control group. However, the treatment group is different in each sub-sample. The first sub-sample encompassed children who received supplements almost daily (column 3), the second sub-sample comprised those who received supplements at least once a week (column 4) and the third sub-sample consisted of those who received supplements at least once a month (column 5). The results indicate that the ATET on MDD is highest among children who received supplements almost

daily (7 pp), followed by those receiving supplements once a week (5.5 pp) and once a month (5.1 pp), compared to children who never received food supplements, indicating a positive relationship between supplement frequency and MDD.

Table 3. Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children aged 6-23 months, India (NFHS-5)

MDD	(1)	(2)	(3)	(4)	(5)
	ATET	ATET	ATET	ATET	ATET
Any Benefits[a]	0.049***				
	(0.026)				
Food Supplementation – Regularly[b]		0.069***			
		(0.033)			
Food Supplementation - Daily			0.072***		
			(0.026)		
Food Supplementation - Weekly				0.055***	
				(0.028)	
Food Supplementation – Monthly					0.051***
					(0.047)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	48,763	24,430	13,988	10,442	17,647
Observations	62,371	41,083	30,641	27,095	34,300

Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. a-Received any benefits from Anganwadi/ICDS centre in last 12 months (food supplements/health check-ups/immunization or early childhood education). b-Treatment - Children received food supplements regularly (daily or weekly); Control- Children never received food supplements. Control group is same for all the results. c-Demographic & SES (Socioeconomic) controls include children's sex, birth order, household wealth, mother's education, mother's employment status, mother's diet diversity, mass media, religion, caste, and regions.

Most of the covariates were in balance after the matching (Table A3, S1). Significant mean differences in observed characteristics prior to matching have either diminished or been eliminated after matching, indicating a higher degree of similarity between children in the control and treated groups when calculating ATET[3]. The results indicate that a higher frequency of receiving supplements from ICDS is associated with increased dietary diversity among children[4]. Further, a sensitivity analysis comparing children receiving regular ICDS supplements (daily or weekly) with a control group receiving supplements irregularly (monthly, less often, or never; Table A5, S1) shows that children receiving regular supplementation were 4% more likely to achieve MDD than those in the control group.

[3]Covariate matching is performed for all the subsamples considered in the PSM analysis.
[4]The results are consistent with state fixed effects (Table A4, S1)

Table 4 presents data regarding the food items distributed through Take Home Ration (THR) and Home Cooked Meal (HCM) in ten states (Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Odisha, Rajasthan, and Telangana), offering insights into which states are offering a diverse range of food items as part of their ICDS program. MDD was defined as the consumption of food items from at least four out of the seven food groups if do not include breastfeeding as a category. Further, it demonstrated that among the ten states, Group 6 "flesh foods" is not provided under take home ration and hot cooked meal. On the other hand, Group 2 "grains, roots, and tubers" and Group 7 "legumes and nuts" are consistently covered under THR and HCM in all ten states. Bihar, Rajasthan, Chhattisgarh, and Haryana only cover these two food groups under SNP, suggesting a need for these states to diversify their food offerings to include at least two more food groups and ensure adequate dietary diversity. Karnataka and Madhya Pradesh covered at least three of the food groups but still fell short of

Table 4. Take Home Ration (THR) and Home Cooked Meals (HCM) food items in selected states, India

State	THR (6-35 months)	HCM (3-6 year)	Food groups covered under SNP
Bihar	Rice, dal, soybean	Rasiyav, khichri, halwa, pulao	2, 7
Chhattisgarh	Ragi, wheat, soybean, Bengal gram, groundnut, fortified oil	-	2, 7
Gujarat	Wheat besan, soybean flour, groundnut, fortified oil, milk	Wheat flour, pulses, rice, vegetables	1, 2, 4, 7
Haryana	Fortified wheat, oil, sugar, besan, peanut	Aloo-puri, parantha, meetha chawal, panjiri	2, 7
Kerala	Wheat, rice, soybean, Bengal gram, groundnut	Milk, banana, egg, seasonal fruits	1, 2, 3, 4, 5, 7
Karnataka	Nutrimix, ragi, rice, greengram, milk	Chitranna, rice kichadi, sprouted greengram	1, 2, 7
Madhya Pradesh	Wheat flour, soy flour, milk powder, moong dal, oil	Daliya mix, khichidi	1, 2, 7
Odisha	Wheat, Bengal gram, groundnut, milk powder	Ragi ladoo, sprouted moong, egg curry	1, 2, 3, 5, 7
Rajasthan	Wheat, Rice, chana dal	-	2, 7
Telangana	Egg, wheat, milk powder, Bengal gram, groundnut	Rice, dal, vegetables, egg	1, 2, 3, 5, 7

Food group numbers correspond to WHO IYCF classifications: 1 = Dairy; 2 = Grains/roots/tubers; 3 = Vitamin A-rich fruits and vegetables; 4 = Other fruits and vegetables; 5 = Eggs; 6 = Flesh foods; 7 = Legumes and nuts. Sources: Compiled from state ICDS portals and NITI Aayog (2022) provided in the reference.

qualifying for providing a diversified meal under SNP. States that provided food items covering four food groups and thus offered a diversified diet under SNP were Kerala, Telangana, Odisha, and Gujarat.

Table 5: Adjusted Odds Ratios (OR) of MDD and ICDS services, Children Aged 6–23 Months, Diversified and Less Diversified States, India (NFHS-5)

	Diversified States				Less Diversified States			
	(1)		(2)		(3)		(4)	
	MDD-OR	95% CI	MDD-OR	95% CI	MDD-OR	95% CI	MDD-OR	95% CI
Food Supplementation								
No®								
Regularly	1.42	[0.94 2.16]			1.49***	[1.23 1.80]		
Frequency								
Never®			1	[1 1]			1	[1 1]
Daily			1.42	[0.94 2.14]			1.46***	[1.20 1.76]
Weekly			1.64*	[1.07 2.51]			1.45***	[1.19 1.75]
Monthly			2.26***	[1.50 3.40]			1.29**	[1.08 1.55]
Less Often			2.44***	[1.44 4.15]			1.20	[0.92 1.58]
Health Checkup	1.04	[0.84 1.29]	1.08	[0.93 1.24]	1.23*	[1.05 1.44]	1.28***	[1.14 1.44]
Immunizations	1.08	[0.83 1.41]	0.94	[0.79 1.12]	0.96	[0.74 1.23]	0.87	[0.72 1.05]
Early Childhood Care	0.99	[0.84 1.16]	0.97	[0.86 1.08]	1.06	[0.92 1.20]	1.02	[0.91 1.14]
Controls	YES		YES		YES		YES	
Observations	3826		7160		6470		10597	

All definitions, controls excluding regions, and specifications are the same as in Table 3.

Table 5 presents the association between ICDS services and MDD across states with more and less diversified ICDS food menus. In less diversified states, regular food supplementation is positively and significantly associated with MDD (OR:1.49, 95% CI: 1.2-1.8), with consistent effects across daily, weekly, and monthly receipt. In contrast, in more diversified states, the association is weaker and mostly insignificant, except for monthly (OR: 2.26, 95%CI: 1.5-3.4) and less frequent receipt.

Further, the PSM results support these findings. Regular (daily or weekly) food supplementation under SNP is not statistically significant in diversified states (Table 6), but shows a significant effect in less diversified states (Table 7). Interestingly, monthly supplementation has a larger impact on MDD in diversified states (12 percentage points) compared to less diversified states (3 percentage points).

Table 6: Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6–23 months), Diversified States, India (NFHS–5)

MDD	(1)	(2)	(3)	(4)	(5)
	ATET	ATET	ATET	ATET	ATET
Any Benefits[a]	0.073**				
	(0.026)				
Food Supplementation – Regularly[b]		0.03			
		(0.033)			
Food Supplementation - Daily			0.045*		
			(0.026)		
Food Supplementation - Weekly				0.037	
				(0.028)	
Food Supplementation – Monthly					0.122***
					(0.047)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	6,968	3,535	2,575	960	3,118
Observations	7,900	4,634	3,674	2,059	4,217

All definitions, controls, and specifications are the same as in Table 3.

Table 7: Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6–23 months), Less Diversified States, India (NFHS–5)

MDD	(1)	(2)	(3)	(4)	(5)
	ATET	ATET	ATET	ATET	ATET
Any Benefits[a]	0.038**				
	(0.011)				
Food Supplementation – Regularly[b]		0.039**			
		(0.010)			
Food Supplementation - Daily			0.057***		
			(0.014)		
Food Supplementation - Weekly				0.049*	
				(0.02)	
Food Supplementation – Monthly					0.034**
					(0.011)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	10,341	4,777	2,396	2,381	3,437
Observations	13,726	9,687	7,306	7,291	8,347

All definitions, controls, and specifications are the same as in Table 3.

Further, among poor households, all forms of ICDS food supplementation, daily (OR: 2.10, 95%CI: 1.82–2.42), weekly (OR: 1.89, 95%CI: 1.64–2.19), and monthly (OR: 1.64, 95%CI: 1.43–1.89) show a strong and statistically significant positive association with MDD (Table 8). For rich households, the association remains significant but with smaller magnitudes: daily (OR: 1.28, 95%CI: 1.06–1.55), weekly (OR: 1.30, 95%CI: 1.07–1.57), and monthly (OR: 1.40, 95%CI: 1.16–1.67)

Table 8. Adjusted Odds Ratios (OR) of MDD and frequency of food supplementation, Children Aged 6–23 Months, Poor and Rich Households, India (NFHS-5)

	Poor Households		Rich Households	
	MDD-OR	**95% CI**	**MDD-OR**	**95% CI**
ICDS Food Supplementation Frequency				
Never®				
Daily	2.10***	[1.82 2.42]	1.28**	[1.06 1.55]
Weekly	1.89***	[1.64 2.19]	1.30**	[1.07 1.57]
Monthly	1.64***	[1.43 1.89]	1.40***	[1.16 1.67]
Less Often	1.50***	[1.27 1.77]	1.46**	[1.15 1.84]
Health Checkup	1.23***	[1.16 1.31]	1.12*	[1.02 1.23]
Immunizations	0.91**	[0.84 0.97]	0.83***	[0.75 0.92]
Early Childhood Care	0.96	[0.90 1.02]	0.95	[0.87 1.04]
Controls	YES		YES	
Observations	34037		13788	

All definitions, controls, and specifications are the same as in Table 2.

Further, in Table 9, the PSM estimates suggest that the impact of regular supplementation from ICDS on MDD is evident for poor households, while there is no significant effect for rich households. Similar results were found across both less and more diversified states, with no significant effect of SNP observed among rich households (Table A7, S1).

Table 9. Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6–23 months) in poor and rich households, India (NFHS-5)

	Poor Households	Rich Households
MDD-Child	**ATET**	**ATET**
ICDS Food Supplementation – Regularly[a]	0.039** (0.010)	0.039** (0.010)
Demographic & SES Controls b	Yes	Yes
Treated Observations (No.)	17,376	7,054
Observations (No.)	32,584	13,023

All definitions, controls, and specifications are the same as in Table 3.

Next, we examine the association separately for rural and urban areas (Table A8, A9 and A10, S1). As expected, food supplementation and its frequency increase the likelihood of MDD in rural areas, while no significant impact is observed in urban areas. Further, we checked rural households by wealth in Table 10. ICDS food supplementation showed a strong positive association with MDD among poor rural households, with daily supplementation more than doubling the odds of achieving MDD (OR: 2.2; 95% CI: 1.9–2.6). Among rich rural households, some association with ICDS services was observed, but the effect of food supplementation on MDD was smaller[5].

Table 10. Adjusted Odds Ratios (OR) of MDD and frequency of food supplementation, Children Aged 6–23 Months, Poor and Rich Households of Rural Region, India (NFHS-5)

	Poor Households		Rich Households	
	MDD-OR	**95% CI**	**MDD-OR**	**95% CI**
Supplementation Frequency				
Never®	1	[1 1]	1	[1 1]
Daily	2.22***	[1.91 2.57]	1.35*	[1.04 1.76]
Weekly	2.00***	[1.72 2.33]	1.46*	[1.12 1.90]
Monthly	1.73***	[1.50 2.00]	1.49**	[1.16 1.93]
Less Often	1.57***	[1.33 1.86]	1.52*	[1.10 2.09]
Health Checkup	1.24***	[1.16 1.32]	1.10	[0.98 1.24]
Immunizations	0.90*	[0.84 0.98]	0.84*	[0.73 0.96]
Early Childhood Care	0.95	[0.89 1.01]	0.95	[0.84 1.07]
Controls	YES		YES	
Observations	32678		8936	

. All definitions, controls, and specifications are the same as in Table 2.

Lastly, from a policy perspective, we compare the effects across EAG and non-EAG states in Table 11. The results show that children in EAG states have about 40% lower odds of achieving MDD compared to non-EAG states. Receiving any ICDS benefits is associated with higher dietary diversity (OR: 1.13, 95%CI: 1.05–1.21), and the interaction term indicates that this effect is significantly larger in EAG states (OR: 1.23, 95%CI: 1.11–1.35). Food supplementation, on average, does not have a statistically significant effect on dietary diversity in non EAG states (OR: 1.08, 95%CI: 0.97–1.19). However, the interaction with EAG states is positive and significant (OR: 1.30, 95% CI: 1.13–1.48), indicating that supplementation is effective specifically in EAG states. Similarly, the frequency of supplementation does not show a significant effect on average in non EAG states, but becomes important in EAG states.

Table 11. Adjusted Odds Ratios (OR) of MDD and ICDS services, Children Aged 6–23 Months, EAG versus Non EAG states using interaction term, India (NFHS-5)

MDD-chid	**(1)**		**(2)**		**(3)**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Variables						
EAG state						
No®						
Yes	0.60***	[0.54 0.65]	0.59***	[0.52 0.67]	0.51***	[0.42 0.63]
Received any benefits						
No®						
Yes	1.13**	[1.05 1.21]				
Received any benefits *						
EAG	1.23***	[1.11 1.35]				
Received food supplementation from ICDS						
No®						
Yes			1.08	[0.97 1.19]		
Received food supp. from ICDS * EAG			1.30***	[1.13 1.48]		
Frequency of Food Supplementation						
Never®						
Daily					1.14	[0.96 1.36]
Weekly					1.15	[0.96 1.38]
Monthly					1.11	[0.93 1.32]
Less Often					1.08	[0.88 1.32]
Daily * EAG					1.57***	[1.26 1.96]
Weekly * EAG					1.38**	[1.10 1.73]
Monthly * EAG					1.50***	[1.20 1.86]
Less Often *EAG					1.33*	[1.02 1.72]
Health Checkup	1.20***	[1.15 1.26]	1.14***	[1.08 1.19]	1.13***	[1.08 1.19]
Immunizations	0.87***	[0.82 0.92]	0.87***	[0.83 0.93]	0.88***	[0.83 0.93]
Early Childhood Care	1.00	[0.96 1.05]	1.00	[0.96 1.05]	0.99	[0.94 1.04]
Controls	YES		YES		YES	
Observations	64,725	50,281	50,281			

All definitions, controls excluding regions and specifications are the same as in Table2.

Discussion

This study provides encouraging evidence on the association between the SNP under ICDS and MDD among children aged 6–23 months in India. First, dietary diversity has improved between NFHS-4 and NFHS-5, particularly in the consumption of vitamin A-rich fruits and vegetables (Group 3), other fruits and vegetables (Group 4), eggs (Group 5), and legumes and nuts (Group 7). Second, more regular receipt of supplementary nutrition is associated with better MDD outcomes, suggesting

that the regularity of programme contact matters. It is important to note that frequency of receipt reflects engagement with Anganwadi services and does not directly measure whether the child consumed the supplement.

Maternal and household characteristics play a central role in shaping children's diets. The positive association between maternal education and children's MDD is consistent with Bhati et al. (2022), who show that higher years of schooling among mothers increase the likelihood of achieving MDD. Similarly, the strong link between maternal and child diet diversity supports the evidence from Amugsi et al. (2015) that improvements in mothers' diets translate into better child feeding practices. Children of currently working mothers have significantly higher odds of achieving MDD. Descriptive patterns show that casually or self-employed mothers have higher ICDS utilisation, followed by unemployed and then salaried mothers (Table A13, S1), while MDD is highest among children of salaried mothers. This indicates that ICDS is reaching more vulnerable groups, while better dietary outcomes remain concentrated among relatively better-off households. Economic status remains a strong determinant, with wealthier households exhibiting higher MDD. Access to mass media is positively associated with MDD, reinforcing findings by Bhati et al. (2022) on the role of information and awareness in shaping feeding behaviour. Regional differences persist, with southern and eastern states showing better dietary outcomes than northern and western regions, where diets are more cereal-based, consistent with earlier evidence on geographical disparities in child nutrition (Jain et al., 2022).

At the same time, weak associations with stunting, wasting, and underweight suggest that although SNP may improve dietary diversity, it is insufficient to address broader nutritional and micronutrient deficits, as reflected in the persistently high burden of anaemia.

The state-level heterogeneity in effects offers important insights into how the SNP operates in different contexts. In states with already diversified SNP menus (Kerala, Telangana, Gujarat, and Odisha) regular (daily or weekly) supplementation shows no significant association with MDD, whereas monthly receipt, likely in the form of Take-Home Rations (THR), remains positively associated. A plausible explanation lies in both behavioural and implementation factors. These states start from a higher baseline MDD (0.28 versus 0.18 in less diversified states), suggesting a possible ceiling effect that limits the marginal gains from more frequent supplementation. In practice, THR in some states is typically distributed on a monthly and relatively predictable basis, and better-educated mothers may be more likely to use these rations consistently at home, spreading them over time and integrating them into children's daily diets. For children aged 6–23 months, an age group for whom THR is more relevant, thus regular and reliable household use of monthly rations may therefore matter more than nominal frequency of contact with centres. Moreover,

non-beneficiary children in these states are more likely to come from better-off households with higher maternal education and better maternal diet diversity (Table A6, S1), implying that home diets are already relatively adequate and reducing the observable marginal impact of ICDS on MDD.

In contrast, in less diversified states such as Bihar, Rajasthan, Chhattisgarh, and Haryana, regular supplementation is strongly associated with improvements in MDD, reflecting the critical role of SNP where baseline nutrition is weaker. These states often exclude items such as eggs or milk from SNP menus due to social or logistical constraints, which may limit overall diet quality. Expanding the diversity of SNP offerings could enhance programme effectiveness in these regions.

The distributional analysis indicates that the gains from regular supplementation are concentrated among poorer households, both in less and more diversified states, and particularly in rural areas, with minimal impact on wealthier households. This highlights that the marginal benefits of ICDS are greatest for disadvantaged populations. Lastly, EAG states are examined separately due to their higher undernutrition and lower dietary diversity. Our findings show that the effect of food supplementation on MDD is stronger in these states, highlighting that ICDS effectively reaches nutritionally vulnerable populations where the need is greatest.

Conclusion

This study highlights the nuanced role of ICDS, particularly supplementary nutrition (SNP), in shaping children's (6–23 months) dietary diversity in India. The findings show that ICDS is effectively targeted towards disadvantaged regions, with stronger impacts of food supplementation on MDD observed in EAG states where baseline dietary diversity is low; the frequency of supplementation also matters more in these contexts. At the same time, programme effectiveness varies across states, those with more diversified SNP menus show smaller marginal gains, while less diversified states benefit more from regular supplementation, indicating that impact depends on the existing food environment. Further, the study finds that the impact of regular (daily or weekly) food supplementation on MDD is stronger in rural areas and among poorer households, with particularly pronounced effects among the rural poor, while limited or no significant effects are observed among richer and urban households. However, the limited effects on anthropometric outcomes and persistent anaemia suggest that improvements in dietary diversity alone are not sufficient. Overall, future progress will require context-specific programme design, with greater focus on improving the quality, diversity, and reliability of food provision, along with stronger implementation to translate dietary gains into broader nutritional outcomes.

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Predicting the Impact of Introducing Front of Package Warning Labels on Overweight and Obesity Reduction among Adolescents (15–19 Years) in India using a Stochastic Microsimulation Model

Abhishek Kumar[#] and William Joe[*]

Overweight and obesity among adolescents in India are rising, with recent estimates suggesting a growing burden alongside high consumption of foods high in fat, sugar, and salt (HFSS). Excessive intake of HFSS foods is a key risk factor for non-communicable diseases. Front-of-Pack Labeling (FOPL), recommended by the World Health Organization, aims to reduce such consumption. This study estimates the potential impact of FOPL on adolescent overweight and obesity in India. Data from the Comprehensive National Nutrition Survey (2018) on consumption of snacks, fried foods, sweets, and aerated drinks were used. Scenarios assuming 8–35% calorie reduction, incorporating partial compensatory intake, were modeled using a dynamic weight-change framework over four years. Changes in overweight and obesity prevalence and associated economic costs (diabetes, asthma, heart disease, cancer) were estimated, along with industry implementation costs. Data from the Comprehensive National Nutrition Survey (2018) on consumption of snacks, fried foods, sweets, and aerated drinks were used. Scenarios assuming 8–35% calorie reduction, incorporating partial compensatory intake, were modeled using a dynamic weight-change framework over four years. Changes in overweight and obesity prevalence and associated economic costs (diabetes, asthma, heart disease, cancer) were estimated, along with industry implementation costs. FOPL is a low-cost, potentially high-impact policy for reducing adolescent obesity in India. However, results depend on key assumptions and limited cost data, highlighting the need for context-specific evidence.

Key Words: FOPL, obesity, India, CNNS, simulation model

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Overweight and obesity are increasing worldwide, affecting 380 million children and adolescents (WHO, 2019). Globally, the proportion of children (5 to 9 years) and adolescents (10 to 19 years) with overweight or obesity is estimated at 21% and 17%, respectively (UNICEF, 2019). Overweight and obese children are more likely to remain obese in adulthood and at life-long risks for non-communicable diseases (NCDs), premature death and disability, and significantly reduced productivity (Zempsky et al., 2020; Ezzati and Riboli, 2013). Simulation-based estimates predict that 80% of severely obese children at the age of 2 years will be obese during adulthood (Ward et al., 2017). The rate of increase in childhood overweight and obesity is disproportionally higher among low-middle-income countries (LMICs) than in developed countries (WHO, 2016).

In India, the prevalence of overweight among children is 3.4% (IIPS, 2021). Among 15-19 years, 4.2% of girls and 5.3% of boys were overweight (IIPS, 2021). India will be home to over 27 million children and adolescents (5 to 19 years) living with obesity by 2030 and account for 11% of the global burden (World Obesity Federation, 2022). Interestingly, data from the fifth round of NFHS shows that India is going through a rapid nutrition transition and has reached a phase where prevalence of undernutrition has remained high, but obesity is also increasing rapidly (IIPS, 2021). Not only among children, but the prevalence of obesity has increased among women from 20.6 per cent to 24 per cent while in men from 18.9 per cent to 22.9 per cent (IIPS, 2019-21). As per the fifth round of NFHS, the prevalence of obesity is higher in urban areas among both males (33.2% vs 19.7%) and females (29.8% vs 19.3%), but the change in prevalence over time in rural areas has been higher which implies that obesity is no longer an urban phenomenon (IIPS 2019-21).

There is plenty of evidence that consumption of ultra-processed foods which are HFSS foods is a significant risk factor for obesity (Crimarco et al., 2021; Askari et al., 2020; Elizabeth et al. 2020; Hall et al., 2019; Juul et al., 2015; Canella et al., 2014). For instance, a scientific study using data from 97 countries for the period 2005-2019 found that a one percent increase in the prevalence of obesity was associated with increase in the consumption of soft drinks and carbonated soft drinks by about 2.37 and 1.11 Liter per person/year, respectively after controlling for several demographic and socio-economic confounding factors (Ferretti, 2022). Another study found that an increase in per capita soft drink sales by 1 litre per year was related to an increase of BMI by about 0.009 kg/m2 ($p < 0.1$) in low-middle-high income countries (Goryakin et al., 2017). This can significantly impact health and nutrition outcomes when seen at a population level.

In this respect, policies aimed at summarizing the nutritional value and content of a food product at the point of purchase have emerged as a viable solution to modify people's consumption behaviour (Croker et al., 2020; Song et al., 2021). One of the policy tools to inform consumers about the nutrition content is the Front-

of-package labeling (FOPL). FOPL conveys information about detailed nutrient declarations found on the back of food packaging (Kelly and Jewell, 2018).

Due to emerging health concerns, implementation of mandatory warning label FOPL has been observed across countries (Kanter et al., 2018). Potential decrease in consumption of beverages and snacks due to introduction of warning labels has also been observed across several countries. Studies indicate that "high in" front-of-package labels (FOPL) significantly reduce sugar, calorie, and sodium content in purchased food and beverages (Croker et al., 2020). Warning labels on sugary drinks lowered the odds of choosing such beverages by 51% and reduced purchase intentions (An et al., 2021). In Chile, a policy led to a marked decrease in products with high sugar and sodium levels within a year (Reyes et al., 2020).

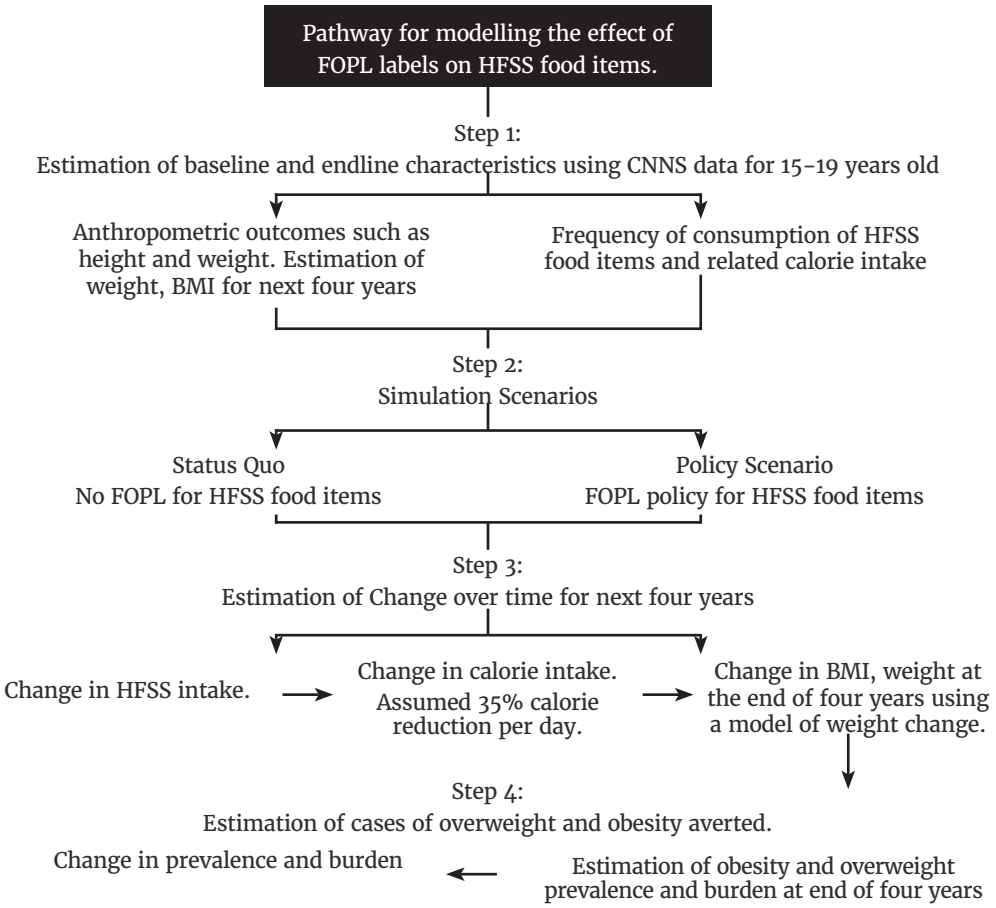
A study based on modelling on the potential impact of mandatory "high in" warning labels in Mexico projected that the initiative may reduce obesity prevalence by 14.7%, or by 1.3 million cases over 5 years (Basto-Abreu, 2020). A simulation study for Canada showed that warning labels led to a 10.5% reduction in the consumption of labeled beverages and a 3.0% reduction in the consumption of labeled snacks. In United States, mandatory FOPL on sugar-sweetened beverages would reduce obesity prevalence by 3.1% in 5 years duration (Grummon, 2019).

A key gap in the existing literature is the limited India-specific evidence on the effectiveness of Front-of-Pack Labeling (FOPL), despite extensive global research demonstrating its potential to reduce consumption of HFSS foods. In this context, adolescents represent a critical group due to their evolving dietary autonomy, susceptibility to marketing, and long-term risk accumulation. Furthermore, as India actively considers FOPL regulations, there is a need to align global evidence with national dietary patterns, consumption behavior, and policy priorities. Given this background, the primary objective of this study is to estimate the impact of introducing front-of-package warning labels on specific food products such as snacks, fried foods, sweets, and beverages on reduction of calorie intake, body mass index (BMI), and consequently on overweight and obesity prevalence among adolescents using a nationally representative dataset for India over a four year period. The secondary objective of this study is to assess the economic implications in terms of potential healthcare costs and cost to the industry.

Data and Methods

Following the methodology adopted by Grummon et al. (2019) to estimate the effect of warning labels on beverages on obesity reduction, we applied a stochastic simulation model to estimate the impact of introducing front-of-package warning labels on snacks and beverages on overweight and obesity reduction among adolescents (15-19 years) in India (Figure 1).

Figure 1: Overall Significance of the Models after Conducting Matching Analysis



Data

The analysis in this study is based on the Comprehensive National Nutrition Survey (2016–18), which contains data on the nutritional status of adolescents (10–19 years) assessed through interviews, anthropometric measures, and biochemical indicators (CNNS, 2019). The prevalence of overweight and obesity for 17440 adolescents (15–19 years) was estimated using the guidelines of WHO and NIH for Asian individuals, which define overweight as a BMI between 23 and 24.9 kg/m2 and obesity as a BMI >25 kg/m2 (Misra, 2015). Although the WHO defines adolescents as 10–19 years old, this simulation exercise focused on the 15–19 age group. This subset was selected because their height is more likely to remain stable. Notably, height was recorded for 16691 individuals, and weight was recorded for 16677 individuals. The final analytical sample size was 16444.

Information on consumption of four food groups which have low nutritional value and could have a detrimental effect on health: fried foods (poori, pakora, vada, samosa, tikki etc.); junk foods (burger, pizza, pasta, instant noodles); sweets (Indian sweets, pastries/cakes, doughnuts) and aerated drinks during the past week was recorded by trained investigators during the survey. Specifically, the adolescents were asked about the number of days the food items were consumed during the past week however, the frequency with which the items were consumed on that day was not collected. The data on the wealth index which is a measure of socioeconomic status based on the possession of a number of common household items was used to create quintiles (poorest, poor, middle, rich, and richest).

Methods

- **Height and weight**

Baseline height and weight provided in CNNS data for adolescents were used to project height and weight for each day till 2022, assuming a growth rate of 3% over the next four years. The assumption was derived by comparing the mean weight of 15–19-years cohort with 20–24 years cohort using NFHS data (IIPS 2019–21).

- **Calorie intake from Snacks and beverages**

Calorie intake for each day was assumed to be 271 calories for fried foods, 217 for junk foods, 436 for sweets and 280 for aerated drinks. The calorie content for each item was obtained from the internet and is presented in Table S1. The calories for the food groups were estimated by taking average calories of items included in that food group. Depending upon the weekly consumption of each individual, calories from consumption of HFSS items for the entire week were calculated. The weekly calorie intake was converted to calorie intake per day by dividing it by 7.

- **Change in Calorie intake from Snacks and beverages**

Based on literature review, we found that introducing warning labels is associated with 11.9–23.3 % and 5.5–11.7% calorie reduction from reduced intake of beverages and snacks, respectively (Basto-abreu et al., 2020). For analyses, we assumed a 35% calorie reduction per day. As sensitivity analysis, two scenarios were created wherein we assumed a 15% and 25% calorie reduction per day. In addition, for the analysis, two samples were created:

1. All the adolescents 15–19 years of age
2. All the adolescents who consumed any of the four food items (snacks, fried foods, aerated drinks, and sweets)

The calculations were conducted for various wealth quintiles and individual states.

- **Change in total energy intake.**

Reducing calorie intake will be accompanied by intake of other health food items which would compensate for the calorie loss. Based on previous literature a compensating factor of 1.84 was used to reflect these changes (Hall, Sacks and Chandramohan; 2011). Here it is worth noting that the compensatory intake assumption reflects the extent to which individuals offset reduced calorie intake from targeted HFSS foods by increasing consumption from other sources. A compensation factor of 1.84 implies that for every unit reduction in calories from HFSS foods, total energy intake falls by a smaller amount due to partial substitution or increased intake elsewhere.

- **Change in body weight**

To estimate a change in body weight a model of weight change dynamics was applied

$$\frac{\partial M(t)}{\partial t} = \frac{[\chi(t) - k(t) * (M(t) - M_o)]}{\tau}$$

Where M is weight, chi (χ) is net change in total energy intake, k is individuals energy expenditure given the resting metabolic rate and physical activity, and τ is the degree of weight change from given calorie intake. The parameters are calculated as follows. The values of parameters used for analysis are presented in table S2.

$$k(t) = \frac{1}{1-d} * \left(\frac{Y_f + c * Y_l}{1+c} + P(t)\right)$$

Where k is individuals energy expenditure and is a function of relative change in mean mass per change in fat mass (c), adaptive thermogenesis parameter (d), resting metabolic rate of fat (Y_f), resting metabolic rate of lean tissue (Y_l) and physical activity level (P).

$$\tau = \frac{n_f + p_f + c * n_l + c * p_l}{(1-d) * (1+c)}$$

Where, degree of weight change expected from a given net caloric intake (τ) is a function of Fat synthesis efficiency (n_f), Protein synthesis efficiency (n_l), Energy content per unit change in body fat (p_f), Energy content per unit change in lean tissue (p_l), Relative change in mean mass per change in fat mass (c), and adaptive thermogenesis parameter (d).

• **Calculating change in overweight and obesity prevalence using population fractions.**

To calculate the number of cases of overweight and obesity averted, data from population projection report 2011-2036 was used for 2016 and 2022 for 15–19-year age group (GOI, 2019). We estimated the number of overweight and obese adolescents for 2016 and 2022, and subsequently, the reduction in the number of overweight and obesity cases was calculated.

• **Estimation of cost-of-illness**

Overweight and obesity are risk factors for several chronic diseases. And overweight and obese adolescents have a higher chance of suffering from chronic diseases. Data on prevalence of diabetes, asthma, heart disease and cancer among overweight and obese was obtained from NFHS-5 for 20-24 years age group (IIPS, 2021).

The number of adolescents suffering from chronic diseases was calculated by multiplying the prevalence of chronic diseases (diabetes, asthma, heart disease and cancer) by number of cases of overweight and obesity, which could be averted due to implementation of policy. Economic burden or cost of illness borne by the society was calculated by multiplying the burden associated with chronic diseases with cost of treatment for the ailments obtained from peer-reviewed articles (Chauhan et al., 2016; Prinja et al., 2023; Kansra et al., 2023; Aneeshkumar et al, 2018).

• **Productivity benefits**

To estimate productivity benefits, we first calculated the Years Lived with Disability (YLDs) by multiplying the disease burden by the corresponding disability weights (DW). The disability weights for the chronic diseases (diabetes, asthma, heart disease and cancer) were obtained from Global Burden of Diseases (GBD, 2019). The productivity benefits were then determined by multiplying the YLDs by the per capita income, obtained from the RBI Handbook.

• **Estimation of Cost-benefit Ratio for Warning Labels**

The primary cost associated with adopting front-of-pack labelling (FOPL) was found to be the cost of labelling. This cost was determined using data from a recent report commissioned by the Australian government, which provided cost information per Stock Keeping Unit (SKU) for the year 2014 (PWC, 2014).

The companies that contribute to a major share of the market for HFSS products were identified by a Google search (Table S9). By utilizing the Wholesale Price Index (WPI) data, we estimated the cost of labelling for the year 2022 (Table S10). These figures were presented in Australian dollars, with an exchange rate of 1 Australian dollar equivalent to 0.64 United States dollars. The cost-benefit ratio was then

calculated by dividing the overall cost incurred by the industry by total number of cases of overweight and obesity averted.

Results

- **Consumption Patterns**

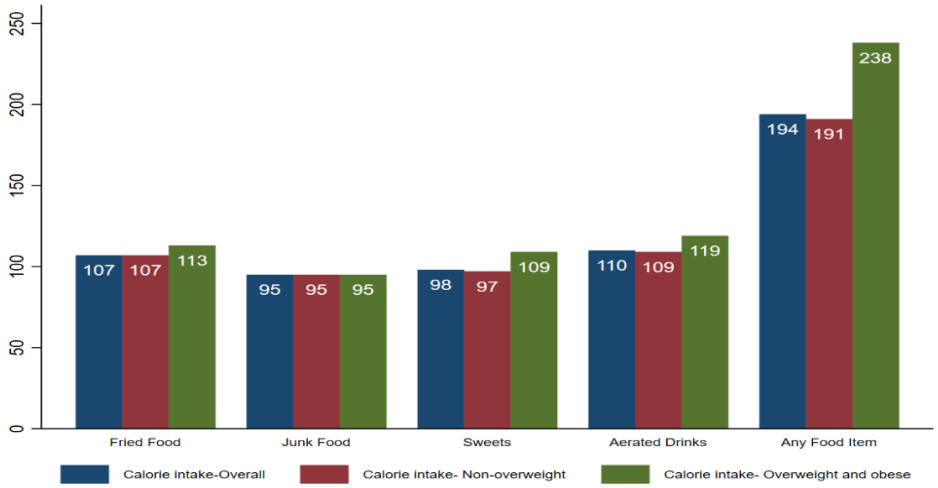
The analysis of consumption patterns of adolescents aged 15–19 for various HFSS food items reveals that 37% consume fried food weekly, 11% consume junk food weekly, 16% indulge in sweets, and 12% drink aerated drinks at least once a week (Table 1, Table S3). The consumption is higher among overweight individuals (Table S4)

Table 1: Consumption of various HFSS food items, CNNS 2016–18

	Fried food		Junk food		Sweets		Aerated Drinks		Consumed Any	
	N	%	N	%	N	%	N	%	N	%
Did not consume	10353	63.0	14581	88.7	13809	84.0	14506	88.2	9,088	55.3
Consumed at least once	6,091	37.0	1,863	11.3	2,635	16.0	1,938	11.8	7,356	44.7
Total	16,444	100	16,444	100	16,444	100	16,444	100	16,444	100

The average daily calorie intake from different food items among adolescents reveals that on average, adolescents consume 194 calories per day from these items (Figure 2). Specifically, the daily calorie intake from fried foods is 107, from junk food is 95, from sweets is 98, and from aerated drinks is 110. Overweight and obese adolescents tend to derive more calories from these items: 113 from fried foods, 109 from sweets, 119 from aerated drinks and 238 from consumption of any of these food items.

Figure 2: Mean Calorie derived from intake of food items for non-overweight and overweight.



- **Impact of introducing warning labels on overweight and obesity reduction**

Introducing the FOPL (Front-of-Pack Labeling) policy is associated with a potential reduction in both overweight (including obesity) and obesity prevalence. After four years, the overall overweight prevalence could decrease from 7.59% to 7.22%, and obesity prevalence could decrease from 3.6% to 3.24%, assuming that introducing FOPL will lead to 35% calorie reduction (Table 2).

A more substantial reduction is observed when considering only the sample of individuals who consume the selected food items affected by the policy. Specifically, overweight (including obesity) could decrease from 7.7% to 3.7% after four years, and obesity could decrease from 4% to 1.9%.

Overall, implementing this policy could potentially avert approximately 470 thousand cases of overweight and obesity, respectively, over a four-year period. In an alternate scenario, where the policy has a broader reach, it could avert approximately 2.7 MN cases of overweight and 1.4 MN cases of obesity over a four-year period.

Assuming a 25% reduction in calorie intake, the prevalence of overweight (including obesity) could decrease from 7.7% to 4.7%, and obesity could decrease from 4% to 2.3% over the next four years. Considering only the sample of overweight and obese, 2.1MN cases of overweight and 1MN cases of obesity can be averted (Table S5). Even if a 15% reduction is assumed, sizeable benefits can be realized (Table S6).

Table 2: Estimated impact of introducing warning labels on overweight and obesity reduction assuming 35% calorie reduction per day, 2018–2022

	Entire Sample			Sample-Consuming specified food items		
	Baseline (2018)	**Endline (2022) Usual scenario**	**Endline (2022) After introducing warning labels**	**Baseline (2018)**	**Endline (2022) Usual scenario**	**Endline (2022) After introducing warning labels**
Weight	47.1	48.5	44.7	47.8	49.2	40.8
BMI	18.9		18.0	19.1		16.3
Overweight (%)	7.59	7.59	7.22	7.7	7.7	3.7
Obese (%)	3.61	3.61	3.24	4.0	4.0	1.9
N	16444	16444	16444	7697.0	7697.0	7697.0
15-19 population	12,68,23,000		12,68,23,000	6,97,52,650		6,97,52,650
Overweight	96,25,866		91,56,621	53,84,905		26,01,774
Obese	45,78,310		41,09,065	27,76,155		13,32,276
Change Overweight		4,69,245			27,83,131	
Change obese			4,69,245			14,43,880

Note: N here is unweighted N

Impact of introducing warning labels on overweight and obesity reduction by wealth quintiles

Consumption of various HFSS food items by wealth quintile reveals that the percentages of individuals consuming fried food, junk food, sweets, and aerated drinks are relatively higher in fourth and fifth quintile groups. Overall, 54.4% in the fifth quintile and 51.9% in fourth quintile consume any of these four items at least once per week (Table 3).

Table 3: Consumption of various food items at least once per week by wealth quintile, CNNS 2016–18

	Fried food	Junk food	Sweets	Aerated Drinks	Consumed any of these four food items	
	%	%	%	%	%	N
Quintile 1	30.6	5.0	9.5	4.3	34.9	2,935
Quintile 2	31.3	6.7	11.5	7.5	36.6	3,143
Quintile 3	36.1	9.2	15.3	10.7	43.6	3,457
Quintile 4	41.9	13.9	19.7	15.7	51.9	3,503
Quintile 5	43.7	20.6	22.8	19.2	54.4	3,406
Total	37.0	11.3	16.0	11.8	44.7	16,444

Introducing the FOPL policy is associated with a potential reduction in both overweight (including obesity) and obesity prevalence across all the quintile groups (Table 4 and S7). The overall prevalence of overweight and obesity could decrease from 15.2% to 7.4% and 8.7% to 4.1% in samples consuming specific food items, respectively.

Table 4: Estimated impact of introducing warning labels on overweight reduction by wealth quintile assuming 15%, 25% and 35% calorie reduction per day

	Overall Sample					Sample-Consuming specified food items				
	N	Baseline	15%	25%	35%	N	Baseline	15%	25%	35%
Quintile 1	2,935	1.4	3.1	3.0	3.0	1,072	0.7	0.7	0.7	0.7
Quintile 2	3,143	4.4	4.9	4.8	4.7	1,205	2.2	1.8	1.6	1.2
Quintile 3	3,457	5.8	6.8	6.2	6.0	1,578	4.7	3.6	2.4	1.8
Quintile 4	3,503	10.5	11.1	10.0	9.4	1,902	10.0	8.1	6.1	5.0
Quintile 5	3,406	14.7	14.6	13.3	12.2	1,940	15.2	11.6	9.3	7.4
Total	16,444	7.6	8.3	7.7	7.2	7,697	7.7	6.1	4.7	3.7

- **State-wise impact of introducing warning labels on overweight and obesity reduction**

Table 5 presents the State wise reduction in prevalence of overweight and obesity due to introduction of FOPL policy. Before the intervention, states like Goa and Kerala exhibited high rates of overweight and obesity, with Goa recording high prevalence in both categories (Overweight: 15.2%, Obesity: 9.2%). Conversely, regions like Jharkhand, Madhya Pradesh, Chhattisgarh, and Telangana had relatively lower rates of overweight and obesity (Overweight: 3.3% to 5.6%, Obesity: 1% to 1.8%).

After the intervention, Himachal Pradesh showed one of the highest prevalence rates of overweight (6.9%), while Goa remained high for both overweight (11.6%) and obesity (6.5%). Jharkhand and Haryana had lower prevalence rates after the intervention (Overweight: 2.3% to 7.4%, Obesity: 1.2% to 2.9%).

The largest reduction will be observed for overweight for states such as Jammu and Kashmir (5), Delhi (4.5), Goa (3.5), Kerala (3.7) and Tamil Nadu (3.5). Similarly, the reduction in obesity will be large for Jammu and Kashmir (1.6) and Delhi (2.7). State-wise distribution of consumption patterns of food items indicates that consumption of these items is higher across Delhi, Goa, Gujarat, Telangana, Tamil Nadu, and Karnataka.

- **Cost-of-illness associated with overweight and obesity**

The prevalence of health conditions among adolescents who are overweight varies, with 0.67% having diabetes and 1.4% having asthma among the overweight, while among the obese, the prevalence increases to 0.97% for diabetes and 3.5% for asthma. The annual projected number of cases among obese adolescents which could be avoided with the intervention is as follows: 14,035 cases of diabetes, 51,229 cases of asthma, 1,040 cases of any heart disease, and 5,689 cases of cancer. The economic burden associated with these conditions is substantial, with a total treatment cost of ₹79 crore for diabetes, ₹132 crore for asthma, ₹125 crore for heart disease, and ₹252 crore for cancer.

In dollar terms, the economic burden for diabetes will be USD 9.6 million and for asthma, it will be USD 16.1 million per year. In comparison, the economic burden due to any heart disease and cancer would be around USD 15.2 million and USD 30.7 million, respectively. The economic burden for diabetes patients for the lifetime treatment could be $441 million, assuming the individual will be on treatment for 46 years.

Diabetes shows the highest reduction in YLDs under a 35% reduction scenario, amounting to 30,597 years saved, followed closely by Cancer (10,102 years), Asthma (28,670 years), and Heart Disease (5,693 years). or a 35% reduction, Diabetes yields the highest productivity benefit at $60M, followed by Asthma at $56M, Cancer at $20M, and Heart Disease at $11M. Sizeable benefits are observed even if 15% and 25% reduction is assumed (Table S9).

Table 5: State-wise reduction in overweight and obesity

	Overweight			Obesity		
	Before	**After**	**Difference**	**Before**	**After**	**Difference**
Jammu and Kashmir	15.3	10.3	-5.0	7.2	5.6	-1.6
Himachal Pradesh	5.3	6.9	1.6	3.5	4.4	0.9
Punjab	14.8	17.0	2.2	6.7	8.8	2.1
Uttarakhand	10.5	9.5	-1.1	3.8	3.5	-0.2
Haryana	8.2	7.4	-0.9	3.5	3.0	-0.5
NCT of Delhi	13.2	8.7	-4.5	6.3	6.4	0.1
Rajasthan	4.0	4.4	0.4	1.6	1.9	0.3
Uttar Pradesh	3.6	4.9	1.3	1.7	1.9	0.2
Bihar	4.8	5.7	0.8	1.7	2.5	0.8
Sikkim	14.3	12.9	-1.4	7.5	6.5	-1.0
Arunachal Pradesh	17.0	15.5	-1.5	6.0	7.3	1.4
Nagaland	11.8	15.0	3.1	2.8	2.7	0.0
Manipur	13.6	12.3	-1.3	5.0	5.1	0.1
Mizoram	14.1	13.0	-1.1	5.5	5.2	-0.3
Tripura	12.2	11.6	-0.6	5.5	6.1	0.6
Meghalaya	5.8	7.0	1.2	1.1	2.6	1.5
Assam	6.6	6.8	0.2	1.7	1.6	-0.1
West Bengal	12.2	9.8	-2.4	6.2	4.3	-1.9
Jharkhand	3.3	2.3	-1.0	1.7	1.2	-0.4
Odisha	10.7	9.3	-1.5	5.6	4.1	-1.5
Chhattisgarh	5.3	5.9	0.6	2.8	3.0	0.1
Madhya Pradesh	5.7	7.1	1.4	1.4	1.0	-0.4
Gujarat	10.3	8.4	-1.9	5.9	4.1	-1.8
Maharashtra	8.7	6.2	-2.5	4.9	3.8	-1.0
Andhra Pradesh	12.7	12.4	-0.3	6.9	5.9	-1.0
Karnataka	11.2	9.4	-1.8	5.8	6.1	0.3
Goa	15.2	11.6	-3.6	9.2	6.5	-2.7
Kerala	16.3	12.6	-3.7	9.0	7.7	-1.3
Tamil Nadu	13.7	10.2	-3.5	7.1	5.0	-2.1
Telangana	11.5	10.0	-1.5	5.8	4.8	-1.0
Total	7.6	7.2	-0.4	3.6	3.2	-0.4

Table 6: Economic cost of chronic conditions related to consumption of HFSS items, assuming 35% reduction

	Among overweight		Among obese		Cost of treatment per year in ₹	Economic burden in $ (overall cost in million)	YLDs =DW*LE	Productivity benefits= Cases *DW*LE* Income per capita (overall cost in million)
	%	Cases	%	Cases				
Diabetes	0.67	9021	0.97	14035	34100	9.6	30597	60
Asthma	1.44	19344	3.55	51229	18737	16.1	28670	56
Any heart disease	0.30	4087	0.07	1040	90000	15.2	5693	11
Cancer	0.14	1923	0.39	5689	331177	30.7	10102	20

Note: In $ assuming exchange rate of ₹82/$, Disability weight assumed to be 0.049 for Diabetes, 0.015 for Asthama, 0.041 for Any heart disease and 0.049 for Cancer. Income per capita assumed to be 161424 and Life expectancy assumed to be 27 years. Cases computed as percentage of additional number of overweight cases which can be averted because of the intervention.

- **Cost to the industry**

A total of 43 companies that contribute to a major share of the market for the HFSS products were identified (Table S10). The cost incurred by each of the 43 companies was assumed to be $2,048 (Table S11). The total cost to the industry for all these companies is USD 2.6 MN for each scenario. The implementation of HFSS is assessed by the number of potential cases of overweight and obesity averted: a 15% calorie reduction is estimated to avert 1,129,993 cases, a 25% reduction averts 2,113,505 cases, and a 35% reduction averts 2,783,131 cases. Cost per case of overweight and obesity averted ranges from less than a dollar to $2.3 across the scenarios.

Table 7: Impact on overweight and obesity; and cost benefit ratio under various scenarios assuming 15%, 25% and 35% calorie reduction per day

	15%	25%	35%
Cost of designing label per company (in $)	2048	2048	2048
Total companies	43	43	43
Total products	30	30	30
Total cost to industry	2641920	2641920	2641920
Cases of overweight and obesity averted	1129993	2113505	27,83,131
Cost per case of Overweight averted	2.3	1.3	0.9
Cost of illness averted in MN	27.4	55.0	71.7
Cost of YLDs averted in MN	55	114	148
Benefit cost ratio	31	64	83

The potential economic savings from reduced healthcare expenses could be around $27.4M, $55.0M, and $71.7M for 15%, 25%, and 35% scenarios, respectively. Similarly, the cost of YLDs averted ranges from $55M at 15% to $114M at 25% and $148M at 35%. The benefit-cost ratio indicate that with every $1 spent yields $31 in benefits at 15%, $64 at 25%, and $83 at 35% calorie reduction per day.

Discussion

The objective of this study was to assess the potential effects of introducing warning labels on specific food items, such as beverages and snacks, on the prevalence of overweight and obesity in India. An attempt was also made to estimate the healthcare economic costs associated with overweight and obesity. The following are five salient findings from this study. First, more than one-third of adolescents aged 15–19 in India regularly consume unhealthy foods, including fried foods, junk food, sweets, and aerated drinks. This dietary pattern contributes to their daily calorie intake, with an average of 194 calories per day from these items. Overweight and obese adolescents derive 238 calories per day from these food items. While comprehensive data on the consumption of junk foods in India is limited, several small-scale studies have been conducted in the country, shedding some light on the issue. For instance, a mixed-methods study conducted in Mumbai revealed that as many as 50% of children under the age of 6 consume junk food and sugary tea daily (Athavale et al., 2020). Another nationwide study spanning across India found that among children aged 9–14 years, a substantial 93% included packed foods in their diets, 68% consumed sweetened beverages, and 25% indulged in ultra-processed foods more than once a week (Singh et al., 2021). These findings collectively suggest an ongoing shift in dietary habits, indicating that the consumption of junk food may be even more prevalent than what our study has estimated. In fact, the consumption of HFSS food items is higher among those belonging to higher wealth quintiles. In addition, Euromonitor sales show a significant, annualized increase of 15% per annum in sale of ultra-processed food between 2011 and 2021, which also indicates that this current estimate is quite conservative (WHO, 2023).

Second, introducing a Front-of-Pack Labeling (FOPL) policy focused on warnings for HFSS is associated with a potential reduction in both overweight and obesity prevalence among adolescents. Assuming a 35% calorie reduction due to FOPL, the overall overweight prevalence could decrease from 7.59% to 7.22%, and obesity prevalence could decrease from 3.6% to 3.24% over the next four years. A more substantial reduction is observed when considering only the sample of individuals who consume the affected food items. In the overall health impact assessment, with a broader policy reach, a total of 2.7 MN cases of overweight and 1.4MN cases of obesity can be averted.

Our results are in line with similar microsimulation modelling studies for Mexico and the US. For instance, a modelling study on the potential impact of mandatory "high in" warning labels in Mexico predicts a reduction in obesity prevalence by 14.7%, or by 1.3 MN cases over 5 years (Basto-Abreu, 2020). In the United States, mandatory FOPL on sugar-sweetened beverages is estimated to reduce obesity prevalence by 3.1% in 5 years duration (Grummon, 2019). Another study based on agent-based simulations showed how warning labels on sugar-sweet beverages may decrease overweight and obesity prevalence in the range of 1.5 to 4% (Lee et al., 2018). In particular, Chile's Food Labeling and Advertising Law led to a more significant reduction in the purchase of high-sugar beverages compared to standalone policies, including sugar-sweetened beverage taxes in Latin America.

Third, different scenarios of calorie reduction (25% and 15%) due to the FOPL policy show varying degrees of impact on overweight and obesity prevalence. Even with a 15% reduction, substantial benefits in terms of cases of overweight and obesity averted can be realized, emphasizing the importance of calorie reduction as a key driver of the policy's success. Experience of Chile also shows that more than 20% reduction can be expected once the warning labels are introduced. (Taillie et al., 2020). Similarly, a systematic review of warning labels found that nutrient warning was associated with a 16% reduced purchase of fat intake from unhealthy products (Song et al., 2021). However, a couple of reviews on nutrition labels have indicated that the reduction in calorie intake could be marginal but also suggests that the effectiveness of FOPL could depend on design, food types and context (Braesco and Drewnowski, 2023; Taillie et al., 2020).

Fourth, not only do overweight and obese adolescents derive higher calories from junk food items, but they are more likely to have non-communicable diseases. Some of the recent studies for India have found a strong association between a higher prevalence of diabetes and hypertension and with consuming junk food (Vispute et al., 2022; Nagarathna et al., 2021; Baskar et al., 2022). In addition, the economic burden of these conditions is substantial, with considerable healthcare costs for treatment. A couple of recent studies estimated the cost savings associated with obesity to be around USD 1.8 billion and USD 0.69 billion for the USA because of implementing FOPL on snacks and beverages (Basto-Abreu et al., 2020; An et al., 2022). Therefore, addressing the root causes of overweight and obesity through policy interventions like FOPL can have broader economic benefits for India by reducing the financial burden of associated health conditions. Here, it is worth mentioning that the cost estimates presented in this study are underestimated since we have only considered the age group 15-19 for which prevalence of non-communicable diseases is low. In the long term, the benefits could be manyfold.

Fifth, the impact of the FOPL policy varies significantly across states in India. States with initially high rates of overweight and obesity may still experience reductions, while states with lower initial rates may see more substantial improvements.

Delhi, Goa, and other southern states such as Karnataka and Tamil Nadu show higher consumption patterns of unhealthy foods, indicating a need for targeted interventions. Although the prevalence of overweight and obesity is still low among adolescents as compared to some of the other developed countries, There is a need to establish robust monitoring and evaluation mechanism to track the impact of FOPL in future. The involvement of local communities, schools, and other stakeholders can lead to culturally sensitive and effective programs that can combat unhealthy dietary practices among adolescents. While FOPL is a cost-effective measure to curb the prevalence of obesity, the impact could be more pronounced if FoPL is implemented as a part of a more comprehensive policy package that includes HFSS taxation and marketing restrictions to children and adolescents as recommended by WHO (WHO, 2023).

There are a few limitations to this study. Unavailability of data on consumption of various junk and fast-food items and the frequency with which a particular item is consumed are some of the key challenges. There could be reporting bias, which could affect the model's predictions. Therefore, the results should be interpreted with caution. Second, we adopted a novel approach by assuming calorie intake for the food items. However, going forward, there is a need to triangulate these findings using other data sources which provide more comprehensive information on consumption of overall food items, junk and fast-food items and calories derived from them. Longitudinal data will allow for the analysis of long-term and behavioural changes that can capture the changing dynamics of food behaviour. Third, the analysis is restricted to the 15-19 age group, which is essential since the BMI during initial years can affect the growth trajectory. However, more studies are required to unravel the patterns in the prevalence of obesity and consumption of junk foods and beverages across other age groups. Fourth, the simulation model is based on a lot of assumptions which might not cover the real-world conditions which might undermine the reliability of the model. For instance, we assumed 35% reduction in calorie intake but in case of India the nature of products is different. There are products which are ready to eat and require no packaging. Given these aspects, it is possible that we might have overestimated the impact of FOPL implementation. Furthermore, we have focused only on weight change. But it is possible that there could be unaccounted for effects. For instance, reduction in consumption of HFSS can prevent risk of non-communicable disease such as heart diseases and cancer among adolescents who are not overweight which have not been considered in this analysis. Lastly, a key limitation of the study is that industry cost estimates for implementing FOPL are derived from Australian data, which may not be directly transferable to the Indian context due to differences in market structure and regulatory environments. Moreover, there are very few costing studies available, making it difficult to identify comparable and context-specific estimates, which may affect the robustness of the cost-benefit analysis.

In addition, there are many indirect effects for a person with overweight or obese status. They include increased absenteeism, reduced productivity at work, disability, and early retirement (Goettler et al., 2017; Menon et al., 2022; Trogdon et al., 2008). Given the majority of those overweight and obese in India are found in higher education and income status groups, these costs to society and the economy could be quite high.

The implementation of FOPL can impose certain costs, which can be broadly categorized as food industry costs (labelling and packing changes), government costs (administration, education, enforcement, oversight), and legislative costs (mandatory scenario only). A study conducted in Australia on cost of changing labels found that the cost could be marginal, and industry will bear the major cost, but it could be subsequently passed on to consumers (Herrera et al., 2018). However, the benefits will outweigh the cost of changing labels in the long run.

To conclude, India being committed to WHA Global Nutrition target of no increase in childhood overweight and with two years to the targets finish line, has not yet set national obesity prevention targets for children and adolescent. The study shows that the consumption of ultra processed food is high among adolescents. This sends a strong message for setting these targets, highest political commitment to act and data availability for children and adolescents to tackle the problem and its risk factors. In addition to FOPL policy interventions, India needs to focus on a few research priorities like developing nationally representative estimates for physical activity among pre-school, school-aged children and adolescents, undertaking in-depth analyses of social and cultural influences on body weight and lifestyle choices, investigating the impact of fiscal policies (taxation, marketing controls) on overweight and obesity prevention and more robust longitudinal data collection could provide insights into understanding the risk factors and prevention of childhood obesity.

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Health Shocks and Vulnerability to Poverty in India: Evidence from the National Sample Surveys, 1995–2018

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The majority of studies on out-of-pocket healthcare payments have focused on current welfare losses to households, reflected in their impact on poverty, while largely neglecting possible future welfare losses. Using consecutive rounds of household-level health survey data and a three-step Feasible Generalised Least Squares method, we examine whether health shocks make households vulnerable to poverty, estimate vulnerability across different population subgroups, and examine its transition in India. We find that the mean household vulnerability has remained above 0.7 from 1995 to 2018, indicating a high probability that a household will fall into poverty due to health shocks. In addition, female-headed households, households in rural areas, households with poor hygiene practices, households with low-educated heads, and households without insured members have a higher incidence of poverty vulnerability. Contrary to expectations, households with members covered by government-sponsored insurance are found to be more vulnerable than others. The results suggest that the determinants of health shocks need to be taken into account when designing poverty-reduction strategies. The paper recommends expanding a pre-designed health insurance, sanitation, and basic education drive that could effectively normalise the effects of health shocks on vulnerable households in India.

Keywords: vulnerability to poverty, feasible generalised least squares method, health shocks, health status, NSS, India

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

A sudden medical crisis often places an immense and multifaceted strain on a family's economic well-being. Health shocks may lead to hospitalisation or death of a family member, triggering high out-of-pocket (OOP) health expenditure or loss of a breadwinner's income. These crises result in temporary or permanent disabilities that diminish a household's long-term earning capacity (Atake, 2018; Mitra et al., 2016). While droughts and floods are collective disasters, a serious illness is an idiosyncratic shock that is just as destabilising but far less predictable. A household's vulnerability to a health shock is determined by two primary factors- its financial capacity and its access to effective insurance. So, for the poor, the intersection of high treatment costs and a lack of coverage, coupled with any illness or injury, is a health shock (Dhanaraj, 2016). Faced with such a shock, vulnerable households resort to distress sales of productive capital in the short run. By selling livestock or land and draining savings, they trade long-term stability for covering the current treatment expenses (Somi et al., 2009). In the long run, the effect of a health shock shifts towards greater reliance on structural austerity, as it reduces budgets earmarked for education, housing, and productive capital (Panikkassery, 2020; Somi et al., 2009). Such a health shock arising from a disparity between rising medical costs and household payment capacity is a major concern for policymakers.

Indian households face a substantial financial burden, as OOP health expenditure accounts for around 62.7% of total health expenditure (WHO, 2021). In fact, during 1993-2012, the growth rate of household health spending was much higher than household consumption expenditure (Mohanty et al., 2016). In addition, a high share of households is pushed below the poverty line annually due to high OOP health expenses (Hooda, 2017). From the point of view of framing public policies aimed at reducing poverty, it is more sensible to forecast the probability that a household will fall below the poverty line in the future (ex ante measurement) than to estimate whether the household was below the poverty line in the past (ex post measurement). This implies that estimating a household's vulnerability to poverty due to a sudden health shock provides a more predictive dimension for policy-making, enabling a transition from relief-oriented measures to risk-management measures. In the context of health shocks, vulnerability to poverty can be defined as the probability that high OOP health expenses in the current period will drive a household's net consumption expenditure below the poverty line in subsequent periods. Unlike ex-post poverty measures, which document past welfare, vulnerability to poverty is a forward-looking, ex-ante construct. It encapsulates households at risk of falling into poverty due to health shocks, not just those already residing in poverty.

Review of Literature

The major reasons for OOP expenses and consequential income losses among households are multiple events of repeated and serious illness and injuries. In these circumstances, the lack of accessible health insurance coverage leaves households facing significant financial instability and economic hardship. (Hoogeveen et al., 2004). Empirical evidence further suggests that households are also unable to stabilise earnings or sustain basic consumption due to serious illness and injuries. Evidence from rural Ethiopia suggests that poorer households lack the mechanisms to stabilise consumption over time; furthermore, the impact of adverse shocks is borne disproportionately by women within households (Dercon & Krishnan, 2000). Utilising similar data, Asfaw and von Braun (2004) found that informal risk-sharing networks in rural Ethiopia are insufficient to stabilise non-food consumption following the illness of a household head.

The impact of illness shocks on household heads, affecting a household's income and consumption pattern, has also been studied in multiple studies. Evidence from China suggests that the illness of a household head correlates with diminished labour supply and income, as well as higher OOP health expenditures, which are significantly higher in insured populations than in the uninsured (Wagstaff & Lindelow, 2005). Wagstaff (2007) found evidence that urban Vietnamese households face higher vulnerability in income following the death or illness or drop in body mass index of a working-age adult, regardless of insurance status. Meanwhile, Nguyet and Mangyo (2010) observed that illness or injury to Indonesian household heads leads to significant reductions in both labour hours and aggregate consumption expenses. Similar evidence from Laos suggests that poor households face more shocks in terms of illness, injury and death, and these are more prominent among the poor households. Many households also reported that consumption expenditures had to be reduced after an illness or injury in the household, which affected their welfare as well (Wagstaff & Lindelow, 2014).

Empirical research also shows that, while medical expenses are a source of economic risk due to illness in Indonesian households, this is largely confined to poor households, rural dwellers, and informal-sector workers who lack formal protection (Sparrow et al., 2014). Investigating the longitudinal effects of injury on a household's welfare and health expenditure levels in Zambia, it has been found that injury significantly reduced earned income and household welfare—measured by consumption—both before and after the 2002 structural adjustment period (Hangoma et al., 2018). Conversely, there is no evidence of income stabilisation among households facing illness, injury, or death-related shocks without a loss in household welfare (Mitra et al., 2016).

A plethora of literature on illness- or injury-related shocks has sought to estimate the level of consumption smoothing by households when they faced such shocks

and the myriad ways these strategies helped mitigate their impact. However, there is less evidence on how these shocks might drive households into future poverty. The fact that high OOP health expenses can push households below the poverty line is well-documented (Hooda, 2017). It is also known that when OOP health expenses rise, this necessitates budget shifting, in which essential spending on education, fuel, and housing is reduced to offset medical costs (Panikkassery, 2020). So, health shocks, measured either by high OOP health expenses relative to a household's capacity to pay or by reduced household income due to illness or injury, can be significant predictors of future poverty.

While the policy implications of health shocks are immense, there is a significant gap in understanding the nexus between health shocks and households' likelihood to fall below the poverty line, especially in the Indian context. There is also a dearth of research on how household- and community-level determinants modulate future poverty risks arising from health shocks. To address this, the study utilises multiple rounds of National Sample Survey (NSS) data to quantify vulnerability to poverty specifically induced by health shocks. To this end, it employs a three-step Feasible Generalised Least Squares (FGLS) framework to identify the key correlates of vulnerability and examine its change over the years.

Empirical Approach, data and variables

The empirical literature identifies three primary approaches for estimating vulnerability: Vulnerability as Expected Poverty (VEP), Vulnerability as Low Expected Utility (VEU), and Vulnerability as Uninsured Exposure to Risk (VER). The VEP approach defines vulnerability as the probability that a household's projected consumption expenditure will fall below a predefined poverty threshold within a future time horizon (Novignon et al., 2012; Chaudhuri, 2003. The VEU approach defines vulnerability as the gap between the utility of a given consumption level and the expected utility associated with that level. Conversely, the VER approach quantifies vulnerability as the net welfare loss resulting from a household's inability to access efficient risk-mitigation or consumption-smoothing mechanisms.

To analyse vulnerability to health shocks, the study uses the VEP, drawing on methodologies established by Chaudhuri (2003) and Novignon et al. (2012). The selection of VEP over alternative frameworks VEU and VER is justified by two reasons. First, unlike the VEU approach, which often requires panel data, the VEP framework is applicable to cross-sectional datasets. This allows for a comprehensive estimation of vulnerability using large-scale surveys where longitudinal data is unavailable (Atake, 2018; Novignon et al., 2012; Chaudhuri, 2003). The VER approach, on the other hand, is ex post in nature as it measures the impact of shocks after they have occurred, while the VEP approach facilitates an ex ante assessment.

Using the VEP approach

Following Chaudhuri (2003), the welfare level of a household is measured in terms of the value of consumption and vulnerability of household h at time $t(V\_{ht})$ is defined as the probability that the consumption level of a household in time $t+k$ ($C_{h,t+k}$) will lie below the consumption poverty line z. In other words,

$$V_{ht} = Pr\ (lnC_{h,t+k} < lnz) \tag{1}$$

It is assumed that the household h's consumption level is determined by the stochastic process given as:

$$lnC_h = X_h\beta + \epsilon_h \tag{2}$$

Where C_h is the consumption expenditure of household h, X_h is the vector of household characteristics, such as the household's location, the household head's education and gender, etc. β is a vector of parameters to be estimated, and ϵ_h is the zero-mean disturbance term.

It must be noted that, when using cross-sectional data, certain assumptions are made. First, the random disturbance term ϵ_h is log normally distributed, implying that C_h is also log-normally distributed. This assumption is made to enable the estimation of the probability that a household with a given set of characteristics. X_h will be consumption poor. Second, the economy is assumed to be stable over the analysis period, thereby excluding the possibility of aggregate shocks or abrupt structural changes.

Thus, a household with characteristics X_h The probability of being vulnerable to poverty at period $t+k$ can be estimated using the coefficients from equation 2.

$$\widehat{V_h} = pr\ (lnC_{h,t+k} < ln\ z|X_h) = \emptyset(ln\ z - X_h\hat{\beta}\hat{\sigma} \tag{3}$$

Where $\widehat{V_h}$ is the estimated vulnerability to poverty of household h (the probability that the consumption level of household h will be below the poverty line, conditional on household characteristics, $\emptyset(.)$ is the cumulative density of the standard normal distribution and $\hat{\sigma}$ is the standard error from equation (2).

- **Presence of heteroscedasticity**

To address the problem of heterogeneous variance of the disturbance term, the variance of ϵ_h

$$(\text{i.e., } \sigma^2_{\epsilon,h})$$

is assumed to be related to household characteristics in some parametric way as:

$$\sigma^2_{\epsilon,h} = X_h\theta + \mu_h \tag{4}$$

To estimate θ , a three-stage Feasible Generalized Least Squares (FGLS) method is used. The FGLS method provides a consistent estimate of the actual variance of consumption even in the presence of measurement errors (Amemiya, 1977).

At the first stage, equation (2) is estimated using the Ordinary Least Squares (OLS) method. The estimated residuals are used to estimate equation (5) by OLS:

$$\hat{\sigma}^2_{OLS,h} = X_h\hat{\theta} + \hat{\mu}_h \tag{5}$$

At the second stage, predicted values from equation (5) are used to transform equation (5) as given below

$$\frac{\sigma^2_{OLS,h}}{X_h\hat{\theta}} = \frac{X_h}{X_h\hat{\theta}}\theta + \frac{\mu_h}{X_h\hat{\theta}} \tag{6}$$

Now, estimation of equation (6) by OLS gives us an asymptotically efficient FGLS estimate,

$$\hat{\theta}_{FGLS}$$

It should be noted that,

$$X_h\hat{\theta}_{FGLS}$$

is a consistent estimate of

$$\sigma^2_{\epsilon,h}$$

Moreover, it is also the variance of the idiosyncratic component of household consumption. The standard error of

$$\hat{\theta}_{FGLS}$$

is now used to transform equation (2):

$$\hat{\sigma}_{\epsilon,h} = \sqrt{X_h\hat{\theta}_{FGLS}} \tag{7}$$

$$\frac{lnC_h}{\hat{\sigma}_{\epsilon,h}} = \frac{X_h}{\hat{\sigma}_{\epsilon,h}}\beta + \frac{\epsilon_h}{\hat{\sigma}_{\epsilon,h}} \tag{8}$$

Estimating equation (8) using OLS gives us β^ . The estimated parameters

$$\hat{\beta}_{FGLS} \quad \text{and} \quad \hat{\theta}_{FGLS}$$

enable us to estimate the expected log consumption (denoted by equation 9) and the expected variance of log consumption (denoted by equation 10).

$$E\left[\left(\widehat{lnC_h}\middle|X_h\right)\right] = X_h\hat{\beta} \tag{9}$$

$$Var\left[\left(\widehat{lnC_h}\middle|X_h\right)\right] = \hat{\sigma}^2_h = X_h\hat{\theta} \tag{10}$$

Finally, vulnerability to poverty can be estimated as

$$\hat{V}_h = \varphi\left(\frac{\ln z - X_h\hat{\beta}_{FGLS}}{\sqrt{X_h\hat{\theta}_{FGLS}}}\right) \quad (11)$$

- **'Vulnerability to poverty' threshold**

Since the estimated vulnerability to poverty $\hat{V}_h$ for a household, h can be any value between 0 and 1 (0 meaning no vulnerability at all and 1 meaning complete vulnerability). It is reasonable to assume 0.5 as a threshold for vulnerability to poverty (Novignon et al., 2012). Any household with an estimated vulnerability of 0.5 or higher is considered vulnerable to poverty; otherwise, it is not. To present our results, we express vulnerability to poverty as the percentage of vulnerable households and the mean vulnerability. A higher mean vulnerability implies a higher probability of being vulnerable to poverty due to health shocks (Atake, 2018). All analyses are conducted using Stata (version 14), with sample weights applied.

- **Time horizon**

The literature does not suggest any specific time horizon for assessing a household's vulnerability. Assessed at time point t, vulnerability can be estimated for any future time point *(t+k)* where *k* is usually ≥ 1 (Atake, 2018; Novignon et al., 2012).

- **Data**

We use data from four NSS health rounds: 52nd (1995-96), 60th (2004), 71st (2014), and 75th (2017-18), with nationally representative samples of 120942, 73868, 65932, and 113816 households, respectively.1 In addition to detailed household and individual-level data, the surveys collected a rich set of information on reported morbidity, healthcare utilisation and healthcare expenditure from the sample households. The recall period for hospitalisation and outpatient (OP) care is 1 year and 15 days, respectively, preceding the survey.

To maintain temporal consistency in the absence of official poverty thresholds for specific survey years, this study employs a deflation-and-inflation indexing strategy to align available poverty lines with the corresponding National Sample Survey (NSS) rounds. For the NSS 52nd Round (1995–96), state-specific thresholds were derived by deflating the official 2004–05 poverty lines. Conversely, for the NSS 71st (2014) and NSS 75th (2017–18) Rounds, the 2011–12 poverty lines were adjusted upward. In all instances, poverty lines for urban households were adjusted using the Consumer Price Index for Industrial Workers (CPI-IW), while poverty lines for rural households were adjusted using the Consumer Price Index for Agricultural Labourers (CPI-AL). For the 60th Round (2004), the proximate 2004–05 state-specific poverty lines were applied directly.

- **Dependent Variable**

The dependent variable utilised to estimate vulnerability to poverty is net monthly household consumption expenditure, defined as total monthly household consumption expenditure minus out-of-pocket (OOP) health expenditure. Since data on household OOP health expenditure were collected using recall periods of varying lengths (15 days for outpatient care and 365 days for inpatient care), they were standardised into monthly equivalents through appropriate scaling factors. In the next stage, we subtracted OOP health expenditure from total household consumption to arrive at net household consumption expenditure. Furthermore, following Asfaw & von Braun (2004), this exercise treats health expenditures as an exogenous component, mitigating endogeneity bias within the consumption function.

- **Independent Variables**

To measure a household's health status, we use a standardised proxy variable. This variable is constructed by calculating the ratio of household members who reported any event of illness or injury (15 days prior to the survey) or hospitalisation in the last year, to the total household size (Atake, 2018; Novignon et al., 2012).

Environmental determinants, such as access to potable water and improved sanitation, serve as indicators of hygiene-related living conditions. It is hypothesised that households with better living conditions exhibit lower morbidity rates and, consequently, have enhanced health outcomes. Demographic factors such as the presence of vulnerable cohorts, specifically children (0–14 years), the elderly (60 and above years), and women of reproductive age (15–49 years), can significantly affect household healthcare demand and expenditure (Atake, 2018; Novignon et al., 2012). Other household-level covariates included in the model are geographic and social indicators (sector, region, and caste), occupational category, household size, and the socio-demographic characteristics of the household head (gender and educational attainment). Additionally, the presence and type of health insurance coverage are important variables in financial protection (Atake, 2018; Mitra et al., 2016). Given the paucity of *ex ante* literature, this study draws on ex post empirical findings to corroborate and contextualise the results.

Results and Discussions

Selected descriptive statistics for the periods 1995–96, 2004, 2014, and 2017–18 are summarised in Table 1. Analysis of household-level morbidity reveals that the proportion of households with at least one ailing member rose from 21.82% in 1995–96 to a peak of 32.84% in 2014, then declined to 25.18% in 2017–18. There has also been a substantial improvement in hygiene indicators, as the share of households with unhygienic latrine facilities plummeted from 74.20% in 1995–96 to 22.59%

in 2017–18. Significant shifts in household demographics have also been observed. The share of female-headed households increased from 10.03% to 12.18% over the study period. The educational profile of household heads improved markedly, as the proportion of uneducated heads decreased from 43.63% in 1995–96 to 28.36% by 2017–18. The descriptive analytics also indicate a transformative expansion in health insurance among households. Household insurance coverage, which was negligible at less than 1% in 1995–96, reached 18.74% by 2017–18. This growth was largely driven by government-sponsored health insurance (GSHI) schemes, which saw coverage increase from 15.39% in 2014 to 18.74% in 2017–18.

Table 2 exhibits the shifts in mean vulnerability estimates and the prevalence of vulnerable households from 1995 to 2018. The data reveal a marginal but consistent contraction in mean household vulnerability, falling from 0.464 in 1995–96 to 0.435 by 2017–18. This downward trajectory is also portrayed in the proportion of vulnerable households, which diminished from 45.08% to 40.97% over the same period. These findings align with ex post estimates from the Ministry of Statistics and Programme Implementation (MOSPI), which report a significant decline in observed poverty incidence—from 45.3% in 1993–94 to 21.9% in 2011–12 (see Table A1 in Appendix). However, a critical finding of this analysis is the widening gap between ex post poverty and ex ante vulnerability estimates. Furthermore, the intensity of risk remains high for those categorised as vulnerable households, i.e. those with a mean vulnerability higher than 0.5. For this sub-group, mean vulnerability scores remained persistently above the 0.7 threshold throughout the study period (0.746 in 1995–96, 0.752 in 2004, 0.737 in 2014, and 0.736 in 2017–18). This lack of substantial improvement indicates that, while fewer households are entering the vulnerability bracket, the degree of vulnerability, or the risk of falling below the poverty line, has remained largely stagnant over the past two decades.

Comparative analysis of mean vulnerability and the prevalence of vulnerable households across various demographic characteristics reveals that rural households consistently exhibited higher levels of vulnerability than their urban counterparts throughout the 1995–2018 period (Table 3). The mean vulnerability index for rural households increased from 0.551 in 1995–96 to 0.579 by 2017–18. During this interval, the proportion of rural vulnerable households increased, rising from 56.68% in 2004 to 60.00% in 2014, and further to 61.73% in 2017–18. These trends suggest a limited capacity among rural populations to ensure earned income and consumption expenditures from the deleterious effects of health shocks (Mitra et al., 2016).

Disaggregation by occupational category indicates that households with members engaged as casual labour have the highest risk of falling below the poverty line. This is evidenced by a higher mean vulnerability and a larger share of vulnerable households across all four data waves than among self-employed or regular wage-

Table 1: Select descriptive statistics

Variables	**52nd round**	**60th round**	**71st round**	**75th round**
Survey month- year	**July 1995- June 1996**	**January - June 2004**	**January – June 2014**	**July 2017- June 2018**
Sample households	120942	73868	65932	113816
Average household size (SE)	4.92 (0.01)	4.82 (2.47)	4.51 (2.16)	4.35 (2.09)
Households with at least one ailing member (%)	20.82	30.29	32.84	25.18
Households with at least one child (%)	44.36	40.96	33	24.92
Households with at least one elderly (%)	21.29	26.47	26.87	22.63
Households with at least one female in the reproductive group (%)	86.78	92.74	92.08	92.11
Households with unhygienic sanitation facilities (%)	74.20	62.62	42.07	22.59
Households without access to safe drinking water (%)	4.56	13.75	8.21	6.43
Female Headed Household (%)	10.03	11.08	12.00	12.18
Households with illiterate head (%)	43.63	39.14	32.38	28.36
Households with primary level educated head (%)	38.57	40.48	38.73	37.38
Households with secondary level educated head (%)	12.12	13.79	19.66	23.34
Households with above secondary level educated head (%)	5.54	6.58	9.23	10.92
Households with any member having health insurance coverage (%)	0.38	1.86	18.60	18.74
Household with any member having GSHI (%)	-	-	15.39	18.74
Households having any member having employer provided health insurance (%)	-	-	1.62	15.31
Households with any member having household arranged health insurance (%)	-	-	1.73	1.72
Households with any member having other types of health insurance (%)	-	-	0.17	1.71

Source: NSS 52nd (1995-96), 60th (2004), 71st (2014), 75th (2017-18) round unit-record data

Note: Data on type of insurance coverage not available for NSS 52nd (1995-96) and 60th (2004) rounds.

Table 2: Estimated vulnerability to poverty for the years 1995-96, 2004, 2014 and 2017-18

Variables	**1995-96**	**2004**	**2014**	**2017-18**
Mean vulnerability score	0.464	0.458	0.441	0.435
Vulnerable households (%)	45.08	43.54	41.28	40.97
Mean vulnerability of vulnerable households	0.746	0.752	0.737	0.736

Source: NSS 52nd (1995-96), 60th (2004), 71st (2014), 75th (2017-18) round unit-record data

earning households. These findings align with ex post empirical literature, which finds limited asset ownership, income volatility, and diminished earning capacity as being the primary drivers of vulnerability to poverty among these specific cohorts (Thorat et al., 2017).

The analysis found that households utilising unhygienic sanitation facilities exhibit higher vulnerability than their counterparts, with mean vulnerability scores rising from 0.568 in 1995–96 to 0.585, 0.647, and 0.668 across the survey waves (2004, 2014, and 2017–18, respectively). The prevalence of vulnerable households for this cohort also rose from 60.03% in 1995–96 to 77.12% by 2017–18. Similar disparities are observed regarding water security, where households lacking safe drinking water consistently displayed higher vulnerability during the study period 1995-96, 2004 and 2017-18. These findings support the hypothesis that improved sanitation and safe drinking water facilities are important for mitigating morbidity and subsequent healthcare expenditures among households. These facilities enhance household welfare and productivity, thereby attenuating vulnerability to poverty in the long term. (Atake, 2018; Novignon et al., 2012).

The gendered dimensions of poverty are also evident from the analysis as female-headed households have both higher mean vulnerability and a larger share of vulnerable households throughout the 1995–2018 period, despite a marginal decline between 1995 and 2014. This aligns with global ex post evidence suggesting that female-headed households face a higher probability of chronic poverty (Kossoudji & Mueller, 1983; Atake, 2018). This might be primarily due to a gendered allocation of material resources such as land and employment opportunities. Coupled with cultural constraints that inhibit the accumulation of social capital and labour productivity among women, this increases the vulnerability of female-headed households to poverty. It is also found that households with uneducated household heads and those with primary-level education exhibit higher vulnerability to poverty compared to those with more educated heads. Households headed by individuals with primary education experienced a deterioration in future welfare,

Table 3: Vulnerability to poverty profile across sample household characteristics for the years 1995–96, 2004, 2014 and 2017–18

Variables	Mean Vulnerability				Vulnerable households (%)			
	1995–96	2004	2014	2017–18	1995–96	2004	2014	2017–18
Sector								
Rural	0.551	0.548	0.568	0.579	57.36	56.68	60	61.73
Urban	0.354	0.376	0.359	0.339	42.64	32.8	29.3	25.94
Occupation type of household								
Self-employed	0.433	0.424	0.458	0.457	39.76	37.59	43.63	43.4
Regular wage and salaried	0.279	0.297	0.347	0.336	18.16	22.56	28.17	26.03
Casual labour	0.659	0.632	0.639	0.612	74.37	71.16	71.51	68.04
Others	0.588	0.644	0.697	0.753	60.77	69.04	74.46	83.87
Type of sanitation and drinking water facilities								
Hygienic sanitation facilities	0.304	0.358	0.393	0.451	21.15	28.81	32.99	42.1
Non-Hygienic sanitation facilities	0.568	0.585	0.647	0.668	60.03	62.66	73.42	77.12
Availability of safe drinking water	0.497	0.494	0.501	0.494	49.53	49.16	50.21	49.12
Non-availability of safe drinking water	0.559	0.54	0.495	0.586	59.86	55.31	47.67	62.91
Gender of household head								
Female	0.728	0.698	0.652	0.692	80.14	77.07	70.08	75.15
Male	0.475	0.475	0.479	0.473	46.64	46.63	47.27	46.52
Education of household head								
No education	0.615	0.607	0.613	0.597	66.89	65.98	66.29	64.13
Up to Primary	0.474	0.502	0.535	0.541	45.65	49.3	55.19	56.5
Up to Secondary	0.319	0.349	0.387	0.437	23.35	27.09	31.03	38.86
Above secondary	0.164	0.166	0.198	0.242	5.11	7.24	11.47	14.95

Source: Estimated from NSS 52nd (1995–96), 60th (2004), 71st (2014), 75th (2017–18) round unit-record data

Table 4: Vulnerability to poverty profile across demographic characteristics for the years 1995–96, 2004, 2014 and 2017–18

Variables	Mean Vulnerability				Percentage of vulnerable households			
	1995–96	2004	2014	2017–18	1995–96	2004	2014	2017–18
Household with at least one child	0.446	0.443	0.464	0.421	43.19	42.82	45.55	40.44
Household without any child	0.543	0.539	0.518	0.526	55.43	54.99	52.20	53.19
Household with elderly member	0.466	0.501	0.520	0.511	43.80	48.56	52.00	50.56
Household without elderly member	0.509	0.499	0.493	0.497	51.68	50.52	49.27	49.85
Household with woman of reproductive age group	0.458	0.472	0.475	0.471	44.46	46.49	46.81	46.4
Household without woman of reproductive age group	0.774	0.853	0.794	0.838	86.40	94.90	87.11	92.19

Source: Estimated from NSS 52nd (1995–96), 60th (2004), 71st (2014), 75th (2017–18) round unit-record data

with mean vulnerability and the proportion of vulnerable households rising from 0.474 (45.65%) in 1995–96 to 0.541 (56.50%) in 2017–18 (Turčínková & Stávková, 2012). These results support the notion that higher education facilitates access to higher wages, which acts as a buffer against future consumption shocks arising from health shocks (Dhanaraj, 2016).

Table 4 presents the impact of household demographic composition and insurance coverage on estimates of vulnerability to poverty. The mean vulnerability to poverty among households with elderly members is higher than that of households without elderly members, and the estimates have risen from 0.466 in 1995–96 to 0.520 in 2014. Additionally, households with women of reproductive age also share a similar trend of rising mean vulnerability to poverty during the study period. Given that the elderly often suffer from chronic comorbidities that require frequent outpatient visits and hospitalisations, this necessitates higher healthcare allocations and reduced net consumption expenditure, thereby exacerbating overall household vulnerability (Mahumud et al., 2017).

As a household's vulnerability to poverty is a non-linear function of its future consumption trajectory, it is theoretically expected to maintain a positive relationship with expected consumption levels and a negative relationship with the volatility (variance) of the consumption levels. To examine these dynamics, Table 5 presents the estimated coefficients for the determinants of ex ante mean and variance of future consumption. The results reveal a significant negative relationship between health status and vulnerability to poverty, as well as greater variance in consumption patterns during the 1995–2018 period. This suggests that a household's current health status is a significant determinant of vulnerability to poverty, as an increase in the proportion of members with any illness or injury raises vulnerability to poverty (Atake, 2018; Novignon et al., 2012).

The study further finds that larger households exhibit lower mean vulnerability to poverty and less variance in future consumption compared to smaller households. This phenomenon can be attributed to economies of household size, in which members achieve greater efficiency through cooperative consumption, including shared housing costs, utility expenses, and bulk purchases of essential commodities (Thorat et al., 2017).

The analysis also suggests other structural factors that significantly exacerbate vulnerability to poverty by simultaneously reducing expected mean consumption and inflating consumption volatility across all four survey waves (1995–96, 2004, 2014, and 2017–18). These risk factors include rural location, belonging to the Scheduled Tribe (ST) or Scheduled Caste (SC) groups, casual labour, and female household headship. The presence of high-dependency groups, such as children and the elderly, in the household also consistently increases the risk of falling below the poverty line in future. It has also been observed that the presence of insured

Table 5: Determinants of vulnerability to poverty for the years 1995-96, 2004, 2014 and 2017-18

Variables	1995-96		2004		2014		2017-18	
	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)
Health Status	-1.059* (0.014)	0.526* (0.005)	-1.356* (0.021)	3.042* (0.030)	-1.605* (0.026)	0.820* (0.009)	-1.293* (0.018)	0.688* (0.007)
Household size	0.136* (0.001	-0.048* (0.001)	0.130* (0.003)	-0.288* (0.003)	0.127* (0.005)	-0.047* (0.002)	0.163* (0.003)	-0.059* (0.002)
Rural household	-0.101* (0.007)	0.041* (0.003)	-0.249* (0.013)	0.560* (0.006)	-0.272* (0.013)	0.100* (0.006)	-0.462* (0.008)	0.167* (0.004)
ST household	-0.135* (0.008)	0.047* (0.004)	-0.110* (0.016)	0.230* (0.007)	-0.118* (0.019)	0.053* (0.008)	-0.137* (0.012)	0.070* (0.005)
SC household	-0.065* (0.005)	0.016* (0.003)	-0.031* (0.011)	0.071* (0.005)	-0.023 (0.014)	0.020 (0.006)	-0.066* (0.009)	0.031* (0.004)
Consumption level category								
Poor household	-0.491* (0.005)	-0.038* (0.002)	-0.620* (0.010)	-0.014* (0.005)	-0.708* (0.012)	0.019* (0.005)	-0.789* (0.008)	0.126* (0.004)
Regular wage/ salaried household	0.046* (0.008)	0.018* (0.005)	0.049* (0.017)	-0.051* (0.009)	0.008 (0.015)	0.006 (0.007)	0.062* (0.010)	0.003 (0.005)
Casual labour household	-0.121* (0.005)	0.011* (0.002)	-0.129* (0.010)	0.240* (0.005)	-0.130* (0.013)	0.016* (0.006)	-0.071* (0.008)	0.004 (0.004)
Other occupation household	-0.090* (0.008)	0.033* (0.004)	-0.202* (0.014)	0.467* (0.007)	-0.151* (0.023)	0.047* (0.009)	-0.117* (0.014)	0.029* (0.006)
Household with hygienic sanitation facilities	0.217* (0.006)	-0.063* (0.004)	0.280* (0.011)	-0.632* (0.008)	0.285* (0.013)	-0.103* (0.006)	0.203* (0.009)	-0.072* (0.004)
Household with safe drinking water	-0.036* (0.010)	0.020* (0.005)	-0.025* (0.012)	0.068* (0.006)	-0.150* (0.019)	0.056* (0.008)	-0.009 (0.014)	0.031* (0.006)

Variables	1995-96		2004		2014		2017-18	
	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)	Ex ante mean Consumption (SE)	Ex ante variance Consumption (SE)
Female head household	-0.109* (0.007)	0.031* (0.003)	-0.048* (0.014)	0.116* (0.006)	-0.077* (0.017)	0.090* (0.007)	0.127* (0.011)	-0.112* (0.005)
Household head's education: Primary	0.112* (0.005)	-0.034* (0.002)	0.089* (0.010)	-0.198* (0.005)	0.058* (0.013)	-0.066* (0.006)	0.054* (0.009)	-0.050* (0.004)
Household head's education: Secondary	0.264* (0.007)	-0.072* (0.004)	0.269* (0.014)	-0.585* (0.009)	0.193* (0.016)	-0.082* (0.008)	0.147* (0.010)	-0.071* (0.005)
Household head's education: above secondary	0.514* (0.010)	-0.107* (0.006)	0.590* (0.020)	-1.270* (0.016)	0.557* (0.022)	-0.166* (0.011)	0.409* (0.014)	-0.138* (0.007)
Number of children in household	-0.075* (0.003)	0.014* (0.001)	-0.054* (0.006)	0.105* (0.003)	-0.044* (0.008	0.005 (0.004)	-0.035* (0.006)	0.005 (0.003)
Number of elderly members in household	-0.023* (0.004)	0.003 (0.002)	-0.006 (0.008)	0.003 (0.004)	-0.056* (0.009)	0.018* (0.004)	-0.044* (0.006)	-0.044* (0.006)
Number of reproductive age women in household	0.066* (0.004)	-0.036* (0.002)	0.032* (0.005)	-0.081* (0.003)	0.015* (0.006)	-0.005 (0.003)	0.004 (0.004)	-0.009* (0.002)
Household having any member having health insurance coverage	0.133* (0.033)	-0.042* (0.019)	0.271* (0.031)	-0.648* (0.019)	0.210* (0.014)	-0.097* (0.006)	0.131* (0.009)	-0.069* (0.004)

Source: Estimated from NSS 52nd (1995-96), 60th (2004), 71st (2014), 75th (2017-18) round unit-record data.

Note: Dependent variables are ex-ante mean of consumption and ex ante variance of consumption.

Standard errors (SE) are given in parentheses.

* Indicates 5% level of significance

members significantly influences the consumption levels in future. While insurance may marginally lower the expected future mean consumption, it substantially reduces the variability in consumption patterns. By smoothing consumption and protecting against OOP health payments, insurance coverage effectively lowers the probability of ex ante vulnerability to poverty.

An analysis of mean vulnerability across social and income strata reveals that households from marginalised groups, specifically Scheduled Tribes (ST) and Scheduled Castes (SC), are more vulnerable to poverty than non-SC/ST cohorts. Throughout the 1995–2018 period, ST households consistently exhibited the highest mean vulnerability among all other caste categories, with scores escalating from 0.615 in 2004 to 0.631 in 2017–18 (Figure 1; Appendix Tables A2, A3). These findings also align with ex post empirical research (Thorat et al., 2017).

The study also illustrates a diverging trajectory across income categories: for poor households, mean vulnerability to poverty and the prevalence of vulnerable households both rise, from 0.510 (51.85%) in 1995–96 to 0.671 (76.07%) by 2017–18. Conversely, a reciprocal downward trend was observed among non-poor households (Figure 2; Appendix Tables A2, A3). This indicates the existence of a medical poverty trap, as diversion of limited resources toward health expenditures subsequently compromises the household's ability to procure nutritional sustenance, preventive and curative health care, and educational opportunities. These findings reinforce the theoretical consensus that poverty is both a primary driver and a consequence of ill health (Atake, 2018).

Figure 1: Change in mean vulnerability and percentage of vulnerable households across caste from 1995 to 2018

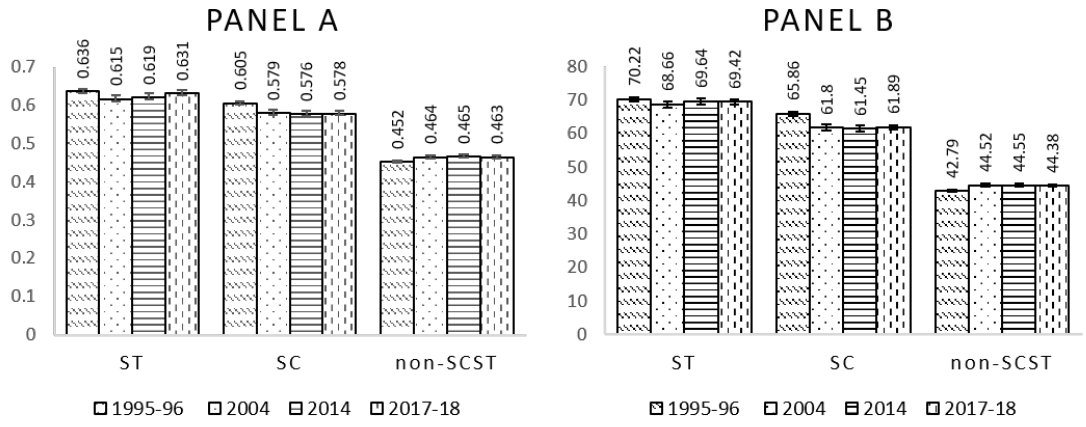
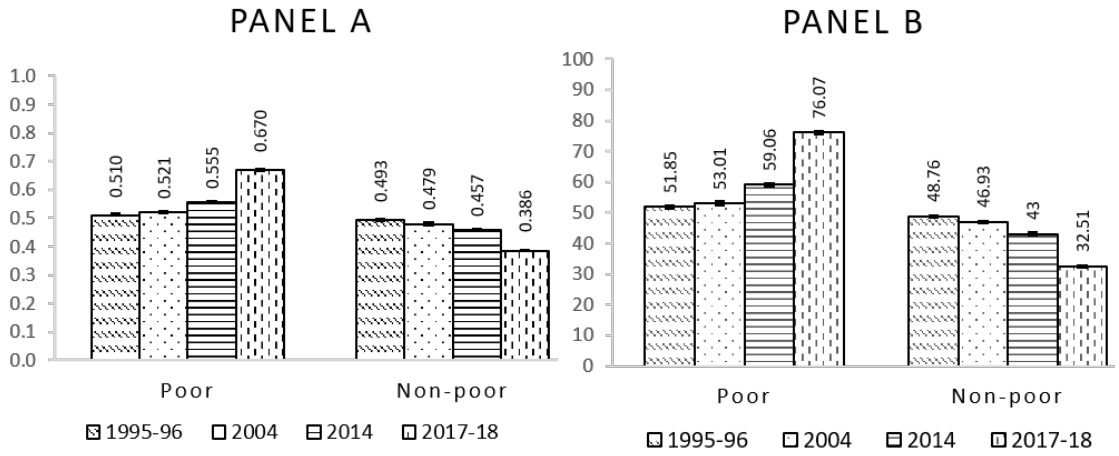


Figure 2: Change in mean vulnerability and percentage of vulnerable households across income categories from 1995 to 2018

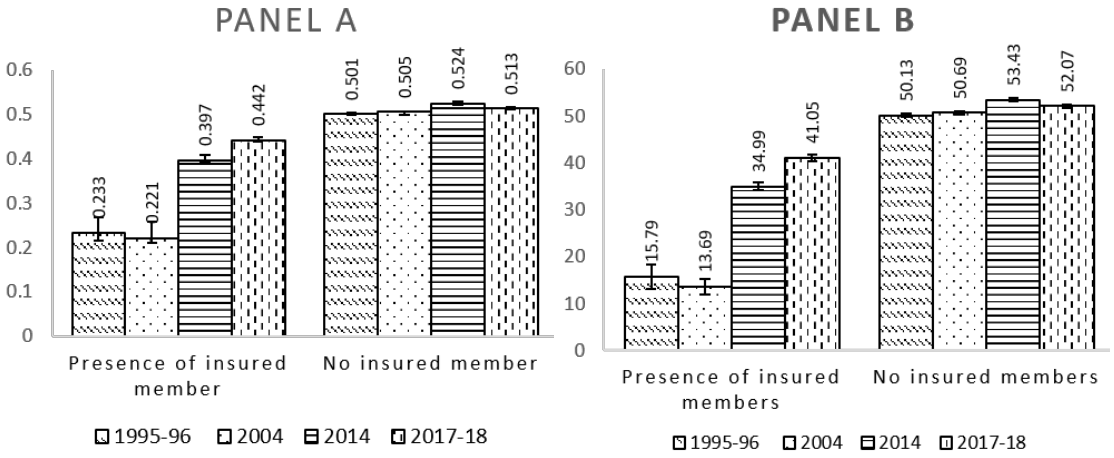


The study also examined the role of health insurance coverage in reducing households' vulnerability to poverty. Comparative analysis between insured and uninsured households reveals that the latter consistently maintained a higher mean vulnerability to poverty than the former. In fact, uninsured households experienced an increase in both mean vulnerability and the prevalence of vulnerable households, rising from 0.501 (50.13%) in 1995–96 to 0.524 (53.43%) by 2014 (Figure 3; Appendix Tables A2, A3). These findings align with existing research suggesting that households with insurance coverage have lower OOP health expenditures (Sepheri et al., 2006).

With the introduction of the Rashtriya Swasthya Bima Yojana (RSBY) in 2008, granular data on types of insurance coverage are available only for the 71st (2014) and 75th (2017–18) survey rounds. Quite surprisingly, households with at least one member enrolled in GSHI schemes have significantly higher mean vulnerability and a higher share of vulnerable households than those covered by alternative insurance schemes. For the GSHI-covered households, mean vulnerability surged from 0.426 in 2014 to 0.667 in 2017–18, while the proportion of vulnerable households nearly doubled from 38.26% to 69.18% during the same period (Figure 4; Appendix Tables A2, A3).

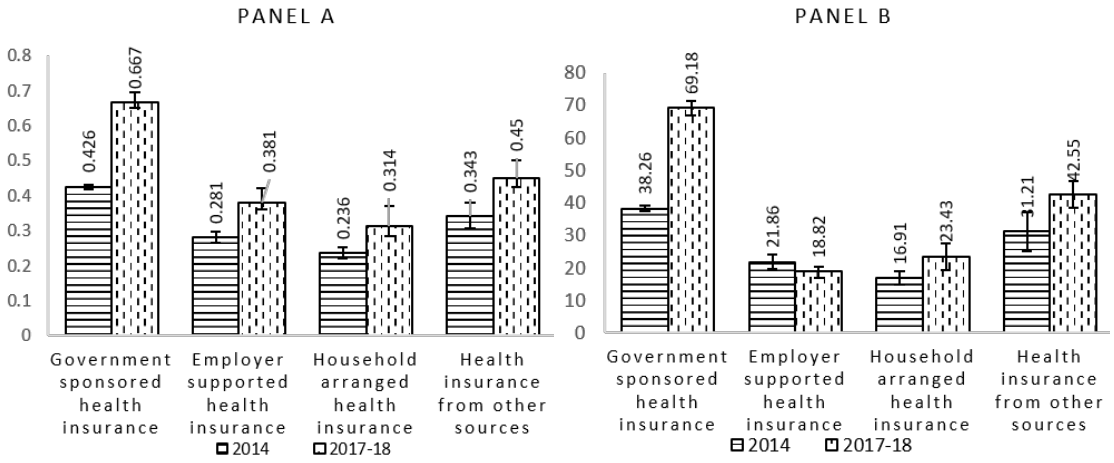
These results indicate that GSHI schemes have largely failed to provide the requisite financial protection necessary to smooth consumption levels in future. This inadequacy is supported by empirical evidence showing an increase in average hospitalisation costs even among GSHI-enrolled households (Selvaraj & Karan, 2012). The ineffectiveness of schemes like RSBY is frequently attributed

Figure 3: Change in mean vulnerability and percentage of vulnerable households across presence of insured and uninsured members in household from 1995 to 2018



to continued OOP spending on pharmaceuticals and diagnostics that are either unavailable at empanelled facilities or excluded from scheme protocols (Karan et al., 2017). Furthermore, limited coverage caps and administrative frictions, such as hospitals' reluctance to admit patients due to lengthened reimbursement cycles, further render the GSHI schemes ineffective (Ghosh, 2014).

Figure 4: Change in mean vulnerability and percentage of vulnerable households across type of insurance coverage among household members from 2014 to 2017-18



Conclusion and Policy Suggestions

The analysis demonstrates that health shocks exert a statistically significant but negative impact on future expected consumption expenditures while simultaneously increasing consumption expenditure volatility. These will make households more vulnerable to poverty. Although there has been a decline in absolute poverty rates and in the percentage of vulnerable households, the widening gap between these two metrics warrants serious concern. This gap suggests that the proportion of households currently at risk of falling into poverty exceeds those currently categorised as poor. This implies that the rate at which households are expected to descend into poverty due to health-related shocks in subsequent periods exceeds the rate at which households successfully exit poverty. Such findings necessitate a strategic shift toward policy interventions that are operationally distinct from traditional poverty alleviation, specifically targeting the mitigation of household vulnerability.

Estimates further reveal that the mean vulnerability of at-risk households has remained persistently above 0.7 across the 1995–96, 2004, 2014, and 2017–18 periods, indicating stagnation for these households. The disproportionate share of vulnerable households falls largely on rural households, ST and SC communities, and households with members engaged as casual labour. These groups exhibit both a higher mean vulnerability to health shocks and constitute a larger share of the vulnerable households relative to their counterparts. For these historically marginalised social groups, the implementation of income-stabilising policy mechanisms, complemented by robust government health insurance schemes, is necessary to reduce future descents into poverty.

Furthermore, the data indicate that households with poor sanitation facilities have experienced increases in both the mean vulnerability to poverty and the percentage of the population that is vulnerable from 1995 to 2018. Enhancing access to improved sanitation facilities is a critical public health intervention that can improve household resilience by preventing specific morbidities and premature mortality. Similarly, female-headed households exhibit a significantly higher risk profile and represent a larger share of the vulnerable population compared to male-headed households. Mitigating these risks requires gender-sensitive, targeted interventions, including expanding income-generating opportunities, providing childcare support, and implementing institutional policies to eliminate market and resource discrimination. Additionally, ensuring equitable access to healthcare and conducting aggressive educational campaigns can minimise welfare losses from health shocks. The results further underscore that households with illiterate or primary-level education heads demonstrate higher mean vulnerability to poverty and an increasing share of vulnerable households over the study period. This calls

for a universal basic education program to augment human capital and mitigate the adverse effects of health shocks on future poverty.

Finally, the study attempts to assess the role of GSHI schemes in reducing economic vulnerability. Paradoxically, the results suggest that the presence of an insured household member increases mean vulnerability and the share of vulnerable households from 2014 to 2018. A comparative assessment of vulnerability metrics across the pre- and post-GSHI (e.g., RSBY) phases indicates that vulnerability to poverty increased for households with at least one GSHI-covered member. These counterintuitive findings highlight the limited success of the current pan-India health insurance framework. Therefore, a fundamental redesign and expansion of health insurance programs are required, focusing on substantially reducing OOP health expenditures to stabilise household consumption in the wake of medical contingencies.

Endnotes

1. NSS is conducted by the Statistics Wing, called the National Statistical Office (NSO) of the Ministry of Statistics and Programme Implementation (MOSPI) in India. The data is available in the public domain and can be downloaded from the MOSPI website (http://mospi.nic.in/).
2. The study has used the Tendulkar committee poverty line, i.e., the minimum consumption expenditure/income required to identify households as poor.
3. The study has categorised households into three strata: Scheduled Castes (SC), Scheduled Tribes (ST), and non-SC/ST (comprising Other Backwards Classes and General Castes). Historically, SC and ST populations have faced systemic socio-economic marginalisation and discrimination owing to their low positions within the traditional Hindu caste hierarchy. Thereby, the Constitution of India have accorded them with special status.

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Parental Migration and Child Undernutrition Evidence form NFHS

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Internal migration is livelihood strategies for poor household. It can have significant impact on children health and well-being because children are especially vulnerable to change living conditions, access to food, and health services. In India, child undernutrition remains major public health concern. Therefore, the study examines impact of parental migration on children nutritional status. The study uses national representative data from National Family Health Survey-4, children nutritional status was measured using anthropometric indicators stunting, wasting and underweight. descriptive study has been use to understand the socio-economic differential. Further, we have applied a Propensity Score matching to estimate the effect of migration on children's nutritional outcomes. Result indicates urban migrant's children nutritional status is better than non-migrant's resident. Additionally, parental education significantly improves child nutrition. To assess the causal impact of migration on children nutritional status, the study employs regression analysis and propensity score matching (PSM) after balancing all covariates. Overall, the findings reveal a negative association between the migration and stunting/wasting/ underweight outcomes. However, migration stream appears to be positive for children health, as the average treatment effect on treated stunting (-0.05.2 % unmatched, ATT -0.02.2 % t=-2.39) and underweight (-0.05.2 unmatched, ATT-0.017% and t=-1.88). The finding suggests the socio-economic condition such a household wealth status, parental education, and regional disparities play a major role for children nutrition.

Keywords: Parental migration, Undernutrition, Urban residence, poor household

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Child undernutrition is a global concern with disproportionately huge and adverse well-being implications for low and middle-income countries (UNICEF & WHO,2025; Birhanu et.al, 2024). Studies have estimated that undernutrition is a major contributor to the global burden of disease (Heemann et.al, 2021; Victora et.al, 2021, Tamir et.al, 2024). In developing countries, undernutrition is associated with elevated risks of childhood mortality and morbidity including high prevalence of childhood ailments, cognitive impairments, and higher risk of chronic non-communicable diseases in adulthood (UNICEF, 2018; Kang et. al, 2018; Prendergast et. al, 2014; Danaei et.al, 2016; Martorell 2012).

Undernutrition has a multifactorial etiology and is caused by a range of demographic, socioeconomic and environmental factors. These contexts have an instrumental role in deciding upon nutritional status of the children and their future well-being (Black et.al 2013; Saidu et.al, 2024; Jiao, L, 2024; Choedon. et.al, 2024; Joe. et.al, 2017). The issue of child undernutrition has assumed increasing policy salience with launch of several national and international programmes aimed at accelerating nutritional improvements worldwide. Specifically, the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) Declarations has provided the much needed impetus to reduce the burden of undernutrition across developing countries (WHO, 2025; United Nation, 2023; Global Nutrition Report, 2020; UNICEF, 2020).

India is no exception and has launched several flagship programmes to curb the persistently high prevalence of undernutrition among children. However, the improvements are far from satisfactory. India accounts for one-third of the global burden of childhood stunting (low height-for age) and one-third of the global burden of underweight (low weight-for-age). The rapid economic growth witnessed in the past two decades has not translated into nutritional gains for the children (Rao, 2016; Sayeed.S, 2021). This is unlike the experience of neighbors such as Bangladesh where the prevalence of stunting has reduced from 36% in 2014-15 to 31% in 2017-18 (BDHS, 2017-18). The poor association between economic growth and child nutrition is a prominent concern for India. While it is argued that bulk of the growth benefits can materialize directly via household income and welfare but this has been an area of concern because of increasing inequalities in incomes and employment opportunities. These aspects can adversely affect food and nutritional security of the households including inadequate dietary diversity which are identified as critical concerns for child nutrition in India.

In this regard, it is important to present greater opportunities for households to improved contexts and circumstances for child well-being.

Migration of individuals and families for economic reasons offers a unique opportunity for households to change their contexts in terms of livelihood options and environmental amenities (De Brauw, 2007; Bhan. T, 2023; Srivastava. R, 2020;

Subbaraman. R, 2012). Several studies have documented the well-being implications of migration in terms of improvements in household income, employment opportunities, and access to health and educational services. The benefits are relatively large for urban migrants and those from advantaged socioeconomic background. In the theoretical prospective migration is always treat as outcome for the economic process of development. But in the same time various literature suggest that migration have adverse effect on heath. However, migration process involved stressor and strain that may increase migrant morbidity (Kristiansen M et.al, 2007; Glover S, 2001; Zimmerman C, 2011; Nauman. et.al, 2015). Moreover, studies suggest that lower socio-economic groups migrant's children are more undernutrition than the non-migrant because migrants as vulnerable and deprived when compared with the native population.

The other side of the argument disagrees. Migration has positive impact on children nutritional status. Evidence suggest that Guatemala population migrated to the US height for age Z score 0.5 standard deviation are higher than other children. Nutrition benefit those who are linked to the migration and China finding shows that migration is positively associate with lower birth weight and overweight. Those parents who have migrated with children have better nutritional status then who left behind child.

However, despite such relevance, there is a dearth of evidence to understand the effect of migration on child undernutrition. Migration can be categorized in four streams: viz. rural to rural migration, rural to urban migration, urban to rural migration and urban to rural migration. Although, studies have noted that migration has beneficial impact on household incomes and remittances but advantages of migration and its contexts (streams) on child nutrition is rather limited and unexplored. Some studies observe that parental absence due to migration is detrimental to children's physical health, psychological well-being whereas a few suggest that parental out-migration has a positive impact on child health. Similarly studies also find that the effects of parental migration vary according to whether one or both the parents are absent. However, no particular attention has been paid to migrant families with children and how migration streams are associated with nutritional status of children.

This study attempts to fill this gap and provides insights on the association of migration with child undernutrition. Based on the analysis of the nationally representative cross-sectional household survey (National Family Health Survey (NFHS), 2015-16), we examine whether migrant households are advantaged in terms of child nutrition then the natives or residents at destination. Also, we examine whether the advantage is associated with the socioeconomic background of the migrants and the stream of migration.

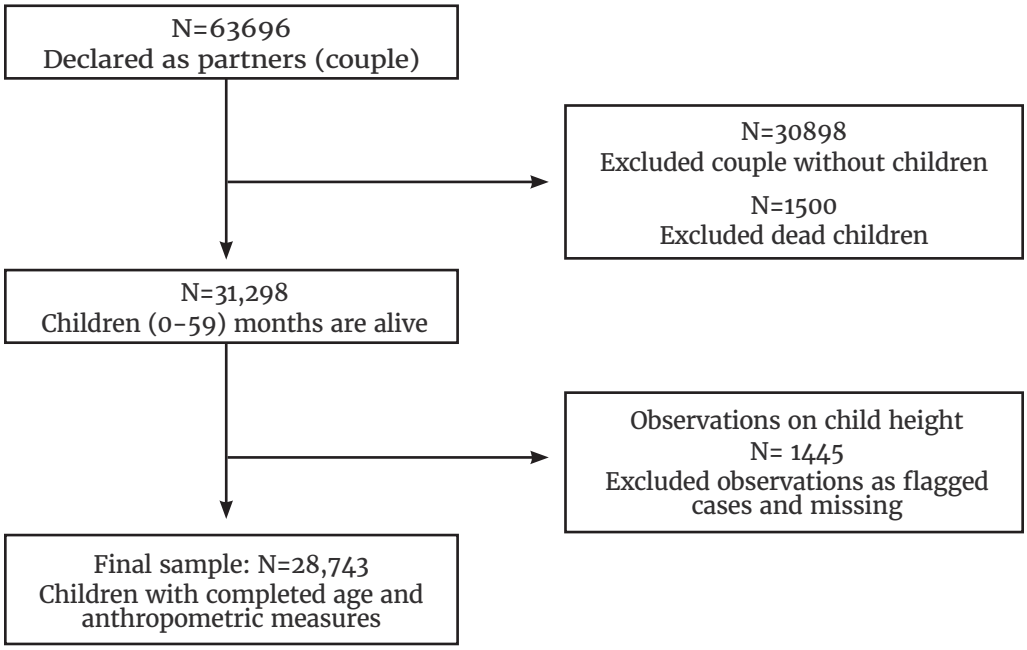
Data and Methods

The study is based on cross-sectional nationally representative National Family Health Survey (NFHS) of India conducted during 2015-16. NFHS sample households are selected based on a stratified two-stage sampling frame within states with stratification based on rural and urban areas (IIPS, 2018). A total of 699,686 women (age 15-49 years) and 112,122 men (age 15-54 years) were interviewed for the survey with a sample response rate of 94.5% for the women respondents and 87.1% for men respondents (IIPS, 2018). The analysis considers information on migration status of the married couples and nutritional status of their children. In India, marriage-related migration, particularly among women is a predominant contributor to overall migration. In order to eliminate cases of such marriage-related migration among women, we have focused on the migration status of men (husbands) and the reported information regarding their length of stay at the current place of residence. Specifically, the NFHS elicits information on time period of residence (in the current place of residence). Based on this information, a household is classified as migrant household if the respondent (man) has reported staying the current place of residence for less than 10 years period. Those men who report staying at the current place of residence for more than 10 years are considered as local residents or natives for the purpose of the analysis. Further, we also categorized in the destination couple migration 1). Both are residence (Native) 2). Male are migrated female are native 3). Female migrated male are native 4). Both are migrant. Individuals who were visiting the place (not an actual resident) were excluded from the analysis. The sample details are provided in Figure 1.

The present study uses NFHS-4 (2015-16) data rather than NFHS-5 (2019-21) for two substantive reason. The COVID-19 pandemic triggered one of the largest episodes of reverse migration in India recorded in history. Millions of urban migrants were compelled to return to their places of rural origin due to sudden lockdown, loss of livelihood and economic distress. Second, NFHS-4 has asked duration of stay of men at their current place of residence which is the key variable used in the study to classify migrant and non-migrant household. Accordingly, the finding of the study should be interpreted within the context of pre-pandemic migration pattern in India.

Thus, the analysis develops two categories of migrant households as follows: a) those who have migrated towards urban areas (urban migrants) and b) those towards rural areas (rural migrants). The nutritional status of children from thus classified migrant households is compared vis-à-vis the residents or native households. It is worth noting that the NFHS 2015-16 does not provide any information regarding the place of last residence. This disallows categorizing of migrant households in terms stream of migration (such as rural-to-urban migrant or urban-to-urban migrant).

Figure 1: Flow diagram to arrive at final analytical sample for the analysis, NFHS (2015-16)



Further, we use the following three anthropometric failure indices – stunting, underweight and wasting – constructed based on age, height and weight of the children and by following the WHO child growth reference standards (WHO 2006) to study nutritional failures among migrant and residents/native households. To elaborate, stunting, which reflects retarded skeletal growth due to chronic deprivation (UNICEF, 2009), was defined as height-for-age z-scores < -2 standard deviation (SD) below the WHO child growth reference standards (WHO, 2006). Underweight was defined as weight-for-age z-scores < -2SD. Wasting, signaling acute malnutrition, was defined as weight-for-height z-scores < -2SD.

The descriptive statistical analysis focuses on discerning the patterns in prevalence of anthropometric failure among children by migration status of their households. The prevalence is estimated for migrant households by their demographic and socioeconomic background. These variables include aspects such as age, place of birth, birth weight and birth order of the child, maternal age at birth, maternal height and BMI, parent's education, utilization of any ICDS services by children, and household factors such as access to improved sources of water and sanitation as well as households social group affiliation, economic status as per the NFHS wealth index quintiles and the region of residence. We also present logistic regression-based odds ratio (adjusted for the key demographic and socioeconomic variables)

to examine the association of nutritional status of children with migration status of the households.

However, for a robust comparison of the influence of migration status it is important to compare groups which are similar in terms of their demographic and socioeconomic background. The children of migrant and non-migrant's families from the study sample are not directly comparable because of the variations in exposure and socio-economic determinant. This may affect the inferences regarding the association of migration status with child anthropometric failures. Therefore, to study the association in a robust manner we have applied propensity score matching (PSM) analysis. The PSM analysis allows examination of average treatment effect related to the migrant households (the treatment group) with same characteristics as households who are natives or residents (the comparison group). The PSM approach has gained popularity as an effective tool to reduce selection bias that may crop in because of observed differences in demographic and socioeconomic characteristics between migrant and native households.

The PSM method comprises of two key steps. In the first step, a probit regression is used to identify the socioeconomic characteristics of the sample households and use this information to develop propensity scores (defined as the probability of family migrant's conditional to the characteristics included in the model). In the second step, the migrant and non-migrant households are matched based on comparisons of their propensity scores. Households which are having similar propensity scores are considered more comparable than those who are deviant in terms of their propensity scores.

The variables used to generate propensity based on the matching algorithm are as follows: age and birth order of the child, skilled birth attendance, maternal body mass index (BMI), mother's age at first birth, parental education, household wealth index, access to sanitation facilities and region of residence. Based on the PSM analysis, three parameters are estimated. These are average treatment

effect (ATE), average treatment effect on treated (ATT) and average treatment effect on untreated (ATU). The Average Treatment Effect (ATE) measures the mean impact of family

who are migrated. These parameters can be defined as follows:

$ATE = E(\delta) = E(Y_1 - Y_0)$

Where $E(\delta)$ represents the mean average and Y_1 represents the potential outcome describing

the nutritional status of children (viz. stunting, wasting and underweight) for the migrant household and Y_0 describing the expected outcome for the native households. In the post- treatment case, the counterfactual model helps to

understand the difference between the average outcome of those who received the treatment and the unobserved counterfactual.

Similarly, the Average Treatment Effect on the Treated (ATT) is estimated as follows:

ATT = E(Y 1 |D = 1) – E(Y 0 |D = 1)

Where E (Y 1 |D = 1) is the average outcome of the migrant households and E(Y 0 |D = 1) is the estimate for the counterfactual. Similarly, the average impact of the treatment only on those

who did not receive the treatment, is estimated using the ATE on the Untreated (ATU). It is defined as the difference between the average outcome of those who did not receive the

treatment and the counterfactual. It is defined as follows:

ATU = E (Y 1 |D = 0) – E (Y 0 |D = 0)

Where E (Y 1 |D = 0) is the average outcome of the residents or native households and E

(Y 0 |D = 0) is the estimate for the counterfactual.

Results

Table 1 shows the descriptive statistics of overall migrants and residents (local) by place of residence and the sample profile of migrants and residents (local) living with their children by place of residence. In the above table, the gender-based classification of migrants represents

those who had migrated and are married to a resident. The first category is native, the second is couples with males as migrants, the third is female migration due to marriage, and the fourth is when both migrants represent 'couple migrants' wherein both the partners are migrants, but their place of origin may or may not

Table 1: Sample description of migrant and native households, India, NFHS 2015–16

Migrant status	**% Migrant sample households**							
	Overall sample households (%)				Households with children (below 5) (%)			
	Urban	Rural	Total	N	Urban	Rural	Total	N
Residents (Natives)	43.8	57.8	52.9	1,924	19.9	30.4	27.2	788
Couples with male as migrant	3.9	2.8	3.2	34,527	2.0	2.2	2.1	9,310
Couples with females as migrant	28.6	33.0	31.5	6,311	50.0	59.4	56.5	3,857
Both as migrants	23.6	6.4	12.5	20,360	28.1	8.1	14.2	18,431

Source: Authors based on NFHS 2015–16

be the same. Out of the total residents (local), 43.8% reside in urban areas, wherein 19.9 % are cohabitating with their children. Moreover, out of 57.8% of residents residing in countryside, almost half of them are living with their children. Whereas, out of all migrants, 3.2% and 31.5% were male and female migrants who were married to a resident, respectively. Out of 12.5% of couples of migrants, more reside in urban areas compared to their counterparts, and 14.2% live with their children.

Table 2: Prevalence of anthropometric failure by place of residence among children of migrants and natives, India, NFHS-4 (2015-16)

10 years migrant	Stunting	95% CI	Wasted	95% CI	Underweight	95% CI
Urban migrant	27.2	[24.2,30.4]	20.6	[17.4,24.4]	26.7	[23.5,30.2]
Rural migrant	37.5	[34.6,40.6]	22.8	[20.2,25.6]	35.4	[32.5,38.4]
Urban native	30.7	[28.9,32.5]	20.2	[18.6,21.8]	29.2	[27.5,31.1]
Rural native	41.9	[41.0,42.8]	21.0	[20.3,21.8]	38.7	[37.8,39.6]
Total	37.8	[37.0,38.6]	20.9	[20.3,21.6]	35.3	[34.6,36.1]

Source: Authors based on NFHS 2015-16

Table 2 depicts the differences in prevalence of children's undernutrition by place of resident among children of migrant and natives. Among all children, 37.8% (CI 95% 37.0, 38.8) were stunted, 20.9% (CI 95% 20.3, 21.6) were wasted and 35.3% (CI 95% 34.6, 36.1) were underweight. Moreover, the prevalence of stunting was lower among urban migrant's children 27.2% (95% CI:24.2,30.4) compared with their counterpart, as rural migrants, urban migrants, rural resident and urban resident. The highest prevalence of wasting 22.8% (CI 95% 20.2, 25.6) was observed among children of rural migrants.

Table 3; shows undernutrition failure across the socio-economic group and regional difference in urban migrant's vs urban residence, rural migrant's vs rural residence. The undernutrition variation was observed and vary significantly between wealth of household and across social group. However, among urban migrant's prevalence of stunting and underweight bottom quintile is higher as counterpart to top quintile. Among urban migrants, stunting declines from 40.0% in the bottom wealth quintile to 21.4% in the top quintile, while underweight decreases from 36.5% (poorest) to 22.4% (richest). While comparison with urban residence vs urban migrants across quintile the prevalence stunting and underweight is lesser in urban migrant's than urban residence. Whereas, rural migrant's the prevalence of stunting and underweight is widening across the wealth quintile. Moreover, in rural migrant's prevalence of stunting and underweight is 43.6% and 40.5 % higher as counterpart to top quintile. Further, the prevalence of stunting and underweight is higher in rural migrant as counterpart to rural residence.

Table 3: Distribution of anthropometric failures by selected correlates among children of migrants and residence, India, NFHS-4 (2015-16)

	U-N1	95% CI	U-M2	95% CI	R-N3	95% CI	R-M4	95% CI
Wealth quintile								
Stunting								
Bottom quintile	40.2	[37.1,43.5]	40.0	[34.2,46.2]	45.3	[44.3,46.4]	43.6	[40.1,47.2]
Top quintile	26.0	[23.9,28.2]	21.4	[18.2,25.0]	28.0	[26.1,30.0]	18.8	[14.3,24.2]
Wasting								
Bottom quintile	20.5	[18.2,23.1]	20.7	[16.3,25.9]	22.1	[21.2,22.9]	24.9	[21.8,28.3]
Top quintile	20.0	[18.0,22.1]	20.6	[16.4,25.6]	17.0	[15.5,18.6]	16.2	[12.1,21.5]
Underweight								
Bottom quintile	38.1	[35.1,41.3]	36.5	[30.9,42.5]	42.4	[41.4,43.5]	40.5	[37.1,44.1]
Top quintile	24.9	[22.8,27.1]	22.4	[18.5,26.8]	23.6	[21.9,25.5]	19.6	[14.9,25.4]
Parental Education								
Stunting								
Illiterate	43.6	[39.5,47.8]	48.9	[40.1,57.7]	51.7	[50.2,53.2]	50.7	[45.2,56.0]
literate	28.2	[26.2,30.2]	24.2	[21.1,27.6]	36.8	[35.7,38.0]	32.0	[28.6,35.5]
Wasting								
Illiterate	20.6	[17.7,23.9]	24.2	[17.6,32.3]	23.9	[22.7,25.2]	26.4	[21.7,31.7]
literate	20.1	[18.3,22.0]	20.1	[16.6,24.3]	19.6	[18.6,20.5]	21.3	[18.2,24.7]
Underweight								
Illiterate	41.0	[36.9,45.2]	44.8	[36.4,53.5]	49.0	[47.5,50.5]	48.1	[42.7,53.5]
literate	27.0	[25.1,29.0]	24.3	[20.8,28.1]	33.4	[32.3,34.6]	30.0	[26.8,33.5]
Caste								
Stunting								
SC & ST	33.9	[30.3,37.7]	35.7	[28.9,43.0]	46.3	[44.8,47.8]	46.3	[41.6,51.1]
OBC & Others	30.2	[28.1,32.3]	24.8	[21.6,28.4]	39.4	[38.2,40.7]	32.7	[29.0,36.7]
Wasting								
SC & ST	21.8	[18.6,25.3]	23.8	[18.0,30.8]	22.5	[21.3,23.8]	29.7	[25.4,34.4]
OBC & Others	19.9	[18.1,21.9]	19.4	[15.6,23.9]	20.7	[19.7,21.7]	19.0	[15.8,22.8]

	U-N1	95% CI	U-M2	95% CI	R-N3	95% CI	R-M4	95% CI
Underweight								
SC & ST	35.7	[31.9,39.7]	36.9	[29.9,44.4]	42.8	[41.3,44.3]	43.4	[38.8,48.2]
OBC & Others	28.5	[26.4,30.6]	24.2	[20.5,28.3]	36.9	[35.7,38.1]	30.8	[27.2,34.7]
Region								
Stunting								
North	30.3	[26.9,33.8]	32.7	[25.3,41.1]	35.4	[33.6,37.2]	35.4	[28.1,43.6]
central	41.0	[38.1,44.0]	32.8	[27.1,39.0]	47.6	[46.0,49.1]	47.7	[42.3,53.1]
East	30.6	[26.0,35.5]	26.0	[16.8,38.0]	42.2	[40.2,44.2]	42.6	[36.0,49.5]
North East	21.9	[16.8,28.2]	32.6	[24.3,42.0]	35.2	[32.5,37.9]	36.6	[30.7,43.0]
west	26.4	[21.7,31.8]	23.1	[16.7,31.1]	45.6	[42.4,48.8]	38.1	[30.1,46.8]
south	24.5	[20.7,28.7]	25.9	[21.3,31.2]	35.3	[32.6,38.1]	29.0	[23.7,34.9]
Wasting								
North	18.5	[16.1,21.3]	21.9	[15.8,29.6]	21.3	[19.8,22.9]	16.3	[10.7,23.9]
central	21.6	[19.1,24.2]	18.3	[14.1,23.4]	21.5	[20.3,22.8]	28.2	[23.7,33.2]
East	15.9	[12.7,19.9]	18.0	[10.9,28.3]	20.9	[19.3,22.6]	24.1	[18.6,30.5]
North East	12.3	[8.2,18.0]	11.4	[6.7,18.5]	15.6	[13.6,17.8]	12.8	[9.3,17.3]
west	21.8	[17.4,26.9]	31.8	[22.0,43.6]	22.9	[20.4,25.5]	27.0	[20.2,35.1]
south	22.1	[18.3,26.5]	15.5	[12.2,19.6]	20.3	[18.1,22.6]	19.8	[14.8,26.0]
Underweight								
North	26.5	[23.3,29.9]	29.7	[22.5,38.0]	31.4	[29.7,33.2]	26.3	[19.6,34.2]
central	39.3	[36.4,42.3]	33.9	[28.3,39.9]	44.2	[42.7,45.7]	44.7	[39.4,50.1]
East	28.5	[24.2,33.3]	31.8	[21.9,43.6]	40.6	[38.7,42.6]	43.0	[36.4,49.8]
North East	21.2	[15.7,28.0]	27.2	[18.9,37.3]	27.5	[24.9,30.1]	26.4	[21.2,32.5]
west	27.4	[22.5,32.9]	29.6	[20.7,40.3]	41.6	[38.6,44.8]	41.6	[33.4,50.3]
south	23.4	[19.8,27.4]	20.6	[16.5,25.4]	32.4	[29.7,35.2]	25.6	[20.6,31.2]

*Notes: 1U-N; Urban Native; 2 U-M; Urban Migrant; 3 R-R; Rural Native; 4 R-M; Rural Migrants

Source: Authors based on NFHS 2015-16

Parental education strongly differentiates outcomes, especially among urban migrants. Migrant families with educated parents appear better able to access urban health services, nutrition practices, and childcare, resulting in improved child health outcomes. It shows that those parents are illiterate their children are higher undernutrition failure than literate parents. In the urban migrant's children are stunting and underweight is closely 20% higher in illiterate as compare to literate. Moreover, in regional pattern of urban migrant's vs rural migrants shows that in the North urban migrant's having a higher prevalence of stunting and underweight. Interestingly, within the south urban migrant vs residence shows that urban residence is less stunting and underweight. Whereas, in rural migrant's vs rural residence western having a higher stunting and north having higher underweight. Finally, the advantage of urban migration is higher in southern region and their children nutritional status as counterpart to northern, central, eastern, north eastern and western regions. Although urban migration may mask caste discrimination for SC/ST migrant children still experience higher nutritional deprivation, indicating structural inequalities, where 35.7% of urban migrant children are stunting as compared to 24.8% among OBC/Others. Urban migrant children remain vulnerable to anthropometric failures due to socio-economic inequalities, caste disadvantages, and regional disparities.

Table 4; represents that association between the undernutrition failure adjustment with socio- economic characteristics. The comparison between urban migrant's vs urban residence and Rural

migrant's vs Rural residence. As compared to affluent urban residents, urban migrants in the bottom wealth quintile has 40% higher odds of stunting, indicating that wealth significantly moderates the nutritional disadvantage among migrant households in cities. Poor migrant families living in urban areas remain highly vulnerable to chronic malnutrition, while wealthier migrant households appear to benefit from the urban advantage. It is interesting to note that neither urban migrant bottom nor top wealth groups show statistically significant differences in wasting.

Parental migration and child undernutrition failure is significantly associated. In urban areas, parental education appears to play a significant role among migrant households. The reduced risk of chronic malnutrition among children with educated migrant parents, as they may have better awareness of childcare practices, nutrition, and access to health services. Urban migrant with illiterate parents have 60 % higher odds of stunting, and underweight as compared with literate parents.

Table 5. Represents the propensity score matching (PSM) to understand the impact of migration on children nutritional outcome. In the overall sample, shows that migrant's children are significantly lower the prevalence of stunting compared to non-migrant children (ATT =-0.022; t=-2.39) while difference in wasting and

Table 4: Adjusted logistic regression for association between the socio-economic characteristics with stunting, wasting and underweight

Wealth Index	**OR Stunting4**	**OR Wasting5**	**OR Underweight6**
U-R Top (ref).	1.0 [1.0,1.0]	1.0 [1.0,1.0]	1.0 [1.0,1.0]
U-M Bottom	1.4** [1.1,2.0]	0.9 [0.6,1.3]	1.2 [0.9,1.6]
U-M Top	0.8* [0.6,1.0]	1.0 [0.7,1.4]	0.9 [0.7,1.2]
R-M Bottom	1.3** [1.0,1.6]	1.1 [0.8,1.4]	1.0 [0.8,1.3]
R-M Top	0.7** [0.5,1.0]	0.8 [0.5,1.1]	0.7* [0.5,1.0]
U-R Bottom	1.3** [1.1,1.6]	0.9 [0.7,1.2]	1.1 [0.9,1.4]
R-R Bottom	1.5*** [1.3,1.8]	0.9 [0.8,1.1]	1.2** [1.0,1.4]
R-R Top	1.1 [0.9,1.3]	0.8** [0.7,0.9]	0.8* [0.7,1.0]
Parental Education			
U-R literate (ref).	1.0 [1.0,1.0]	1.0 [1.0,1.0]	1.0 [1.0,1.0]
U-M illiterate	1.6** [1.0,2.6]	1.3 [0.8,2.1]	1.5* [0.9,2.5]
U-M literate	0.8* [0.6,1.0]	1.0 [0.7,1.3]	0.9 [0.7,1.1]
R-M illiterate	1.0 [0.8,1.4]	0.9 [0.6,1.4]	0.9 [0.7,1.3]
R-M literate	0.8* [0.7,1.0]	1.0 [0.7,1.2]	0.7** [0.6,0.9]
U-R illiterate	1.1 [0.9,1.5]	0.9 [0.7,1.2]	1.0 [0.8,1.3]
R-R illiterate	1.3*** [1.1,1.6]	1.0 [0.8,1.2]	1.2** [1.0,1.4]
R-R literate	1.0 [0.9,1.2]	0.8** [0.7,1.0]	0.9** [0.7,1.0]
Caste			
U-R OBC & Others (ref).	1.0 [1.0,1.0]	1.0 [1.0,1.0]	1.0 [1.0,1.0]
U-M SC & ST	1.0 [0.7,1.5]	1.1 [0.7,1.6]	1.2 [0.8,1.8]
U-M OBC & Others	0.8* [0.7,1.0]	1.0 [0.7,1.4]	0.9 [0.7,1.2]
R-M SC & ST	1.0 [0.8,1.3]	1.2 [0.9,1.6]	0.9 [0.7,1.2]
R-M OBC & Others	0.7*** [0.6,0.9]	0.8 [0.6,1.1]	0.7** [0.6,0.9]
U-R SC & ST	1.0 [0.8,1.2]	1.0 [0.8,1.3]	1.1 [0.9,1.4]
R-R SC & ST	1.1 [0.9,1.3]	0.9 [0.7,1.0]	0.9 [0.8,1.1]
R-R OBC & Others	1.0 [0.9,1.2]	0.9 [0.8,1.1]	0.9 [0.8,1.1]
Region[2]			
N-U Migration (ref).	1.0 [1.0,1.0]	1.0 [1.0,1.0]	1.0 [1.0,1.0]
N-R Migration	0.8 [0.5,1.5]	0.6 [0.3,1.2]	0.5** [0.3,0.9]

Wealth Index	OR Stunting4	OR Wasting5	OR Underweight6
N-U Residence	1.2 [0.7,1.9]	0.9 [0.6,1.5]	1.0 [0.6,1.6]
N-R Residence	1.0 [0.6,1.5]	0.9 [0.6,1.4]	0.8 [0.5,1.3]
C-U Migration	0.9 [0.5,1.5]	0.9 [0.5,1.6]	1.1 [0.7,1.9]
C-R Migration	0.9 [0.6,1.6]	1.1 [0.7,1.9]	0.9 [0.5,1.5]
C-U Residence	1.3 [0.8,2.0]	1.0 [0.6,1.6]	1.3 [0.8,2.0]
C-R Residence	1.0 [0.6,1.5]	0.8 [0.5,1.3]	0.9 [0.6,1.4]
E-U Migration	0.5 [0.2,1.2]	0.7 [0.4,1.5]	0.7 [0.3,1.3]
E-R Migration	0.6** [0.3,1.0]	0.7 [0.4,1.3]	0.5** [0.3,0.9]
E-U Residence	0.6* [0.4,1.1]	0.7 [0.4,1.2]	0.6* [0.4,1.0]
E-R Residence	0.7 [0.4,1.1]	0.8 [0.5,1.2]	0.7 [0.4,1.1]
N-E-U Migration	1.0 [0.5,1.8]	0.5* [0.2,1.1]	0.9 [0.4,1.6]
N-E-R Migration	0.5** [0.3,0.9]	0.4*** [0.2,0.8]	0.4*** [0.2,0.7]
N-E-U Residence	0.5** [0.3,0.9]	0.5** [0.3,0.9]	0.5** [0.3,0.9]
N-E-R Residence	0.6** [0.4,1.0]	0.5** [0.3,0.9]	0.4*** [0.3,0.7]
W-U Migration	0.7 [0.4,1.3]	1.9* [1.0,3.8]	1.1 [0.6,2.3]
W-R Migration	0.8 [0.4,1.4]	1.3 [0.7,2.3]	1.0 [0.5,1.7]
W-U Residence	0.9 [0.5,1.4]	1.1 [0.7,1.9]	0.9 [0.6,1.6]
W-R Residence	1.2 [0.8,1.9]	0.9 [0.6,1.5]	1.0 [0.6,1.6]
S-U Migration	0.8 [0.5,1.4]	0.8 [0.5,1.3]	0.7 [0.4,1.1]
S-R Migration	0.6* [0.4,1.1]	0.9 [0.5,1.6]	0.6** [0.3,1.0]
S-U Residence	0.7 [0.5,1.2]	1.2 [0.7,1.9]	0.8 [0.5,1.3]
S-R Residence	0.9 [0.6,1.4]	0.9 [0.6,1.4]	0.8 [0.5,1.3]

Source: Authors based on NFHS 2015-16

*Notes: 2 N-U; North Urban, N-R; North rural, C-U; Central urban, C-R; Central rural, E-U; East urban, E-R; East rural, N-E-U; North east urban, N-E-R; North east rural, W-U; West urban, W-R; West rural, S-U; South urban, S-R; South rural

*Notes 3; Regression model for Adjusted: Variables Child ICDS services, Parental education, Maternal BMI, Child age, Birth order, Maternal height, Mother age at birth, Children birth weight, caste, Skilled birth attendance, Toilet facility, Water facility and region

*Notes 4; Regression model for Adjusted: Variables Child ICDS services, Parental education, Maternal BMI, Child age, Birth order, Maternal height, Mother age at birth, Children birth weight, caste, Skilled birth attendance, Toilet facility, Water facility and region

*Notes 5; Regression model for Adjusted: Variables Child ICDS services, Maternal BMI, Child age, Birth order, Maternal height, Mother age at birth, Children birth weight, caste, Skilled birth attendance, Toilet facility, Water facility, Wealth Index and region

*Notes 6; Regression model for Adjusted: Variables Child ICDS services, Maternal BMI, Child age, Birth order, Maternal height, Mother age at birth, Children birth weight, caste, Skilled birth attendance, Toilet facility, Water facility, Wealth Index and region

Table 5: Propensity score matching estimates showing the effect of migration on children nutritional outcome

Migrant vs non-migrant children	Treated	Controls	Difference	S.E.	T-stat
Stunting					
Unmatched	0.312	0.365	-0.052	0.009	-5.77
ATT	0.312	0.334	-0.022	0.009	-2.39
ATU	0.365	0.346	-0.018	.	.
ATE			-0.019	.	.
Wasting					
Unmatched	0.193	0.207	-0.014	0.008	-1.84
ATT	0.193	0.195	-0.003	0.008	-0.35
ATU	0.207	0.205	-0.002	.	.
ATE			-0.002	.	.
Underweight					
Unmatched	0.280	0.332	-0.052	0.009	-5.88
ATT	0.280	0.296	-0.017	0.009	-1.88
ATU	0.332	0.317	-0.015	.	.
ATE			-0.015	.	.
Migrant vs non-migrant children urban					
Stunting					
Unmatched	0.287	0.301	-0.014	0.013	-1.08
ATT	0.287	0.285	0.002	0.013	0.16
ATU	0.301	0.292	-0.009	.	.
ATE			-0.006	.	.
Wasting					
Unmatched	0.186	0.196	-0.010	0.011	-0.92
ATT	0.186	0.194	-0.008	0.011	-0.67
ATU	0.196	0.188	-0.009	.	.
ATE			-0.008	.	.
Underweight					
Unmatched	0.262	0.276	-0.014	0.013	-1.07
ATT	0.262	0.261	0.002	0.013	0.14
ATU	0.276	0.275	-0.001	.	.
ATE			0.000	.	.

Migrant vs non-migrant children	Treated	Controls	Difference	S.E.	T-stat
Migrant vs non-migrant children Rural					
Stunting					
Unmatched	0.339	0.386	-0.047	0.013	-3.63
ATT	0.339	0.377	-0.038	0.013	-2.97
ATU	0.386	0.362	-0.023	.	.
ATE			-0.025	.	.
Wasting					
Unmatched	0.200	0.211	-0.010	0.011	-0.95
ATT	0.200	0.205	-0.005	0.011	-0.43
ATU	0.210	0.208	-0.002	.	.
ATE			-0.002	.	.
Underweight					
Unmatched	0.298	0.351	-0.053	0.013	-4.17
ATT	0.298	0.338	-0.039	0.012	-3.20
ATU	0.350	0.322	-0.028	.	.
ATE			-0.029	.	.

Source: Authors based on NFHS 2015-16

ATT = Average treatment effect on the treated. ATU = Average treatment effect on the untreated. ATE = Average treatment effect.

Note: control variables are Parental education, Maternal BMI, Child age, Birth order, Mother age at birth, Children birth weight, Skilled birth attendance, Toilet facility, region.

underweight are small and statistically insignificant. Moreover, in urban areas match indicate no significant differences in nutritional outcome between migrant and non-migrant children. The ATT among migrant is close to zero (0.002; t=0.16) and wasting and underweight difference is negligible. Whereas, in rural areas, migrant children exhibit lower level of stunting (ATT=-0.038) and underweight (ATT=-0.039) compared to non-migrant children.

Robustness check

The relationship between parental migration and children are complex and may depends on urban living condition and destination. Therefore, we have also checked the robustness to ensure the reliability of the study. Moreover, capturing a migration from NFHS is challenging, because migration is mostly being due to marriage. Therefore, we have used duration of father's residence at current place and living at current location less than 10 years were considered as migrants. This approach can use with NFHS data.

To further validate the migration pattern, we have used age specific migration pattern from census, 2011 (Table s1 and Table s2). The census table shows broadly comparable migration pattern between NFHS-4 and census data. Particularly prime age of 15-49 (women) and 15-54 (men) age groups. This analysis consistency provides confidence of migration definition which we have used for the analysis.

Moreover, to estimate the causal effect of migration on children nutritional outcome, PSM was employed first we use logit model to estimate the propensity score, where parental migration was treated as dependent variable and several socio-economic demographics characteristics were including as covariates. Afterwards, matching was done to ensure that the treated group (Migrants household) and control groups (non-migrants household). Further, to assess the quality of matching we conducted a balancing test (Table 6). The results indicate a substantial improvement in covariates balance after matching. For overall, Pseudo R2 decreased from 0.052 in the unmatched sample to nearly after matching, and the likelihood ratio (LR x2) statistic became statistically insignificant. Similar pattern was observed in rural and urban, it is suggesting that matching procedure effectively balance the covariates between migrants and non-migrants.

Migration research in India often face challenges particular related to endogeneity and selection bias, because migration pattern often influences by age, education, household composition, skill, employment, opportunities etc. According to migration theory is always seen as investment in human capital. In result, these factors of migration may influence the migration behavior and children health.

Also, additional validation has been performed by comparing a state's level migration pattern of NFHS-4 and census-2011 (Table S3). Although some difference

Table 6. Overall Significance of the Models after Conducting Matching Analysis

Sample for migration	Pseudo R2	LR χ2	p > χ2
Overall			
Unmatched	0.052	953.61	0.000
Matched	0.000	4.360	0.930
Urban			
Unmatched	0.036	265.44	0.000
Matched	0.000	0.800	1.000
Rural			
Unmatched	0.035	360.90	0.000
Matched	0.001	5.420	0.862

Source: Authors based on NFHS 2015-16

exists due to survey differences, but the overall distribution of migration pattern remains consistence.

Table 6: Represents overall significance of the model is shown. The pseudo R2 gives us an estimation of how well the predictors explain the probability of the outcome for child health outcomes (stunting, underweight, and wasting). After matching the value is decreasing, Further, it was found that mean difference became insignificant after matching for almost all covariates. Therefore, all the covariates were sufficiently balanced.

Discussion

Internal migration represents an India's economy transformation, approximately 450 million internal migrants (Census, 2011) and 17.5 million International migrants globally (IOM, 2019). These migrants are originated from rural states such as Bihar, Uttar Pradesh and Jharkhand to urban hubs such as Delhi, Mumbai and Chennai. While migration promote a better livelihood, but health is remained ambiguous. There are studies has been reveals that migration having negative impact on worker health such as lack of proper safety, extreme heat stress, construction accidents and exposure of hazardous chemical.

Moreover, the finding indicates effect of migration on children varies by residential context and socio-economic composition rather than migration itself. The descriptive finding shows differences among migrant and non-migrant group for example children of urban migrants has a lower prevalence of stunting (27.7%) and underweight (26.7%) compared with urban natives (30.7% and 29.2% respectively). Similarly, with rural migrant's children also appears to lower level of undernutrition than rural natives.

Parental education demonstrates a strong association with children nutritional status. Children of illiterate parents show considerably high stunting and underweight than those parents are literate. For instance, stunting is 48.9% among children of illiterate parents compared with 24.2 % among those literate parents. It is evidently shows importance of parental knowledge and health awareness shaping child nutrition. Further, adjusted regression analysis exhibit the importance of socio-economic factors. Children from poor household have significantly higher odds of stunting compared to a wealthier household, but the parental illiteracy remain the positively associated with poor nutritional outcome.

However, the descriptive and regression results may still influence by migration selectivity (In the context of internal migration), labour migration is always driven by the search of better economic opportunities for the better survival of the household. Further, applied a Propensity score matching to compare the migrant and non-migrants with similar socio-economic characteristics. After controlling

a household characteristic, there is no difference are observed between urban migrant with native children for stunting, wasting and underweight. it means the urban migrants children and urban native similar nutritional conditions after socio-economic difference are taken into account. The advantage of urban migrants has been observed in descriptive table, largely changed after PSM matching. Hence, indicating that differences are primarily due to household characteristics such as education, wealth and demographic factors rather than migration itself.

These results differences also reflect in the context of destination. Urban migrants may have relatively better access food market, health services and infrastructure, where rural migrants are often engaged in seasonal work, it may experience greater food insecurity. The finding pattern are consistence with the UNICEF conceptual framework which emphasis the role of underlying determinants such as parental education and access to services. Therefore, policy needs more portable ICDS services target to rural migrants and urban creches.

Recommendation

Taking together all the findings, support that view of migrants to urban area significantly positive impact on children growth and development. Moreover, if a migrant is educated, that it will definitely enhance children's education and lead to reduction in poverty for the upcoming generation of the migrants. Whereas, in the rural-to-rural migration or urban migration specially in case of short-duration where they take their children, especially in case of the marginalized social groups resulted in chronic poverty (Thorat & Jones, 2011). For migrant children should be provided a crèche, as mandated under labor laws in the construction, mining and plantation sectors and at MGNREGA worksites.

Limitations

While, NFHS-4 analysis acknowledge the limitation as cross-sectional design limit the causal inference on migration timing and decision. Migration data also constrained stream specific analysis for example Bihar to Delhi. Moreover, NFHS-4 capture the Pre-COVID migration pattern. Whereas, NFHS-5 has distorted the pattern due to reverse migration flow.

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Understanding Progression and Management of Diabetes in Indian Settings From Electronic Medical Records of an Urban Community: The Case of Chips Cohort Study

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There has been a growing demand for comprehensive studies on the management of type II diabetes in Indian settings. This paper presents a case study demonstrating how electronic medical records (EMR) from a community covered under the Contributory Health Services Scheme (CHSS) can help address important research gaps in diabetes care and management. The Hospital Information Management System (HIMS), which covers 89,204 CHSS beneficiaries, records every interaction between beneficiaries and healthcare providers. Using this database, a cohort of 835 patients newly diagnosed with diabetes during 2011–2012 was identified, and their 10-year medical history following diagnosis was reconstructed. For comparison, a cohort of 1,670 age- and sex-matched non-diabetic beneficiaries with similar longitudinal medical histories was also created. This cost-effective cohort dataset enabled researchers to examine several issues related to diabetes incidence and management, including the risk of diabetes in the community, transitions between non-diabetic, pre-diabetic, and diabetic stages, excess morbidity among diabetic patients, and seasonal variations in glycaemic levels. The findings underline the significant potential of EMR-based cohort reconstruction for understanding diabetes risk, progression, and management in community settings.

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Global trends and projections on the prevalence of diabetes indicate that it is one of the most hostile chronic health conditions threatening the quality of healthy life globally. The situation is similar in India, where one out of every five persons aged 45 years and above, amounting to over 50 million people, are self-reporting a previous diabetes diagnosis or having HbA1c of 6·5% or higher (Sekher et al., 2025). According to the International Diabetes Federation, of the global estimate of 589 million people with diabetes in the 20–79 age group, 17 percent reside in India (IDF, 2025). The number of persons with diabetes in India is estimated to be 101 million by 2030. Such an elevation in the number of diabetes patients would lead to an exponential increase in financial resources required to prevent, diagnose, and treat this non-reversible condition. Estimates show that diabetes accounts for 3 percent of deaths in India and that years of life lost (YLL) due to diabetes-induced premature mortality is more than years of life lived with disability (YLD) due to diabetes (Tandon et al., 2018). With the ongoing epidemiological transition, these YLD will be more than YLL in future years, which underlines the need for more research and interventions for countering the comorbidities in the life cycle of patients diagnosed with diabetes.

As noted in most of the less developed countries, the prevalence of self-reported diabetes in India is relatively higher in the urban population than in the rural population and in higher socio-economic strata than in lower socio-economic strata (IIPS et al., 2020, 2020; IIPS & ICF, 2017). Though there are several studies on the self-reported prevalence of diabetes in India, only a few studies provide estimates of the incidence of diabetes in Indian settings (Mohan et al., 2014; Narayan et al., 2021; Vijayakumar et al., 2019). These studies, based on longitudinal surveys of population cohorts from various sites, have illustrated the effect of various behavioural risk factors on the incidence of diabetes. Additionally, Indians are characterized by a stronger genetic predisposition to diabetes and a greater degree of insulin resistance (IIPS & ICF, 2017; Narayan et al., 2021; Tripathy et al., 2017).

Diabetes is often accompanied by connected chronic comorbidities. Conditions like hypertension, hypertriglyceridemia, retinopathy, thyroid disorder, hypercholesterolemia, dyslipidaemia, cardiovascular disease, stroke, and chronic kidney disease are prevalent in Indian diabetes patients (Kumar et al., 2013; Murthy et al., 2012; Pradeepa et al., 2008; Premalatha et al., 2000; Rema et al., 2005; Tripathy et al., 2017; Unnikrishnan et al., 2007). Though comorbidities are part of diabetes, little is known about their onset in diabetic patients, which is essential for a better understanding of risk stratification for the incidence of these morbidities. Another significant issue is the lack of preparedness of the health systems to manage diabetes effectively. All these strengthen the call to fill the research gaps in understanding the incidence, disease burden, spectrum of complications, and management of diabetes in the country (Kaveeshwar & Cornwall, 2014; Unnikrishnan et al., 2016).

This is a brief description of the scientific investigation process initiated to study the onset and multiple aspects of the management of diabetes in the life cycle of patients in an urban community in Greater Mumbai. All the members of the community are beneficiaries of the contributory health services scheme (CHSS) provided by their government employer. The CHSS functions under the medical division, Bhabha Atomic Research Centre (BARC), which collaborated with the International Institute for Population Sciences (IIPS) for this research study. The CHSS-IIPS project titled CHIPS study aims to augment evidence base towards the strengthening of diabetes management in India. Innovative element here is the effective use of electronic medical records for preparing the CHIPS cohort data. The objective of this paper is to disseminate the experience in setting CHIPS cohort and to highlight usefulness of this data in public health research.

- **Contributory health service scheme**

The CHSS had 89,204 beneficiaries in the year 2021, which includes current employees, retired employees, and their dependent family members. Out of these, 49,030 beneficiaries reside in the well-planned gated township, and 40,174 beneficiaries living outside the township are spread over various localities in Greater Mumbai. CHSS offers medical care to the employee, spouse, and their children aged up to 25 years. Employees and their spouses are entitled to CHSS benefits even after retirement from the service till death or unless they opt out for some reason like migration, employee's resignation, etc. Employee's dependent parents are also enrolled as beneficiaries of this CHSS. The CHSS covers all preventive and curative care needs of all beneficiaries.

Each CHSS beneficiary, based on their residential pin code, is attached to a CHSS zonal dispensary. Beneficiaries can walk into that facility where the family physicians attended to their health care needs. The beneficiaries can also avail services under specialist doctors' advice whenever needed at a dedicated multispecialty hospital, which is situated inside the township. The hospital and all the dispensaries are connected with a computerised hospital information management system (HIMS). There are 16 such dispensaries and one multispecialty hospital with 390 beds. The hospital and dispensaries are manned by about 65 specialist doctors, 200 family physicians, and an adequate number of nursing and technical staff.

Methods

- **Cohort Design:**

A 10-year retrospective cohort data set is constructed using the medical records maintained for these CHSS beneficiaries. The uniqueness of the CHIPS cohort is the universal access to health care in this urban community. Results from most of

the cohort-level studies available are likely to have a bias arising out of extreme inequities in access to health care services in the country (Balarajan et al., 2011; Baru et al., 2010; Hazarika, 2013). Factors like limited access to medical facilities, perception of disease, and treatment continuity could have added to the delay in diagnosis of diabetes, leading to aggravation of diabetes-related complications (Deepa et al., 2014; Mohan et al., 2014; Wangnoo et al., 2013). Universal access reduces the risk of undiagnosed diabetes in the study community and complications arising due to delay or discontinuity in treatment. A retrospective type of design is preferred due to the irreversible nature of diabetes and to make use of existing medical records data already available for the study population. This cost-effective design has the potential to answer a plethora of patient and medical care provider-level questions relating to the management of diabetes.

The cohort was designed after taking stock of the secondary data from existing medical records maintained for the newly diagnosed diabetes patients availing the medical services. The specific objectives of the CHIPS cohort study, initiated in 2022, were to:

- Estimate the incidence of diabetes and disease burden in the study population using hospital medical records.
- To understand the probability of and the time duration for transitioning from a pre-diabetic to a diabetic.
- To study the clinical progression and major clinical events in the course of the disease.
- To understand the seasonal pattern in glycaemic levels in diabetic patients.
- To study the interrelationship between frequency of interaction with the health care provider and glycaemic control.
- To determine COVID-19-induced temporal variation in glycaemic control among diabetes patients.

- **Health Information Management Systems Data**

Near-uniform protocols were used for completing the medical records of every beneficiary who visits the medical facilities under this CHSS. All relevant investigations were offered to the patients, and laboratory reports were available in the HIMS. Details of medicines issued to the patients from an in-house pharmacy, and the prescription was available in HIMS. We extracted details about their visits to casualty, dispensaries, outpatient departments, Inpatient discharge notes, medical case progress notes, laboratory investigations, medical prescriptions, and death summaries. Details of patients referred to outside health facilities for specialized treatment or other reasons are also captured in the HIMS. The other vital parameters of patients, such as body weight, blood pressure, etc., expected

to be recorded by the physician in the case-sheet during an outpatient care visit, were noted to be incomplete in HIMS. The digitization of medical records in HIMS was started in 1996; however, connectivity to peripheral zonal dispensaries was extended in phases till 2009. Hence, complete data on all interactions between each beneficiary and health facilities are available from 2010.

Each beneficiary is issued an individual Medical Record Department (MRD) identity number at the time of inception into the CHSS. To follow the ethical code of conduct in this research, every patient's MRD number was masked using an encrypted version, as per a pre-defined algorithm. Anonymous patient records with encrypted identity numbers were provided to the CHIPS study team. All study objectives in the CHIPS study were within the limits of information available from the medical records of beneficiaries. No primary data collection or interaction with patients occurred in this phase of the study.

- **Identifying diabetes patients from medical records:**

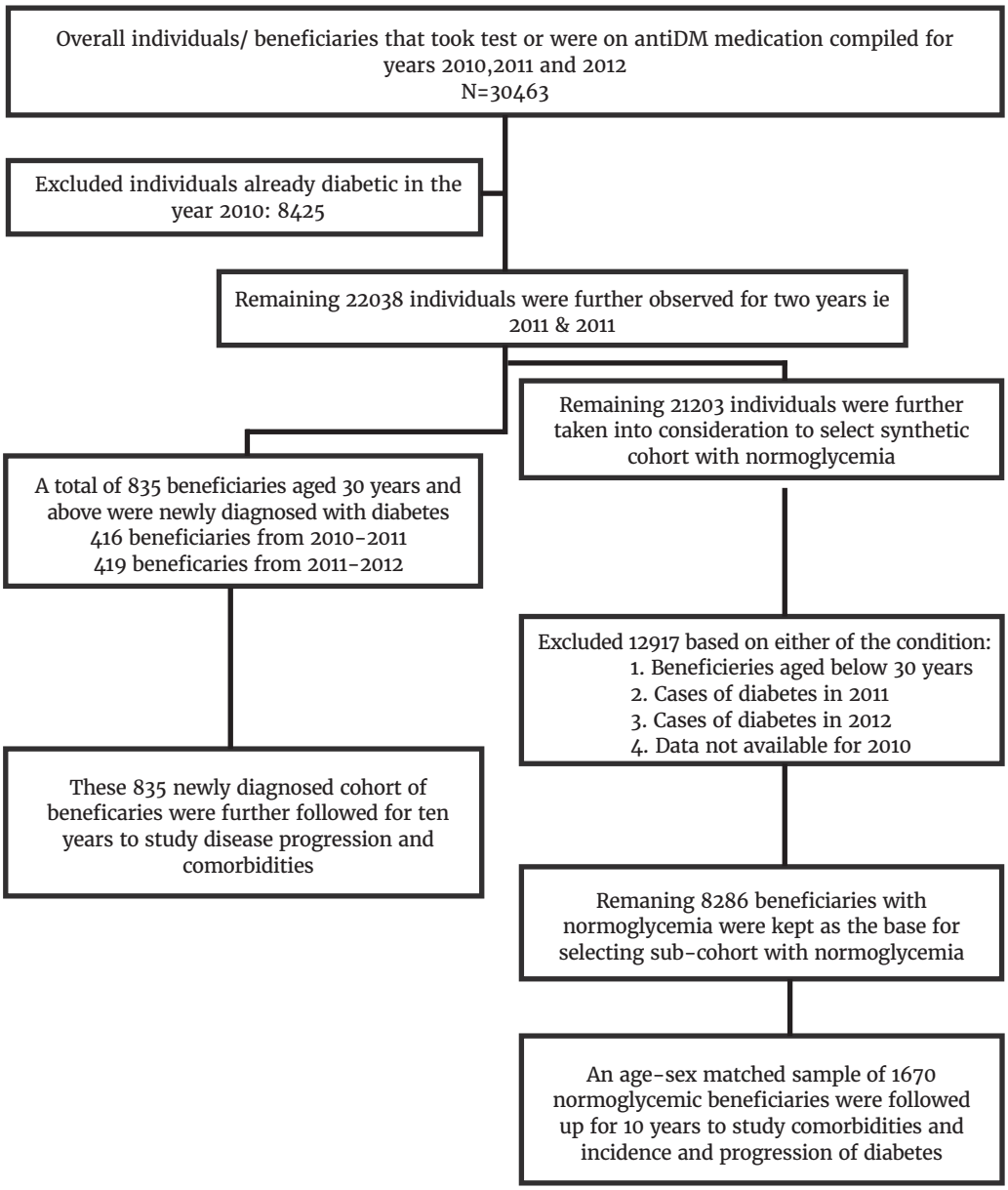
We used an operational definition to identify diabetes patients from the medical records of all beneficiaries who utilized CHSS between 2010 and 2012. Medical records also contained information on all beneficiaries who were tested for diabetes, as well as those receiving medication for diabetes. The CHSS beneficiaries with either glucose levels above cut-off (FPG>=126 mg/ dL or PPG>=200 mg/dL or HbA1c >=6.5%) or who had taken diabetes medication in that calendar year or patients with classic symptoms of hyperglycaemia or hyperglycaemic crisis, were identified and categorized as diabetic.

- **Identification of newly diagnosed diabetes cohorts for follow-up:**

The next important step is the identification of newly diagnosed diabetes patient cohorts and eliciting their medical history from HIMS records through a retrospective follow-up. Considering the availability of digitized data from HIMS, we fixed the retrospective follow-up period for the newly identified patients to 10 years. Despite this data constraint, we consider a 10-year follow-up period to be sufficient to study the type II diabetes-related comorbidity and excess mortality among the patient cohorts. The CHSS beneficiaries diagnosed as diabetic in 2011-2012 were eligible to be in this cohort. Those who were found to be diabetic in a particular year but were tested as non-diabetic and were not taking any medicine for diabetes in the previous year were defined as newly diagnosed diabetic patients.

To identify the cohorts for follow-up the first task was to identify all CHSS beneficiaries who underwent diabetes-related diagnostic tests between 2010 and 2012 or received anti-diabetic medication. For this, a scrutiny of the entries in 144,511 lab records and 247,473 drug records available in HIMS for the period 2010 to 2012, was performed. The study followed the American Diabetes Association

Figure 1: Flowchart showing the selection of 835 newly diagnosed diabetes cases and 1,670 normoglycemia cases from medical records (2010–2012) for cohort wise follow-up.



(ADA) diagnostic criteria for diabetes, Fasting Plasma Glucose (FPG) level of ≥126 mg/dL, Postprandial Glucose (PPG) level of ≥200 mg/dL during a 75 g Oral Glucose Tolerance Test, and Haemoglobin A1c (HbA1c) of ≥6.5%. The total count of such CHSS beneficiaries who either underwent these diagnostic tests or were prescribed antidiabetic medications was 30,463, with annual figures standing at 16,485 in 2010, 17,183 in 2011, and 18,606 in 2012.

Those previously diagnosed with diabetes or were taking anti-diabetic medicine in 2010 or before were dropped. Beneficiaries who exhibited diagnostic markers such as FPG, PPG, and HbA1c levels indicative of diabetes or those who were started anti-diabetic medication in 2011 and 2012, were specifically retained. This strategy ensured that the cohort consisted only of individuals newly diagnosed with diabetes in 2011 or 2012, thereby establishing a clear baseline for subsequent analysis. To ensure focus on Type 2 Diabetes, those aged less than 30 years were excluded. Ultimately, 835 participants were identified as individuals with newly diagnosed diabetes (See figure I). These individuals were meticulously followed over the next decade, forming a critical diabetic cohort for our longitudinal examination.

- **Identification of non-diabetic beneficiary cohorts for follow-up**

A separate cohort comprising beneficiaries without diabetes at the time of initiation of the original cohorts (i.e. 2012) is required for comparison purposes for arriving at excess co-morbidity and for understanding the transition from the pre-diabetic stage in 2012 to diabetes in the 10-year follow-up period. For this, an age-sex matched control group with double the size of the newly diagnosed diabetes cohort was created from the same HIMS database. This group of 1670 non-diabetic CHSS beneficiaries were selected from a list of persons who were tested as non-diabetic in 2012 and were not taking any medicine for diabetes. More details of selection this normoglycemic cohorts who were followed up for next ten years is in figure 1.

Cohort characteristics

In summary, the CHIPS cohort comprised 835 newly diagnosed diabetic patients in 2011-2012, of which 55 percent were females (Table 1). Male-female distribution indirectly hints at relatively higher risk on diabetes in women between 30-49 ages. The majority of males (83 percent) in CHSS were employees, while the majority of females (85 percent) were dependents of employees. This composition is a reflection of the overall work participation among women in India. Age distribution of newly diabetic patients shows the onset of diabetes to be earlier in females than in males. As can be expected, the characteristics of the age-sex matched control group of 1670 non-diabetic patients were similar to those of newly diagnosed diabetic cohorts.

- **Attrition in the cohort size**

The 10-year retrospective medical record data on the above-mentioned diabetes-related parameters were compiled for the 835 newly diagnosed patients. There were 586 patients who were available at the end of the follow-up period in 2021. The year-wise attrition in sample size or loss to follow-up cases in the cohort is presented in Figure 2. Of the 249 patients lost during follow-up, we discovered that

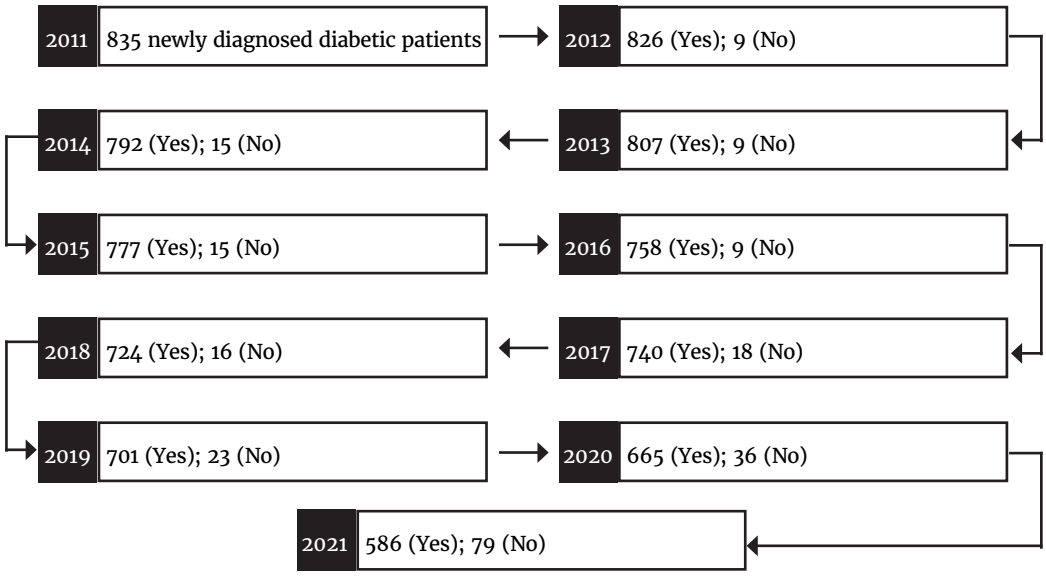
Table 1: Baseline characteristics of CHIPS study subjects, 2011–12

	Newly diabetic patients (Cases) % (N)			Non-diabetic beneficiaries (Controls) % (N)		
	Females	**Males**	**Total**	**Females**	**Males**	**Total**
Age in years						
30–39	13.2 (61)	5.3 (20)	9.7 (81)	13.2 (122)	5.3 (40)	9.7 (162)
40–49	30.2 (139)	18.2 (68)	24.8 (207)	30.2 (278)	18.2 (136)	24.8 (414)
50–59	27.1 (125)	30.5 (114)	28.6 (239)	27.1 (250)	30.5 (228)	28.6 (478)
60–69	18.7 (86)	25.7 (96)	21.8 (182)	18.7 (172)	25.7 (192)	21.8 (364)
70–80	10.4 (48)	17.9 (67)	13.8 (115)	10.4 (96)	17.9 (134)	13.8 (230)
>80	0.4 (2)	2.4 (9)	1.3 (11)	0.4 (4)	2.4 (18)	1.3 (22)
Type of beneficiaries						
Employees	14.9 (69)	83.2 (311)	45.5 (380)	16.9 (156)	84.6 (633)	47.2 (789)
Dependents	85.1 (392)	16.8 (63)	54.5 (455)	83.1 (766)	15.4 (115)	52.8 (881)
Total	100 (461)	100 (374)	100 (835)	100 (922)	100 (748)	100 (1670)

Source: CHIPS cohort database

78 patients had expired. The details of the causes of death, including whether it was a diabetes-related death or otherwise, were not available from the HIMS. Another 36 beneficiaries have left the CHSS and cannot be followed up. About 159 of the remaining patients were not seeking CHSS health services, and the reason for this is being traced as part of the research project. Mortality, gestational diabetes cases, migration of beneficiaries and discontinuation of health services were the potential reasons for this attrition.

Figure 2: Attrition in the cohort of 835 newly diagnosed diabetes patients followed up from 2011 to 2021



Discussion

Results from a sizeable number of research articles using the CHIPS data set is already available. To start with, the age-adjusted incidence of Type II diabetes in the 30+ population within the urban community during this 10-year follow-up period was found to be 40 cases per 1000 person-years, with risk being elevated in males than females (Sharma, Dilip, Kulkarni, & Bhandarkar, 2024). Further, the lifetime risk of type II diabetes in the 40+ population was 40% and a decline in risk with advancing age was illustrated. Then, the expected years of life that a person can live without diabetes was estimated across broad five-year age groups (Sharma et al., 2023). To illustrate, a person aged 40-44 years in this community, on average, can live another 7.5 years without diabetes (Sharma, Dilip, Kulkarni, Mishra, et al., 2024). The other major contribution coming out of this cohort analysis is that it generated estimates of transition between normoglycemia, pre-diabetic and diabetic stages. Here, the reversion from prediabetes to normoglycemia peaked at around 60% within the first 2–3 years and later declined, indicating the critical importance of early detection and timely intervention during the pre-diabetic phase to prevent progression to diabetes and associated complications (Sharma et al., 2025).

Research on overtime changes in glycaemic control, comorbidity, and health services in the 10-year follow-up period among the newly diagnosed diabetic patient cohort is in progress. A time series-wise decomposition of seasonal variations in glycemic control revealed that blood sugar levels decline during the monsoon (June–September) and pronounced peaks during the pre- and post-monsoon months of April–May and October–November (Goswami, Thandassery, et al., 2025). An examination of the vitamin D levels in the diabetic cohort showed that poor glycaemic control was strongly associated with increased odds of deficiency (Goswami, Dilip, et al., 2025). Further analysis about risk of diabetes-related comorbidities (hypertension, hypothyroidism and dyslipidemia), overtime changes in glycaemic control, and health service use among this cohort is in progress.

More importantly, the results from this research study in a population with universal coverage provide unbiased estimates of disease progression in the life cycle of the patients, including diabetes-related comorbidity, to the larger medical research community. This is important as disease progression and management in a community is often dependent on the economic and physical access to treatment in health care systems characterized by shortage of adequate resources. The results from this type of cohort studies in population with universal access to health care are relatively free from biases arising from several cultural and gendered roles of patients within their families, which determine their capacity to seek treatment and pursue medical advice.

Limitations

The characteristics of a government employer-based CHSS cohort will not match exactly with a population-based cohort. Firstly, the age composition in any similar CHSS cohort will be older than the general population cohort. For this, the age-adjusted rates were prepared for comparison of results from this study with other national or sub-national scenarios. Secondly, there will not be any representation for the very poor in this cohort as CHSS only comprises salaried/ retired government employees and their dependents. Due to this factor, the prevalence of diabetes is relatively higher in this relatively more affluent CHSS population than in the general population.

Conclusion

The near-uniform protocols for patient evaluation and follow-up in the CHSS are the major strength of the CHIPS study. Additionally, this research initiative illustrated the potential for reconstructing medical history from electronic medical records in a limited timeframe and their prospective research applications. There is a need to promote similar cost-effective cohort studies among existing private/ private sector entities in formal sector that provide comprehensive medical care for their employees and their dependents. Results when pooled can serve as a resource for generating much needed evidence base while preparing or updating national/ regional level treatment guidelines and policies.

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Who Reaches Old Age? Socioeconomic Inequality in Survival and Its Implications for Ageing in India

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The discourse on Population Ageing is mostly premised on the rising share of older adults in the population that overlooks the heterogeneous pace of attaining this age by different population sub-groups. The exceptionality of surviving to older ages affects the distribution of the population subgroups over the life course, leading to an 'unequal ageing experience'. To address this knowledge gap, this study considers ageing as a survival experience at the individual and the population level and tries to exposit the volume of unequalness in the ageing experience and its significance while reading the speed of population ageing. Using NFHS-5 (2019–21) data, we employ period life table techniques to examine socioeconomic gradients in survival to age 60, using adult survival probabilities and temporary life expectancy as outcome measures. Among adults, 59.3% of deaths in the richest quintile occurred above the median age, compared to 40.6% in the poorest. Scheduled Tribes and Scheduled Castes had 4.4% and 3.3% lower survival to older ages than the national average, while Higher Castes and the Richest Quintile had 3.0% and 6.4% higher survival, respectively. Only 72.2% of the poorest reached older ages, compared to 86.2% of the richest. The study illustrates the need to accommodate this heterogeneity in survival experience in the assessment of population ageing, given the differential survival experience of population subgroups to make attaining older ages not a privilege for a few.

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Population aging represents a scenario in which the share of older individuals tends to increase as a consequence of declining fertility and increasing longevity. With advances in health and gains in survival, it is necessary to acknowledge the phenomenon of population ageing and understand its varying dimensions with long-term implications. The global experience of this count has been unprecedented since the mid-twentieth century, with its clear manifestation in the developing world reflected in the evolving imbalance in the population age structure. This imbalance can be gauged in terms of the growth rate of older adults being systematically higher than that of the population (Giridhar et al., 2014). Although the phenomenon of population ageing has been of limited concern in the Global North, its onset in the developing region since the first decade of the twentieth century has received renewed emphasis, given the rapid ageing in Asia in contrast with the European trajectory of population ageing (Balachandran, 2020). The speed of ageing in countries such as India is alarming, as ageing occurs before the poor become rich (James, 2011; Chakrabarti & Sarkar, 2011), which has coined a quote 'getting older before getting richer'.

In India, the proportion of the population aged 60 years and above was 7 per cent in 2001 and is projected to increase to 15 per cent by 2036 (ORGI, 2020). In absolute numbers, the number of older adults in 2001 was approximately 76 million and is expected to increase sharply to more than 227 million by 2036. Even more significant in its implications for population ageing, life expectancy at age 60 has also increased dramatically, rising from approximately 12 years in 1950 to 18 years in 2015, and that at age 65 is projected to increase further to more than 18 years by 2050, with a median age of 38.1 (United Nations, 2022).

Population ageing could have significant societal consequences. Population ageing could result in higher dependency ratios, which in turn could economically burden the working population, increase long-term care expenditures (Muszyńska & Rau, 2012), increase public expenditures on the basis of pensions and welfare schemes (Abramson, 2015; Borsch-Supan, 2003) and raise a debate on increasing retirement ages.

The phenomenon of ageing could either be evaluated with a segmentation approach by assigning a specific cut-off age to designate the onset of ageing or by considering the changes in the propensity of survival to advanced ages from a specific age during the life course. Despite this dual construct of evaluating the ageing phenomenon, the dramatic and complex nature of demographic shifts in India and its resulting ageing remains limited in its comprehension with a chronological age-based approach. With its population size and pace of transition, Indian ageing needs an evolving approach in its comprehension that should go beyond its count to characterisation. This type of comprehension needs to consider the role of mortality reduction in shaping the process of ageing, which varies across population groups. The experience of survival gains varies with age; therefore, the

dynamic count of the aged population should never equate today's older adults with tomorrow's older adults. Therefore, any measure of ageing needs to account for such differences to make it temporally comparable. Recognition of the differences in survival from older ages remains fundamental to comprehension of ageing, which makes its experience unequal among individuals of a given population.

The exceptionality of surviving to a particular threshold age should serve towards analysing the disparities in ageing. In diverse populations, the onset and pace of the first demographic transition are highly affected by socioeconomic factors that could trigger the demographic transition (Willekens, 2014). As population Ageing is a phase in the transition, the differences in the onset and pace among different groups within the population could affect the representation of the population in the advanced age stage. The existence of considerable heterogeneity in the process of population ageing should be addressed when discussing population ageing and its inherent inequalities. The fundamental premise of differentiating the aged population rests on the fact that all are not equally likely to survive to older ages (Holman & Walker, 2021).

Among academics, the debate over defining old age can be traced back to the period when the Global North experienced the phenomenon of the 'ageing of the population'. In a study of the 1990s in India (Rajan et al., 1999), the criterion of defining old age was asked to select a set of 'aged' respondents, and a good proportion of the respondents shared the opinion that old age cannot be defined by numerical ages (chronological age); instead, it needs to be associated with their functional disabilities. This opinion was put forward much prior to formulation of the characteristic approach (Sanderson & Scherbov, 2013). While the median age is frequently employed as a summary threshold for assessing the overall level of population ageing, it has been widely critiqued for its insensitivity to underlying heterogeneities and its limited compatibility with characteristic-based approaches. A similar revision to the count of older adults on the basis of chronological threshold age was made, accounting for the intensity of ageing (Mishra & Dash, 2011).

In the genre of the revised outlook on comprehension of ageing, the survival aspect of ageing measures accommodates the remaining life expectancy (RLE), also known as Prospective Age (Sanderson & Scherbov, 2007, 2008, 2010) which has received universal recognition in ageing studies of the Global North and in policymaking. Chronological age-based measures are discrete approaches with their inherent shortcomings for comparison; the survival-based approach is a dynamic one to account for concurrent changes in the survival regime. Countries such as Denmark, Estonia, Finland and the Netherlands use the RLE as the threshold for fixing the retirement age (Alvarez et al., 2021). The advantage of prospective age over chronological age is that the former considers the number of years a person is expected to live more (Sanderson & Scherbov, 2008). From a policy standpoint, this methodology could address the sustainability of pension systems, as in Denmark.

The primary defect of using the RLE methodology is that it cannot exist as a measure to compare the level of ageing among populations. It is not necessary that the concerned populations will experience a comparable mortality level, as in India. Studies suggest that life expectancy significantly differs with respect to the social and economic characteristics of the population (Subramanian et al., 2006; Mohanty & Ram, 2010; Po & Subramanian, 2011; Asaria et al., 2019;Saikia et al., 2019; Kumari & Mohanty, 2020; Vyas et al., 2022; Gupta & Sudharsanan, 2022). Mortality selection takes place within the population on the basis of social, economic and educational characteristics (Saikia et al., 2019). Personal endowments from wealth and social privileges also influence health-related behaviors, with Caste, in India, playing a major role in this (Preston & Paul, 1994; Thorat & Attewell, 2007). Considerable heterogeneity exists in premature mortality (survival to age 70 from age 40) among the states, where the risk of dying for males ranges from 351 per 1000 in Kerala to 558 per 1000 in Chhattisgarh, and for females, it ranges from 198 per 1000 in Himachal Pradesh to 409 per 1000 in Assam (Rao et al., 2021).

To include mortality impacts in this approach, Balachandran et al. (2017) developed the comparative prospective old age threshold (CPOAT), which adjusts the RLE for the adult survival ratio (ASR). While comparing ageing among populations with differential mortality patterns, the CPOAT can provide a robust threshold (Balachandran et al., 2020). As Sanderson and Scherbov (2013) suggested, health characteristics associated with ageing could be included along with mortality adjustment, which could explain the multidimensional approach to measuring ageing (Balachandran & James, 2021).

Mortality selection, where individuals with lower survival prospects are more likely to die at younger ages, leaving a select group of individuals who are more resilient to survive into old age. This means that as people age, they become a more selective group of individuals who have already survived many of the risks and challenges that contribute to mortality (Kannisto, 2001). The pool of surviving individuals becomes healthier over time, and the age-specific survival disparities decrease among the heterogeneous groups within the population (Rehnberg et al., 2017). The convergence of survival inequalities at older ages is partly due to mortality selection. Those who survive to older ages tend to be a more homogeneous group in terms of survival prospects, regardless of their initial demographic and socioeconomic characteristics.

The heterogeneity in the population distribution due to the differential impacts of socioeconomic development on mortality experiences leads to unequal entry into the general old age threshold of 60, which remains uninvestigated, whereas the inequalities in health and well-being among older adults have been well explored (Alam et al., 2015).

Objectives

During recent decades, mortality improvements have been driven mainly by the decline in young-age mortality, with a majority of the states having witnessed an over 50% reduction in infant and under5 mortality rates between 1992 and 2016 (Bhatia et al., 2019). As a result, the proportion of individuals who reached adulthood and subsequently reached older ages increased significantly. Hence, mortality changes in adulthood form the basis for successful survival to older ages. When population ageing is discussed well with changes in life expectancy at age 60, the underlying force of adult mortality is least discussed within the ageing framework.

While the phenomenon of population ageing is of universal concern and is inevitable, its microlevel experience, which refers to individual experiences of survival that translate into population ageing, remains overlooked. This essentially refers to the differential likelihood of reaching old age. In that sense, the population share beyond 60 years of age is perhaps a limited representation of ageing. It merely counts those who are 60 years of age. However, is it equally likely for everyone to reach the age of sixty, or this privilege is conditioned by some attributes/identities. This particular aspect of differences in survival propensity to reach the age of sixty is itself a dimension overlooked in the discourse on ageing. Hence, the phenomenon of unequal ageing becomes relevant given that everyone neither attains the qualifying age of being designated to be aged nor does one age equally after attaining this age. The point in contention therefore is differential survival propensity.

Considering the vast disparities in survival rates among Indian states and within Indian states, tracing the survival pattern of attaining the age of sixty in different states while examining the ageing process in India becomes imperative. The survival differential undoubtedly makes a difference to attainment of age sixty, and any measure of ageing needs to account for the same. Given the mortality differentials among Indian states, there can be large differences in survival propensity until the age of sixty as well as beyond, which are conditioned by socioeconomic attributes. Hence, this aspect needs accommodation within the comprehension of ageing for eligible comparisons.

Instead of a head-count approach for the assessment of ageing, this study considers ageing as a survival experience at the individual and population levels and aims to explore the volume of unequalness in the ageing experience and its significance while reading the speed of population ageing. Hence, the recognition of heterogeneity in ageing within the population is studied.

Methods and Measures

- **Study setting and data sources**

This analysis aims to derive survival estimates of early adults to a defined threshold age across varying socioeconomic attributes for measuring their unequalness in ageing experience on the basis of the fifth round of the National Family Health Survey (NFHS 5) (International Institute for Population Sciences (IIPS) & ICF International, 2017). NFHS 5 had approximately 636,699 households representing 707 districts and interviewed more than 724,115 women in the eligible age group of 15–45 years and approximately 101,839 men via computer assisted personal interviewing (CAPI) on mini-notebook computers. The survey provided data on the key population and health and nutrition indicators, including fertility, reproductive health and mortality indicators.

NFHS 5 contains mortality information on birth history and in the household file. The birth history from the pregnancy history module of the women's questionnaire is used for extracting mortality rates at infancy and childhood, as it is often considered the most reliable from any DHS data (Moultrie et al., 2013). Similarly, in the household module, the deaths that occurred in the last three years were recorded along with the socioeconomic characteristics of the household, which were used to extract the mortality rates in higher age groups. Since the household questionnaire often responds to the head of the household and child mortality remains a sensitive matter, household heads often fail to point out it under the household mortality category, whereas birth history is a response from women, which is always regarded as a reliable source for under5 mortality. Hence, a birth file is used for the under5 mortality data, and the household death data are used for the mortality data from age 5 onwards. Life tables were constructed for social and economic groups using the mortality rates extracted by creating life lines for three years, which started at the date 3 years prior to the interview and ended at the date of the interview for all living individuals, whereas the life lines ended at the date of death for the dead individuals (Gupta & Sudharsanan, 2022; Gupta, 2022). Using the standard methodology for the construction of a period life table, as mentioned by Preston et al., (2001), life tables were constructed for all the concerned groups under study.

Deaths have been grouped into four broad age groups, namely, child deaths (0–4), later childhood deaths (5–15), adult deaths (16–59) and older adult deaths (60+), and the median age of deaths for all these groups has been estimated to be the distribution of deaths in the oldest 50% of deaths in the respective categories.

Social and economic categories were created as mutually exclusive groups. The study considered wealth quintiles from the NFHS for economic groups on the basis

of information on the availability of household assets and further indexed them via principal component analysis, followed Gupta and Sudharsanan (2022) for social groups, namely, scheduled castes (SC), scheduled tribes (ST), other backwards castes (OBC), Muslims (MUS), Hindu higher castes (HC) and others (Rutstein & Staveteig, 2014). The estimates for the 'Others' group are not shared here, considering the relatively small sample size for constructing the life table (see the supplementary files for the tables in this category).

From each study group–residence– and sex-specific life table, the following summary survival/mortality risk measures were estimated:

1. Distribution of deaths above the median age of death for death groups.
2. Survival rate between age 15 and age 60 (45l15).
3. Survival rate between age 40 and age 60 (20l40).
4. Temporary life expectancy (TLE) between the ages of 15 and 60.
5. Survival differences till age Sixty and Beyond: A Lifetable Derivative.

Using the cluster- bootstrap method with 100 samples, 95% confidence intervals were estimated for each of the above parameters (see appendix in Supplementary Material).

- **Survival rates**

Survival rates for each social and economic group and their intersectional group were calculated between the ages 15 and 60 (45l15) and the ages 40 and 60 (20l40). Here, 45l15 gives the proportion of those living at age 15 who continue to survive until age 60, whereas 20l40 gives it for those alive at age 40 who survive until age 60. The former represents the overall chances of survival from early adulthood to the defined threshold of 60, whereas the latter could reflect the influence of occupational or lifestyle-induced mortality, if any, after passing midway through one's occupational life (Vollset et al., 2006). The deviations of the category-specific survival rates from the country-level survival rates were calculated. Here, age 60 is not considered a threshold to old age but rather a cut-off age in the life cycle as the target age of survival. It is also selected because it is a general retirement age, and population ageing is often read along with the proportion of the population aged 60 and above.

- **Temporary life expectancy (TLE)**

Temporary life expectancy or partial life expectancy (yex) refers to the expected average length of life between exact ages x and y (Arriaga, 1984; Saikia et al., 2010). Life expectancies were estimated conditional on survival to 15 years of age, with the maximal theoretical life expectancy at 15 years of age being 45 years. For

the analysis, mortality experiences between the exact ages of 15 and 60 years are considered, and TLE provides an aggregate mortality measure at ages between 15 and 60 years.

$$_{45}e_{15} = (T_{15} - T_{60}) \; / \; (l_{15})$$

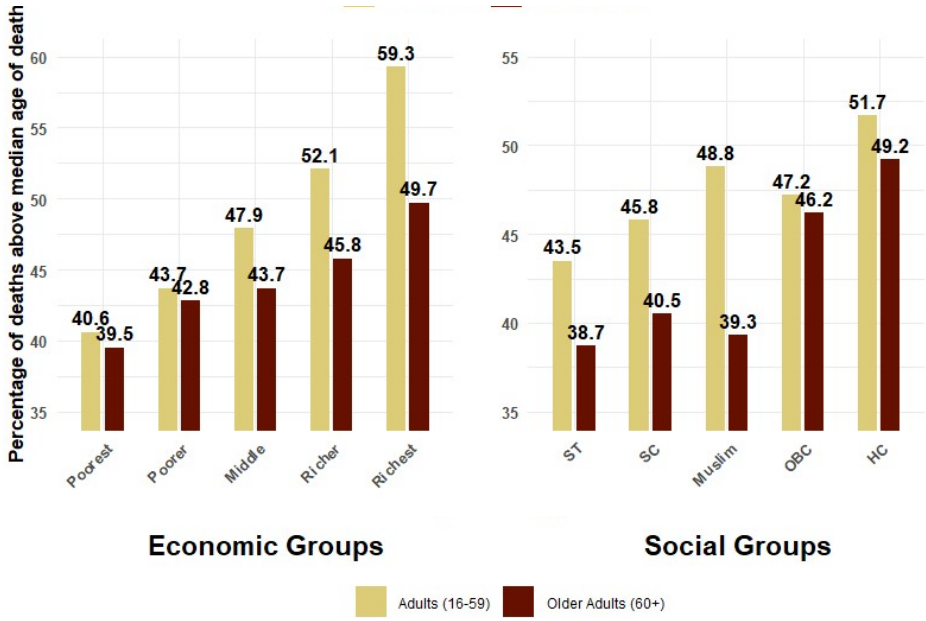
The difference between the TLEs of the groups is considered to be years of life lost (YLL) as a consequence of social or economic differences. TLE excludes mortality experiences outside its age references (here, it is 15-60). The life expectancy at birth is associated with mortality throughout the age groups and is thereby also influenced by early- and late-age deaths. To isolate the survival experiences during a given reference age bracket and convert them into life expectancies and years of life lost, temporary life expectancy is used as a measure here.

Description of the observations

- **Distribution of deaths above the median age of death for death groups.**

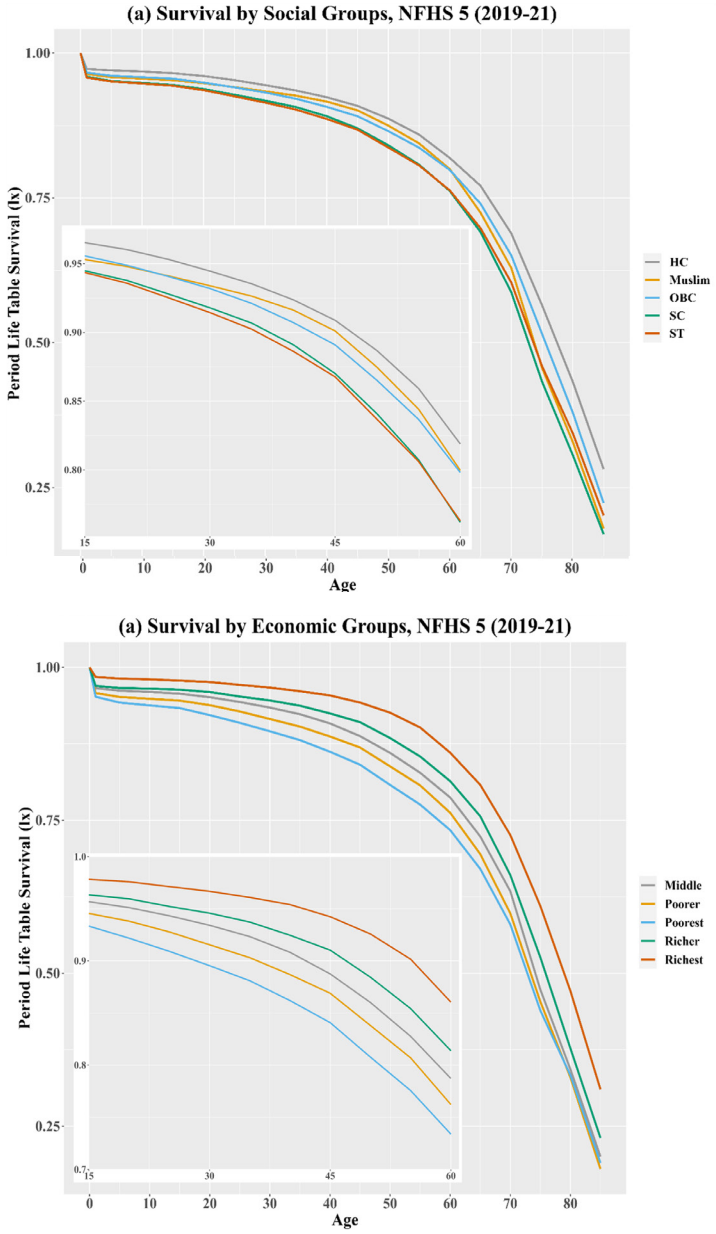
In the primary investigation, the proportion of deaths that occurred at an age above the median age of death for death categories increased significantly with increasing socioeconomic status. Figure 1 shows that while 40.5% of the deaths among the older adults belonging to the SC population are reported to have occurred above

Figure 1. The proportion of deaths that occurred above the median age of death for socioeconomic groups at the national level, NFHS 5 (2019-21), India



the median age of older adult deaths (overall), only 38.7% of the deaths among the ST population and HCs, the most privileged social group, accounted for 49.2% of the deaths. Similarly, those in the poorest quintile had only 39.3% of its deaths in the oldest 50% of the deaths, whereas this figure is 49.7% for the richest quintile. The proportions of adult deaths are more alarming. Among the wealth quintiles,

Figure 2. Period of lifetable survival (lx) at all ages and ages 15–60 by social (a) and economic (b) groups of India, NFHS 5 (2019–21)



the richest quintile had a share of deaths above the median age of 59.3%, whereas the poorest quintile had only a 40.6% share. These distributional abnormalities are investigated further via the life table approach in the following sections.

Table 1 shows the adult survival rates from ages 15-60 and 40-60 years and their deviation from the overall survival rates for corresponding ages at the national level for the social and economic groups under study. The table reveals significant differences in survival among extreme social and economic groups from the ages of 15-60. When 85% (CI 83.8% - 85.4%) of the individuals in the higher castes (HC) at age 15 reached age 60, the same per centage remained at 81% among the SC and ST groups. The survival of the social groups from ages 40-60 also showed a similar trend, where 86% of the SC and ST groups survived to age 60, whereas 89% of the HCs survived. The OBC and Muslim individuals experienced survival chances between the extreme groups. Across the wealth groups, the survival differentials are more evident, as shown in Figure 2. Only 12% of the individuals from the richest quintile households failed to survive to age 60 from age 15, whereas 21% from the poorest quintile experienced such failure. The survival probability increases systematically with the upwards movement in wealth status. Similarly, the survival rate from age 40 to 60 for the poorest remains the lowest, at 85%, whereas the survival rates are 88% and 90% for the richer and richest, respectively.

Compared with the overall survival rates at the national level, the extent of deviations in adult survival to age 60 is revealed (here, the deviation is measured against the overall survival propensity at the national level (for females, $_{45}l_{15}$ = 0.876 & $_{20}l_{40}$ = 0.909; for males, $_{45}l_{15}$ = 0.784 & $_{20}l_{40}$ = 0.837; for total, $_{45}l_{15}$ = 0.830 & $_{20}l_{40}$ = 0.874) and not the group-specific survival at the national level). Such a comparison across caste groups places SCs in the most disadvantaged position. The SCs survived 2.8% less than the overall level, followed by the STs, with a depreciation of 2.6%. All other social groups experienced survival more than the overall national level, with 2.23% more survival for the HCs. In terms of adult survival, Muslims are estimated to be at a more advantageous position than Hindu OBCs are. Among the wealth groups, the poorest quintiles experienced a survival probability that was 5% less than the overall probability, which improved as the wealth status reached the richest quintiles, with a survival rate that was 6% greater than the national average. Only the highest two quintiles observed a positive deviation among the wealth groups.

- **Temporary life expectancy between the ages of 15 and 60 years**

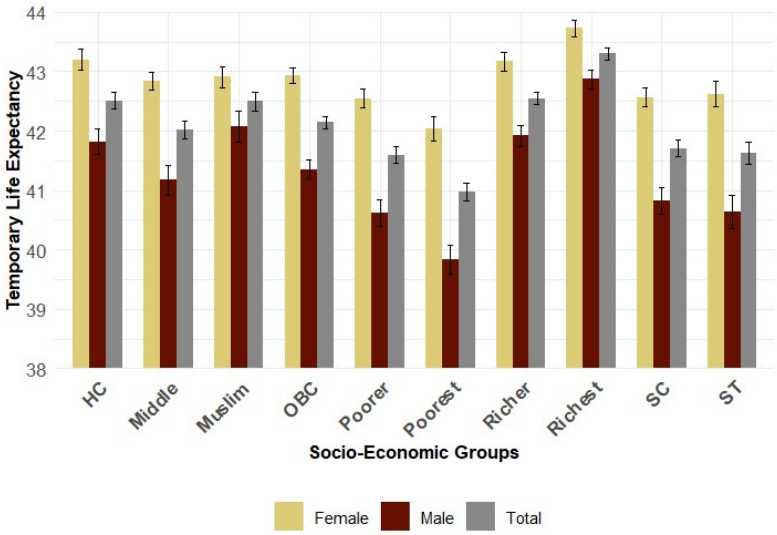
Figure 3 shows the temporary life expectancy (TLE) for individuals aged 15-60 years, which depicts the years of life lost during 45 years. In men and women combined, partial life expectancy at 15 years was reduced by more than 2 years because of low economic status. When the SC group had a TLE of 41.7 years, the

Table 1. Survival rates to age 60 from ages 15 and 40 and their deviations (in %) from the survival propensity at the national level, NFHS 5 (2019–21), India

Social/Economic Groups	Female				Male				Total			
	Survival rates		Deviations (in %)		Survival rates		Deviations (in %)		Survival rates		Deviations (in %)	
	$45\rfloor_{15}$	$20\rfloor_{40}$	$45\rfloor_{15}$	$20\rfloor_{40}$	$45\rfloor_{15}$	$20\rfloor_{40}$	$45\rfloor_{15}$	$20\rfloor_{40}$	$45\rfloor_{15}$	$20\rfloor_{40}$	$45\rfloor_{15}$	$20\rfloor_{40}$
SC	0.86	0.90	−1.88	−1.34	0.75	0.81	−3.92	−3.06	0.81	0.86	−2.83	−2.12
ST	0.86	0.90	−1.53	−0.92	0.76	0.82	−3.63	−2.03	0.81	0.86	−2.57	−1.46
Muslim	0.87	0.90	−0.48	−0.81	0.81	0.84	2.81	0.68	0.84	0.87	1.11	−0.10
OBC	0.88	0.91	0.37	0.30	0.79	0.85	0.89	1.15	0.84	0.88	0.63	0.71
HC	0.89	0.92	1.88	1.27	0.81	0.85	2.76	1.82	0.85	0.89	2.23	1.48
Poorest	0.84	0.89	−3.81	−1.84	0.73	0.81	−7.16	−3.57	0.79	0.85	−5.25	−2.54
Poorer	0.86	0.90	−1.73	−0.97	0.75	0.82	−4.17	−2.41	0.81	0.86	−2.86	−1.62
Middle	0.87	0.91	−0.27	−0.27	0.77	0.83	−1.45	−1.34	0.82	0.87	−0.86	−0.79
Richer	0.89	0.91	1.30	0.62	0.80	0.85	2.45	1.00	0.84	0.88	1.80	0.76
Richest	0.91	0.93	3.87	1.90	0.85	0.88	8.44	4.82	0.88	0.90	6.00	3.24

HCs had 42.5 years, the poorest quintile had 41.0 years, and the richest quintile had 43.3 years. This summary measure could explain life expectancy in a more effective manner, as the target age is fixed at 45 years and increases steadily with improvement in economic status (see Figure 3). Among men, the ST group and the poorest quintile lost 4.4 and 5.2 years, respectively, whereas HCs and the richest quintile lost only 3.2 and 2.1 years, respectively. A difference of 2.3 YLLs exists between the poorest and richest quintiles, and a difference of 0.9 years exists between STs and HCs. In contrast to the health disadvantages of Muslims, the TLE of Muslims is estimated to be similar to that of HCs. TLE excluded those mortality experiences before age 15 and after age 60, making it exclusive for a selected age group. Such exclusion could have given Muslims a greater advantage in the computation of TLE. Life expectancy at birth, which combines mortality experiences throughout the life cycle, depicts the disadvantaged position of Muslims in terms of overall survival (see the Supplementary file).

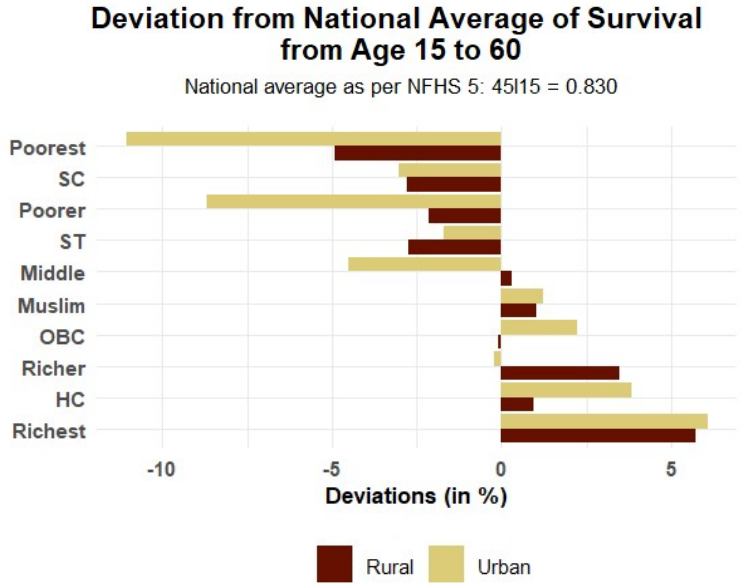
Figure 3. Temporary life expectancy in years (ages 15-60) for socioeconomic groups in India, NFHS 5 (2019-21)



- **Disparities by Residence**

The urban-rural dichotomy, which is often discussed in the context of child survival, clearly persists until adulthood. Table 2 shows the survival rates and their deviations compared with those of the national average. The urban poorest remain the most disadvantaged, whose survival rate is 11% less than the national average, whereas the rural poorest are only 4.9% disadvantaged relative to the national average (see Fig. 4). At the other extreme, the urban richest population has a survival advantage of 6.1% over the aggregate population, and the rural richest population has a similar advantage of 5.7%. Among the urban population, the differences between the survival deviations of the poorest and richest quintiles are 27.2% and 17.2% for males and females, respectively, whereas they are 15.5% and 10.67% for rural men and women, respectively. The survival rates between the ages of 40 and 60 also followed a similar pattern.

Figure 4. Deviations in Survival Disparities by Type of Residence, NFHS 5 (2019--21)



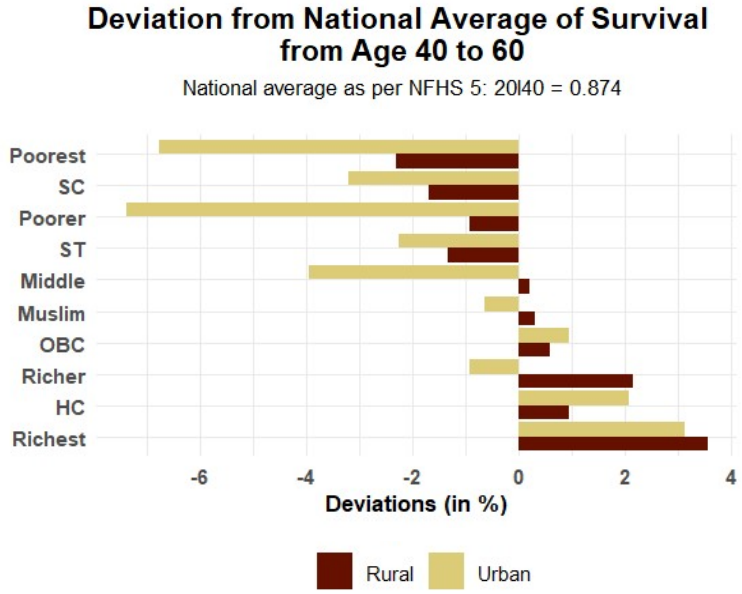


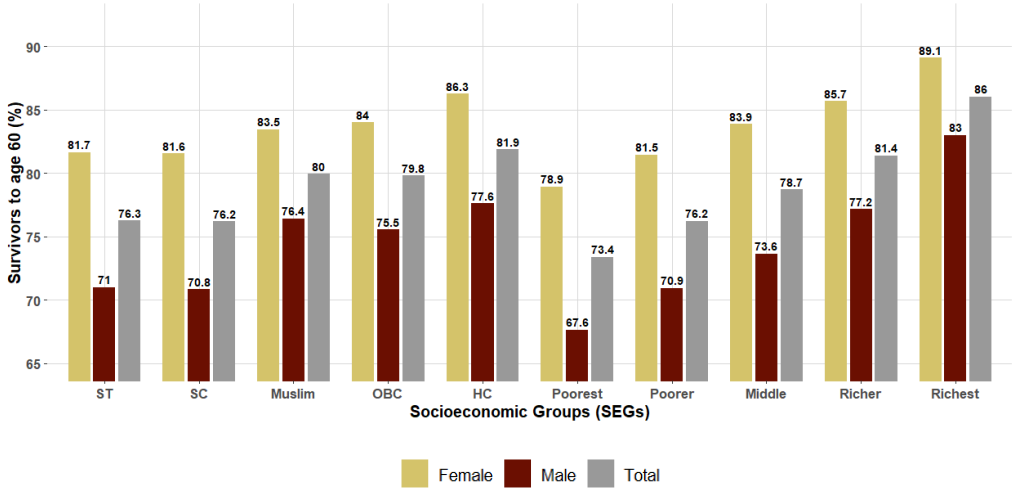
Table 2 Survival disparities by type of residence, NFHS 5 (2019--2021)

Residence	Social/ Economic Groups	Female				Male				Total			
		Survival rates		Deviations (in %)		Survival rates		Deviations (in %)		Survival rates		Deviations (in %)	
		$_{45}q_{15}$	$_{20}q_{40}$	$_{45}q_{15}$	$_{20}q_{40}$	$_{45}q_{15}$	$_{20}q_{40}$	$_{45}q_{15}$	$_{20}q_{40}$	$_{45}q_{15}$	$_{20}q_{40}$	$_{45}q_{15}$	$_{20}q_{40}$
Urban	SC	0.80	0.85	-3.02	-3.15	0.73	0.78	-7.20	-7.07	0.88	0.91	-3.04	-3.21
	ST	0.82	0.85	-1.68	-2.19	0.77	0.81	-2.36	-2.94	0.87	0.90	-1.70	-2.25
	Muslim	0.84	0.87	1.24	-0.58	0.79	0.82	0.92	-1.83	0.89	0.91	1.22	-0.63
	OBC	0.85	0.88	2.26	1.02	0.80	0.84	2.16	0.91	0.90	0.92	2.24	0.96
	HC	0.86	0.89	3.85	2.13	0.82	0.86	4.96	3.02	0.90	0.92	3.83	2.07
	Poorest	0.74	0.81	-11.05	-6.72	0.63	0.74	-19.99	-11.65	0.86	0.89	-11.07	-6.78
	Poorer	0.76	0.81	-8.69	-7.33	0.68	0.74	-13.67	-11.69	0.85	0.88	-8.71	-7.38
	Middle	0.79	0.84	-4.51	-3.90	0.71	0.77	-9.94	-8.58	0.88	0.91	-4.53	-3.96
	Richer	0.83	0.87	-0.18	-0.88	0.78	0.82	-0.81	-2.03	0.88	0.91	-0.20	-0.94
	Richest	0.88	0.90	6.11	3.17	0.85	0.87	8.11	4.27	0.91	0.93	6.09	3.11
Rural	SC	0.81	0.86	-2.77	-1.64	0.76	0.83	-2.63	-1.44	0.85	0.89	-2.79	-1.70
	ST	0.81	0.86	-2.71	-1.27	0.75	0.82	-3.84	-1.85	0.86	0.90	-2.73	-1.33
	Muslim	0.84	0.88	1.04	0.37	0.82	0.86	4.24	2.65	0.86	0.89	1.02	0.31
	OBC	0.83	0.88	-0.07	0.64	0.79	0.85	0.27	1.21	0.87	0.91	-0.09	0.58
	HC	0.84	0.88	0.96	1.01	0.79	0.84	0.93	0.77	0.88	0.92	0.94	0.95
	Poorest	0.79	0.85	-4.91	-2.26	0.73	0.81	-6.41	-3.15	0.84	0.89	-4.93	-2.31
	Poorer	0.81	0.87	-2.12	-0.86	0.76	0.83	-2.94	-1.21	0.86	0.90	-2.14	-0.91
	Middle	0.83	0.88	0.34	0.26	0.79	0.85	1.39	0.98	0.87	0.90	0.32	0.20
	Richer	0.86	0.89	3.50	2.20	0.82	0.87	5.15	3.48	0.89	0.92	3.48	2.14
	Richest	0.88	0.90	5.76	3.62	0.86	0.89	9.34	6.30	0.90	0.92	5.74	3.56

- **Survival differences until age Sixty and Beyond: A Life table derivative**

The life table computed for all potential characteristic groups can indicate differences in survival until the ages of sixty years and older (see Fig. 5). This differential is marked by the poorest quintile having the lowest chances, as only 73.4% of the population survives to older ages when 86.0% of the richest quintile population survives. The SCs among the social groups had the lowest chances, as only 76.2% of the HCs survived, whereas 81.9% of the HCs did. The greatest disparities were observed between the poorest and richest quintiles of men, with a difference of 15.4%. The results suggest that among both social and economic groups, men experience more disparities than women do.

Figure 5. Survival Differences Till Age Sixty and Beyond: A Life-table Derivative



Discussion and Conclusion

Ageing experience and its assessment are commonly performed in terms of the share of the older adult population beyond the age of sixty years. However, this necessarily involves a survival propensity, which is perhaps not common across all individuals of a population and is conditioned by socioeconomic identities. This can give rise to unequal ageing, where ageing is a survival experience and could differ across different socioeconomic identities. This exercise is intended to highlight such unequalness in terms of a select set of characteristic identities. Although inequality in ageing is recognised, it routinely involves inequality among those beyond the ageing threshold, and further, such inequality has a focus on other

welfare aspects of inequality among them. In contrast, inequality in ageing needs to focus on the differential propensity of reaching old age in the first place and later survival beyond that age. This exercise primarily exposes the differential extent of survival, as revealed by a life table across socioeconomic features of the population that depicts the severe gap in survival to the given threshold age (60) among different social and economic groups. Although survival differentials among social groups in India have been discussed in previous studies, this study highlights the need to read them during the population ageing process. When increased survival or life expectancy is responsive to the fertility transition to result in 'population ageing', this phenomenon has its own inherent differences given that survival is not equal for one and all in the population.

Reading an upwards shift in life expectancy loses sight of the differential dynamics of survivorship in the life cycle, wherein differences in survival to age 60 from ages 15 and 40 generate a significant gap in the loss of the workforce due to mortality. While 26.6% of individuals from the poorest quintile fail to survive to or beyond age 60, similar failure is only 14% among those from the wealthiest quintile. Despite the gain in life expectancy, on average, the socially disadvantaged still die substantially younger. Such differential longevity across the economic spectrum might well be shaped via multiple pathways, including better occupational position leading to higher income and reduced occupational hazard, more physical activity, healthier diet, low smoking and increased self-care, and adherence to medical treatments. An additional 2 YLLs were lost between the ages of 15 and 60 years by the economically weakest group, whereas the socially weakest group lost a year of life in the population. Social discrimination and the restriction of opportunities due to social and economic disadvantages could be reasons for such disparities.

Ageing as an individual life-course event depends on an individual's survival to older ages, which are aggregated into a measure of population ageing in the form of the share of the older population implied positively by increasing longevity. However, increased longevity (a parameter without an individual construct) is experienced differently by individuals when it is conditioned by their attributes. Such attrition in terms of length of life could very well differ between individuals and, more so, systematically between rich and poor individuals. This exploration offers evidence regarding differential survivorship until the age of sixty and beyond, where the poorest fail to achieve attainment of sixty years two times more than the richest segment of the population. Therefore, the fast pace of ageing, i.e., the changing proportion of older adults, needs to account for the share of the rich and the poor within the stock of older adults.

These findings have important policy implications. First, conventional ageing indicators based solely on the proportion of older adults may misrepresent the true distribution of ageing by overlooking differential survival across socioeconomic groups. Policy frameworks for ageing, including pension design and social

protection, need to account for the unequal probability of reaching older ages. Second, redistributive mechanisms such as contributory pensions may inadvertently favour socioeconomically advantaged groups who are more likely to survive long enough to benefit, thereby raising equity concerns. Third, targeted interventions to reduce premature adult mortality among disadvantaged groups, through improved access to healthcare, safer working conditions, and preventive health measures, are essential to ensure a more equitable ageing process. Recognising ageing as a stratified survival process is therefore critical for designing inclusive and equitable ageing policies.

Attaining old age need not be an exclusive privilege of a few but should be a general implication of the realised demographic transition. The interpretation of all possible adversity in old age in general and financial hardship in particular may well be a myth in case the rich live longer vis-à-vis the poor. The socioeconomic composition of older adults needs rethinking as to whether the ideal protection offered to this segment of the population is in keeping with the principle of equity. When an eligible segment does not make to this age and another not only makes to this age but also lives longer beyond reaching old age, then a real scene of adversity should come down. In fact, this should prompt the recognition of heterogeneity in the aged population, as all do not survive until this age, and survival until late ages is responsive to socioeconomic identities. Moreover, if individuals with higher socioeconomic status disproportionately represent older adults, the redistribution of income as welfare pensions will take place in opposition to the idea of equity, i.e., those with lower status will survive less to benefit from the schemes for which they have also contributed. Those with high life expectancies will survive long enough to benefit from the entitlements of contributory or social welfare pensions while the disadvantaged fail.

Given the unequal survival of older individuals, inequalities in physical and mental morbidities create multiple burdens on socially disadvantaged groups, as the disadvantages accumulate over the life course (Serrano-Alarcón & Perelman, 2017). Both unequal ageing and ageing under unequal circumstances should be read together to comment on the burden of the increasing magnitude of older adults. Ageing should not be restricted as a process with a proportional increase in older adults; instead, it should be considered a "stratified process that reflects the inequalities that structure our life chances from birth onwards" (Abramson, 2016).

This exposition is not without its limitations given that the National Family Health Survey may not be sufficient to derive mortality experience and, further, socioeconomic stratification. However, this may offer the first opportunity to obtain a socioeconomic stratification of survival experience, which otherwise remained limited to the gender and residence divide. Given the large size and coverage of the survey, the stratification is perhaps reasonable, but the mortality experience inferred therein may well be conditioned by the age composition of the stratified

population as well as the usual recall/reporting bias of reporting mortality. The other limiting aspect of this exercise lies in considering social and economic features independently, although there is a possible connection between the two. Hence, the real magnitude of the characteristic divide in the older adult population may not be possible on the basis of this assessment. In sum, this exercise highlights the survival divide across socioeconomic identities, which has far-reaching implications for conceptualising population-based indicators. One immediate implication is that the number of older adults is heterogeneous not only in terms of their observed characteristic features but also in terms of their propensities for survival. Therefore, the formulation of common indicators with a population in the denominator and an outcome in the numerator needs to recognise mismatches in the characteristic composition of the two. Reading about the ageing phenomenon should recognise differential survival and the implied compositional features of the aged.

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Book Review

Paradigm Shifts in Population and Health in India: An In-depth Analysis of SDGs

Edited by Sanghmitra S. Acharya, Sampurna Kundu and Sampurna Singh, Singapore: Springer Singapore, 2025. 244 pp. ISBN: 978-981-95-1719-0

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Contextual Introduction

For some time now, India has been known for the paradoxical combination of high rates of child malnutrition, anaemia, and healthcare need despite economic growth. Following the post-2015 adoption of SDGs as the key international goals, researchers have turned their attention to the issue of inequalities in India. While there is a considerable body of research about failures of Indian healthcare system (Balarajan et al., 2011) or the country's demographic advantage (Bloom, 2011), there are few studies which seek to establish links between demographics, healthcare, and inclusive development. This is what Paradigm Shifts in Population and Health in India addresses.

The volume is edited by Sanghmitra S. Acharya, Sampurna Kundu, and Sampurna Singh, the academics associated with the Jawaharlal Nehru University and the University of Exeter respectively. The book was produced by the Centre of Social Medicine and Community Health. The volume stands out due to the fact that the authors do not present population health issues only from the epidemiological or bio-statistical perspective. On the contrary, the book critically assesses the ways in which hierarchical structures result in suffering that could be easily prevented.

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

Analytical Summary

This book comprises five sections, where each section deals with an aspect of the population, health, and development triangle. Following the foreword written by Prof. F. Ram (Director, IIPS) and a prelude written by the editors, the first part (Population, Health and Development) lays out the theoretical framework. Of importance is Aalok Ranjan Chaurasia's chapter on revitalizing India's health system. The author provides a historically critical review of Bhore and Mudaliar Committee legacies while suggesting a novel approach based on a WHO standard and hospital beds. Gender-based infant and under-five mortality trends from 1950 to 2100 are described in the chapter written by Usha Ram et al. using UN statistics and NFHS rounds. The persistence of excess mortality among female children despite general mortality decline is a disturbing fact revealed by the authors. Lastly, in his chapter about early childhood inequalities, Shilpa Jadhav-Bhakare discusses the capabilities approach proposed by Sen (1993), and Nussbaum and makes a convincing case to consider children as rights bearers.

Part II (Innovations in Health Care) moves the attention to response strategies. The first paper in this section, by Jayanti Saha, discusses the history of the MHCs in India from their inception during wartime until their use during the recent COVID-19 pandemic and shows how crucial they are in disaster situations. One exceptional piece of writing that stands out for its qualitative approach to the problem is 'Anganwadi Workers Under Poshan Abhiyan', authored by Vaishnavi Mangal.

Part III (Emerging Issues in Health) focuses on clinical and behavioral burdens. An analysis of unmet healthcare need by Sandhya R. Mahapatro using NSS data shows an alarming phenomenon: although overall levels of unmet need have fallen since 2004, socioeconomic differences increased, and the acceptability barrier (for instance, "illness not considered serious") is now more important than supply-side barriers. Sampurna Kundu et al.'s chapter provides a technically rigorous ordered logit model examining nutritional anaemia among adolescents in India based on CNNS data (2016-18). This study identifies a strong association between deficiencies of iron, zinc, and vitamin A and anaemia, and finds that dietary diversity, especially consumption of dairy products and flesh food, reduces the probability of anaemia. Manali Swargiary et al.'s chapter analyzes hysterectomy in 40-plus women in India using LASI Wave-1 data. This chapter reveals that wealthier and urban women were more likely to be hysterectomized, and excessive menstrual bleeding was the common reason for undergoing the operation—a result which challenges one's understanding regarding medical indications and business motives behind the operation.

Part IV (Towards Well-Being) widens the lens beyond standard morbidity. Debayanti Bhowmick presents an academically rigorous application of political

ecology to the interlinkages between climate change and health by drawing on feminist and post-colonial theories. Trisha Mukhopadhyay and Sumanta Roy study elderly well-being by drawing on the data generated by the Longitudinal Ageing Study in India (LASI), whereby living alone, depression, and ADL problems are prevalent among widowed individuals and those residing in rural areas. The case study presented by Malika B. Mistry provides the most ethnographic perspective by analysing the experiences of the Muslim Naikin women of Maharashtra, whose minority identity allows them to grapple with sexual exploitation, religious hybridity, and economic vulnerability. Similarly, Sampurna Singh and Sanghmitra Acharya discuss domestic violence amid the pandemic and draw on data from NFHS-5 survey and primary data collected in four urban settings, where domestic violence correlates significantly with alcohol consumption and coercive control.

Critical Evaluation

Theoretical Contribution: The main theoretical merit of this volume lies in its rejection of methodological individualism. Through its focus on structural factors, such as caste, patriarchy, neoliberal health governance, and spatial inequality, the book positions itself as an embodiment of critical epidemiology and social medicine perspectives. Utilisation of theories, including capabilities approach by Sen and Nussbaum (Jadhav-Bhakare), and political ecology (Bhowmick) lend rigour to analyses. But there have been several instances of using theoretical concepts in a descriptive manner. The theoretical concept of "intersectionality," for example, appears multiple times in different parts of the book but remains limited to labelling rather than analytical interaction of concepts.

Methodological Soundness: The collection is methodologically eclectic, involving UN projections, NFHS, NSS, CNNS, LASI, and qualitative fieldwork. The ordered logit specification employed by Kundu et al. and the Fairlie decomposition in Swargiary et al. are both methodologically rigorous. Mangal's study of Anganwadi workers based on qualitative data is a fine example of an empirical work focused on lived experiences and sociotechnical critique. However, one weakness in some of the quantitative studies is that their use of cross-sectional data means that any claims about causality (e.g., the effects of hysterectomy on morbidity) are impossible to make. Finally, although there are a few chapters that highlight problems in the health system, none conduct a political economy analysis of health funding/private healthcare providers in India.

Evidence Use: This book does a good job in triangulating multiple sources. In particular, the chapter by Ram et al does a good job in comparing and contrasting the data from UN, NFHS, and Economic Surveys to demonstrate the fact that India's share of deaths among the children in the world is declining but there are still gender disparities. The utilization of concentration curve to explain the pro-poor

unmet need made by Mahapatro was appropriate. At the same time, some of the arguments made especially about the success of programs like Ayushman Bharat lacked citations and evaluation findings.

Strengths and Limitations: Undoubtedly, the biggest advantage that this book possesses is its steadfast concern about the marginalized, such as the Scheduled Castes/Tribes children, the migrant labor community, Muslim Naikin women, and the elderly. Another advantage of the book is that it challenges the binary opposition by presenting the internal differences that exist in one category, for instance, between slums and non-slum urban areas. An inherent weakness of the book lies in its inconsistency in integrating the various parts of the book. For instance, the conclusion provided by the editors at the end of the book is very brief and disappointing.

Comparative Positioning

Where does this volume stand among existing literature? This volume is in the company of The Lancet's India health series (2011) and Oxford Handbook of Caste (2022); however, the distinction of the former lies in its commitment to situate each chapter within specific SDG targets. While biomedical appraisals have been attempted (India Health Report by PHFI), this volume focuses consistently on the dimension of social suffering. Relative to international health equity literature (such as Kawachi & Subramanian's study on social capital), the Indian contribution makes relevant context-specific mechanisms evident, such as precarity of Anganwadi workers, effects of caste discrimination such as manual scavenging, and geographical exclusion of the slum population from access to WASH facilities. Relative to other global South health systems monographs (Waitzkin's study on Latin America), this volume is deficient in engaging with health worker unionization or the role of pharmaceutical capital.

Relevance and Contribution

For the readers of Health Empirics, the volume is valuable in many ways. First, the evidence that acceptability issues (lack of seriousness perception) have become the biggest contributors to unmet needs indicates that demand side measures (health literacy, mobilisation) need equal attention with the supply side expansion. Second, the findings from the hysterectomy chapter show the necessity of conducting audits of gynaecological quality of care, especially in those regions where private facilities proliferate, such as Andhra Pradesh. Third, chapters on digitalisation present a warning signal to health informatics: when technology implementation is not user-oriented and workers receive insufficient remuneration, mHealth initiatives only cause more burnout and misdiagnosis.

Discourse of the multidisciplinary nature of the book, combining medical sociology, demography, public health nutrition, and political ecology, qualifies the volume for use in graduate education, public health professionals, and policy-makers engaged in implementing the goals of SDGs 3 (health), 5 (gender equality), and 10 (inequalities reduction).

Conclusion

"Paradigm Shifts in Population and Health in India" is a pertinent, empirical, and socially committed work. In this book, it is well argued that the demographic transition in India has not gone hand in hand with the health transition. There is sufficient evidence in support of the core evaluation presented in this book regarding how an integrated and equity-oriented approach is essential for achieving the SDGs. Despite some limitations, such as lack of synthesis and analysis in some places, and inadequate use of theory at certain points, it is certainly an important contribution to critical studies of health.

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About IHEPA

The Indian Health Economics and Policy Association (IHEPA) is a registered society under the Society's Registration Act 1960. The secretariat is located at the International Institute for Population Sciences, Mumbai. IHEPA welcomes all those interested in issues relating to health economics and policy to be a part of this association. IHEPA welcomes young scholars and researchers, grassroots practitioners, the private sector and community - based organizations to participate actively so that all views and experiences can be heard, debated, understood and absorbed.

Aims and Scope

Health Empirics welcomes original research contributions across a broad spectrum of topics related to health economics, healthcare delivery, and health policy assessment. The journal serves as a critical forum for academic researchers, policy analysts, and healthcare leaders, aiming to bridge the gap between rigorous empirical evidence and actionable health policy.

We are committed to publishing original research that demonstrates analytical depth, addressing complex health challenges through robust methodological frameworks.

Key Areas of Inquiry: The scope of the journal encompasses, but is not limited to:

1. **Applications of Health Econometrics:** Advanced statistical methods, causal inference, and quantitative evaluation.
2. **Assessment of Health Policies:** Impact evaluation, cost-effectiveness analysis, and policy design methodologies.
3. **Determinants of Health:** Social, economic, and environmental factors, including risk factor quantification.
4. **Healthcare Management & Financing:** Insurance systems, provider incentives, efficiency analysis, and financial protection.
5. **Inequalities in Health:** Measurement of disparities, equity in access, and distributional analysis.
6. **Methodological Innovations:** Novel data collection, mixed-methods frameworks, and Big Data applications.

Audience: The journal addresses a diverse audience including academic researchers, health policy analysts, healthcare administrators, and international development practitioners.

Health Empirics

Editorial Note
Udaya Shankar Mishra

Targeting Nutrition in Early Life: Evidence on ICDS and Minimum Dietary Diversity in India
Swati Singh

Predicting the Impact of Introducing Front of Package Warning Labels on Overweight and Obesity Reduction among Adolescents (15-19 Years) in India using a Stochastic Microsimulation Model
Abhishek Kumar and William Joe

Health Shocks and Vulnerability to Poverty in India: Evidence from the National Sample Surveys, 1995-2018
Priyanka Dasgupta and Subrata Mukherjee

Parental Migration and Child Undernutrition Evidence form NFHS
Rinju

Understanding Progression and Management of Diabetes in Indian Settings From Electronic Medical Records of an Urban Community: The Case of Chips Cohort Study
Anjali Kulkarni, Yogesh K Shejul, Palak Sharma, Puja Goswami, Prashant Bhandarkar, Priti Patil and TR Dilip

Who Reaches Old Age? Socioeconomic Inequality in Survival and Its Implications for Ageing in India
Amrit Jose John, Udaya Shankar Mishra and T V Sekher

Book Review
Beyond Biomedicine: An In-depth Examination of the Changing Population and Health Profile of India
Mayadhar Sethy and Menaka Das

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