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Explaining the poor-rich gap in anthropometric failure among children in India: An econometric analysis of the NFHS, 2021 and 2016

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A B S T R A C T

Wealth inequality in anthropometric failure is a persistent concern for policymakers in India. This necessitates a comprehensive analysis and identification of various risk factors that can explain the poor-rich gap in anthropometric failure among children in India. We analyze the fifth and fourth rounds of the Indian National Family Health Survey collected from June 2019 to April 2021 and January 2015 to December 2016, respectively. Two samples of children aged 0–59 and 6–23 months old with singleton birth, alive at the time of the survey with non-pregnant mothers, and with valid data on stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting are included in the analytical samples from both rounds. We estimate the wealth gradients and distribution of wealth among children with anthropometric failure. Wealth gap in anthropometric failure is identified using logistic regression analysis. The contribution of risk factors in explaining the poor-rich gap in AF is estimated by the multivariate decomposition analysis. We observe a negative wealth gradient for each measure of anthropometric failure. Wealth distributions indicate that at least 60% of the population burden of anthropometric failure is among the poor and poorest wealth groups. Even among children with similar modifiable risk factors, children from poor and poorest backgrounds have a higher prevalence of anthropometric failure compared to children from the richest backgrounds. Maternal BMI, exposure to mass media, and access to sanitary facility are the most significant risk factors that explain the poor-rich gap in anthropometric failure. This evidence suggests that the burden of anthropometric failure and its risk factors are unevenly distributed in India. The policy interventions focusing on maternal and child health, implemented with a targeted approach prioritizing the vulnerable groups, can only partially bridge the poor-rich gap in anthropometric failure. The role of anti-poverty programs and growth is essential to narrow this gap in anthropometric failure.

1. Introduction

Despite the country's substantial economic growth at an annual average growth rate of more than six percent during the last two decades, India hasn't made significant progress in reducing anthropometric failure (AF) (Chatterjee, 2021). Equally alarming is the persistent poor-rich gap in AF among children within India (Porwal et al., 2021) as its detrimental effects have long-lasting implications that hinder social progress and equality across multiple generations (Shirisha et al., 2022). However, what contributes to this poor-rich gap in AF remains unclear. An extensive literature has documented a range of risk factors – child's age, gender, birth order, birth weight, maternal age, health, education, awareness, health care during and after pregnancy, household characteristics such as sanitation facility, religion, caste among others – as significant determinants of AF (Bhutta et al., 2008; Black et al., 2013; Corsi et al., 2016; Kim et al., 2017, 2019; Ruel & Alderman, 2013; Schott et al., 2019; Subramanian, 2009). Less well understood is the relationship between these risk factors and the poor-rich gap in AF.

Few studies have examined the poor-rich gap in AF and its correlates in India (Kanjilal et al., 2010; Karlsson et al., 2021; Khadse & Bansod, 2021; Kumar et al., 2015; Kumar & Paswan, 2021; Mokalla & Mendu, 2020; Mukhopadhyay & Chakraborty, 2020; Nguyen et al., 2021; Pathak

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& Singh, 2011; Shirisha et al., 2022; Singh et al., 2020; Subramanian et al., 2008; Subramanyam et al., 2010). However, the small number of studies exploring this issue are either outdated (Kanjilal et al., 2010; Kumar et al., 2015; Pathak & Singh, 2011; Subramanian et al., 2008; Subramanyam et al., 2010) or haven't focused on identifying risk factors that contribute to the poor-rich gap in AF using data from all the states and regions of India (Karlsson et al., 2021; Khadse & Bansod, 2021; Kumar & Paswan, 2021; Mokalla & Mendu, 2020; Mukhopadhyay & Chakraborty, 2020; Nguyen et al., 2021; Shirisha et al., 2022; Singh et al., 2020). One recent study (Porwal et al., 2021) has documented the poor-rich gap in AF using the Comprehensive National Nutrition Survey (2016–18) data. However, this study fails to account for significant maternal and household-level determinants of AF, such as maternal height, maternal anemia status, water facility, sanitation, and hygiene.

In light of this, our study makes a fresh attempt to utilize the data of children aged 0–59 months from the fifth round of the Indian National Family Health Survey (NFHS-5) to address the following questions: (1) is there a wealth gradient in AF? If yes, then what is the direction of the wealth gradient; (2) what is the wealth distribution among children with AF; (3) To what extent do risk factors account for the wealth gap in AF; (4) which are the most significant risk factors that can reduce the poor-rich gap in AF? This analysis is also done for children aged 0–59 months surveyed in the fourth round of the Indian National Family Health Survey (NFHS-4) to assess change in the poor-rich gap in AF and its risk factors over time. The extent to which risk factors explain the poor-rich gap in AF has significant ramifications for public health policy.

2. Data

We use the NFHS-5, a nationally representative survey that covered 707 districts from 28 states and eight union territories in India. A stratified two-stage sampling frame by states and urban and rural areas within each state is used to select survey respondents. The cross-sectional survey contains records of 232920 children aged 0–59 months from 636699 households surveyed from June 2019 to April 2021 (International Institute for Population Sciences (IIPS) & ICF, 2021). It collects information on essential demographic and socioeconomic characteristics, child and adult health, health service utilization, and other related variables (International Institute for Population Sciences (IIPS) & ICF, 2021). Moreover, the measurements of height, weight, and hemoglobin levels are collected in the biomarker schedule. This study also uses the NFHS-4, which contains records of 259627 children aged 0–59 months from 601509 households interviewed from January 2015 to December 2016 (International Institute for Population Sciences (IIPS) & ICF, 2017).

2.1. Outcomes

We construct six AF outcomes based on children's height and weight measures. Stunting, a measure of chronic malnutrition, is defined as height-for-age z-scores (HAZ) < -2 standard deviation (SD) of the median for their age and sex according to WHO child growth standards (De Onis & Onyango, 2008). Underweight, which reflects a combination of acute and chronic malnutrition, is defined as weight-for-age z-scores (WAZ) < -2 SD (Van de Poel, 2008). Wasting, an indicator of acute malnutrition, is described as weight-for-height z-scores (WHZ) < -2 SD (Kim et al., 2019). We also use the measures of severe malnutrition captured by severe stunting (HAZ < -3 SD), severely underweight (WAZ < -3 SD), and severe wasting (WHZ < -3 SD).

2.2. Covariates

Household wealth is proxied by a wealth index based on household characteristics (such as materials used for housing construction and water and sanitation facility) and ownership of assets (such as television, mobile phone, and bicycle) reported in the survey and verified by the surveyors (International Institute for Population Sciences and ICF, 2021). As reported by the NFHS, this wealth index is constructed using principal component analysis of these household characteristics and assets (International Institute for Population Sciences (IIPS) & ICF, 2021). Analysis based on a range of countries validates this index as a robust measure of household wealth (Filmer & Pritchett, 2001). Moreover, we rely on this wealth index because it reflects the household's long-term economic situation and therefore does not necessarily consider temporary fluctuations in economic well-being or economic disruptions (Filmer & Pritchett, 2001). It is also important to recognize the concerns, such as the possibility of urban bias, use of arbitrary weights, and unavailability of per capita wealth estimates associated with the wealth index (see Mohanty et al., 2022 for more details). However, the wealth index continues to be widely used as a proxy to assess the long-term economic status of households in the absence of data on household income and expenditure (Kumar et al., 2015; Kumar & Paswan, 2021; Pathak & Singh, 2011). We further construct cutoffs to rank households into four wealth quartiles (poorest, poor, rich, and richest) based on the weighted frequency distribution of households. We use these four wealth quartiles to examine the wealth gradient in AF, wealth distribution among children with AF, and estimate the extent to which the risk factors account for the wealth gap in AF. Moreover, we merge the bottom two categories of poor and poorest as poor (bottom 50%) and rich and richest as rich (top 50%) to identify the most significant risk factors that can reduce the poor-rich gap in AF.

We divide the other risk factors, such as child, maternal, and household characteristics associated with AF (Bhutta et al., 2008; Black et al., 2013; Corsi et al., 2016; Kim et al., 2017, 2019; Ruel & Alderman, 2013) into two groups: a) Modifiable Risk Factors (MRF) and b) Non-Modifiable Risk Factors (NMRF). To minimize loss of information and potential selection bias, we code the missing data and special responses such as "do not know" in various variables as a separate category. MRF include risk factors whose distribution can be modified in a short period through policy interventions such as the child's birth weight (low [$<$2500 g], average or more [$\geq$2500 g], not weighed at birth, and don't know/missing), antenatal care visits during pregnancy (0–3, 4–7, $\geq$8, and don't know/missing), skilled birth assistance at the delivery (no vs yes), breastfeeding initiation ($\geq$1 h of birth, $<$1 h, and missing), vitamin A supplementation in the last six months (no, yes, and don't know/missing), drugs for intestinal parasites in the last six months (no, yes, and don't know/missing), oral rehydration therapy for children during diarrhea in the past two weeks (no, yes, no symptoms of diarrhea in the past two weeks, and don't know/missing), received care for children for fever/cough in the past two weeks (no, yes, no symptoms of fever/cough in the past two weeks, and don't know/missing), maternal BMI ($<$18.5 kg/m^2, 18.5–25 kg/m^2, $\geq$25 kg/m^2, and flagged/missing), maternal anemia status (no, yes, and don't know/missing), maternal exposure to mass media (no vs yes), consumption of iodized salt (not used, used, and other [due to unavailability of salt or testing facility]), drinking water facility (unsafe vs safe), sanitary facility (not improved vs improved), household air quality (non-solid fuels, solid fuels in separate kitchen, solid fuels in non-separate kitchen, solid fuels with no information on kitchen, and other), and presence of water at the hand-washing place (no vs yes). We also include the following three additional MRF for the subsample analysis of 6–23 months old children: currently breastfeeding (no vs yes), minimum feeding frequency (no, yes [if two times for 6–8 months breastfed children, three times for 9–23 months breastfed children, and four times for 6–23 months non-breastfed children], and don't know/missing), and minimum diet diversity (no, yes [if having foods from four or more of the following food groups: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products (milk, yogurt, cheese); 4) flesh foods (meat, fish, poultry, and liver/organ meats); 5) eggs; 6) vitamin-A rich fruits and vegetables; and 7) other fruits and vegetables], and don't know/missing).

NMRF include risk factors whose distribution is unlikely to change or can be modified in a relatively long period, such as the child's age (0–5, 6–11, 12–23, 24–35, 36–47, and 48–59 months), gender (female vs. male), birth order (1, 2–3, 4–5, and ≥6), maternal education (no schooling, primary, secondary, and tertiary or above), maternal height (<145, 145–150 [excluding 150], 150–155 [excluding 155], 155–160 [excluding 160], ≥160 cm, and refused/missing), maternal age at birth (<20, 20–29, 30–39, ≥40 years), religion (Hindu, Muslim, Christian, and other), caste (schedule caste, schedule tribe, other backward classes, other, and don't know), household size (<5, 5–6, and >6), and area of residence (urban vs. rural).

2.3. Statistical analysis

A descriptive analysis of the risk factors by wealth quartiles is calculated, accounting for the sample weights (Table 1 and Tables A.1-A.2 in the Appendix). Prevalence estimates of each measure of AF by wealth quartiles are calculated after adjusting for sample weights (Fig. 2 and Figure A.2 in the Appendix). The distribution of wealth status among children with stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting is quantified, accounting for the sample weights (Fig. 3 and Figure A.3 in the Appendix).

We use logistic regression to assess the wealth gap in outcomes based on three different specifications accounting for survey design characteristics and sample weights. Unadjusted odds ratios (UOR), NMRF adjusted odds ratios (NMAOR), and MRF and NMRF adjusted odds ratio (MNMAOR), along with their 95% confidence intervals, are calculated. We also estimate the attenuation in odds ratios due to MRF (Table 2 and Table A.3 in the Appendix).

To quantify the contribution of MRF, NMRF, and their coefficients in explaining the poor-rich gap in AF, multivariate decomposition analysis (based on the mvdcmp (Powers et al., 2011) STATA package) is used after adjusting for sample weights. We merge the categories of poor and poorest as poor and rich and richest as rich. Using a regression model, the decomposition analysis partitions the components of poor-rich difference in every outcome of AF into a component associated with the difference in the characteristics (MRF and NMRF) and a component with the difference in the effects of those characteristics (coefficients of MRF and NMRF) and the constants (Figs. 4–6 and Figures A.4-A.5 in the Appendix) (Powers et al., 2011). The second component of this decomposition analysis is the unexplained component that estimates the magnitude of the poor-rich gap due to differences in the returns of these risk factors between the poor and the rich.

We assume that each measure of AF is a linear combination of characteristics (MRF and NMRF) and their regression coefficients:

$$AF = F(X\beta) \tag{1}$$

where AF denotes the N x 1 dependent variable vector, X is an N x K matrix of K characteristics, and β is a K x 1 vector of coefficients. F is the logit function mapping the linear combination of $X\beta$ to AF. We decompose the mean difference in AF between poor (P) and rich (R) as follows:

$$\overline{AF}_P - \overline{AF}_R = \overline{F(X_P\beta_P)} - \overline{F(X_R\beta_R)} \tag{2}$$

$$\overline{AF}_P - \overline{AF}_R = \underbrace{\overline{F(X_P\beta_P)} - \overline{F(X_R\beta_P)}}_{\text{Explained}} + \underbrace{\overline{F(X_R\beta_P)} - \overline{F(X_R\beta_R)}}_{\text{Unexplained}} \tag{3}$$

The individual contribution of the characteristics to the explained component is determined in relation to their relative contribution to the decomposition at the level of linear prediction (Powers et al., 2011). Specifically, the explained component in (3) can be expressed as a sum of the weighted sum of the individual contributions (E_k).

$$\overline{AF}_P - \overline{AF}_R = \sum_{k=1}^{K} E_k + Unexplained\ Component \tag{4}$$

where $E_k = \left\{ \frac{\overline{X}_{P_k}\left(\beta_{P_k} - \beta_{R_k}\right)}{\sum_{k=1}^{K} \overline{X}_{P_k}\left(\beta_{P_k} - \beta_{R_k}\right)} \right\} * Explained\ Component$

All analyses are conducted in Stata statistical software version 16.0 (StataCorp LLC).

3. Results

The NFHS-5 survey (2019–21) covered 232920 children aged 0–59 months. From this surveyed sample, we define an analytical sample of 182230 children with singleton birth, alive at the time of survey with non-pregnant mothers, and valid data on anthropometric outcomes (Fig. 1). An additional analytical sample of 203550 children aged 0–59 months available in the NFHS-4 survey (2015–16) is used to supplement the main results (Figure A1 in the Appendix). We also do a subsample analysis of 61765 and 53200 children aged 6–23 years old surveyed in the NFHS-4 survey (2015–16) and NFHS-5 survey (2019–21), respectively (Figure A.1 in the Appendix). This subsample analysis includes three additional MRF unavailable for the main analysis of 0–59 months old children.

3.1. Sample characteristics

We provide the distribution of the MRF (NMRF) by wealth quartiles for the main analytical sample in Table 1 (Table A1 in the Appendix). Compared with children in the richest households, the poorest groups have a lower proportion of children with average or more birthweight (absolute difference, 15.67%), at least four antenatal care visits (8.97% for 4–7 and 19.06% for eight or more antenatal care visits), skilled birth assistance at the delivery (16.01%), breastfeeding initiation within 1 h of birth (6.89%), vitamin A supplementation (4.19%, drugs for intestinal parasites (2.36%), no symptoms of diarrhea (3.58%) or cough (3.21%) in the past two weeks, overweight mothers with BMI ≥25 (27.80%), non-anemic mothers (13.22%), mothers with exposure to mass media (60.39%), consumption of iodized salt (6.10%), unsafe drinking water facility (4.78%), improved sanitary facility (54.75%), non-solid fuels in the kitchen (81.55%), and presence of water at the hand-washing place (19.87%). Considering NMRF (Table A1 in the Appendix), we observe statistically significant differences in age, birth order, maternal education, maternal height, maternal age at birth, religion, caste, household size, and area of residence among children belonging to the poorest group relative to the richest group.

3.2. Wealth gradient

Each measure of AF distribution among the poorest, poor, rich, and richest households indicates a transparent negative gradient with stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting (Fig. 2). We observe a clear decreasing relationship between wealth quartiles and the percentage of children with stunting. Specifically, the proportion of stunted children is 45.5%, 37.3%, 30.4%, and 23.5% among the poorest, poor, rich, and richest groups. The proportion of children with severe stunting varies between 20.9% among the poorest households to 9.2% among the richest; underweight, 40.5%–18.8%; severely underweight, 13.0%–4.9%; wasting 22.4%–16.4%; and severe wasting 8.5%–6.8%.

3.3. Wealth distribution

We examine the distribution of wealth among individuals with every measure of AF (Fig. 3). The distribution of wealth status among stunted children indicates that 38.2% belong to the poorest group, 27.6% to the poor group, 20.7% to the rich group, and 13.5% to the richest group.

Table 1
Percentage Distribution of Modifiable Risk Factors of children aged 0–59 months old by the wealth quartiles, India 2019–2021.

	Quartiles				Difference (Poorest-Richest)	p-value
	1	2	3	4		
	Poorest	Poor	Rich	Richest		
Birth weight (in grams)						
low (<2500)	16·11	16·04	15·02	13·32	2·79***	(0·000)
average or more (≥2500)	67·95	76·29	80·65	83·62	−15·67***	(0·000)
Not weighed at birth	13·41	6·07	3·22	2·01	11·40***	(0·000)
Don't Know/Missing	2·52	1·60	1·11	1·05	1·48***	(0·000)
Antenatal care visits						
0-3	39·21	30·38	25·59	22·61	16·59***	(0·000)
4-7	25·49	31·35	32·43	34·46	−8·97***	(0·000)
≥ 8	6·33	12·81	20·00	25·39	−19·06***	(0·000)
Don't Know/Missing	28·97	25·46	21·99	17·53	11·44***	(0·000)
Skilled birth assistance at the delivery						
No	19·64	10·42	6·07	3·63	16·01***	(0·000)
Yes	80·36	89·58	93·93	96·37	−16·01***	(0·000)
Breastfeeding initiation						
≥1 h of birth	46·49	46·78	46·24	49·25	−2·77***	(0·000)
< 1 h of birth	29·79	32·42	35·83	36·67	−6·89***	(0·000)
Missing	23·73	20·80	17·93	14·08	9·65***	(0·000)
Vitamin A supplementation in the previous six months						
No	24·36	23·18	21·95	21·43	2·93***	(0·000)
Yes	33·18	34·82	37·05	37·37	−4·19***	(0·000)
Don't Know/Missing	42·46	42·01	41·00	41·20	1·26***	(0·010)
Drugs for intestinal parasites in the previous 6 months						
No	37·24	36·06	35·86	36·22	1·02**	(0·034)
Yes	20·42	22·08	23·15	22·77	−2·36***	(0·000)
Don't Know/Missing	42·34	41·86	40·98	41·01	1·33***	(0·006)
Oral rehydration therapy for children during diarrhea in past two weeks						
No	3·48	3·18	2·61	1·94	1·54***	(0·000)
Yes	5·30	4·56	4·38	3·32	1·98***	(0·000)
No symptoms of diarrhea in the past two weeks	91·08	92·18	92·92	94·66	−3·58***	(0·000)
Don't Know/Missing	0·13	0·08	0·09	0·08	0·05*	(0·051)
Received care for fever/cough in past two weeks						
No	3·22	2·63	2·18	1·77	1·46***	(0·000)
Yes	11·86	11·12	10·88	9·44	2·42***	(0·000)
No symptoms of fever/cough in the past two weeks	79·47	80·50	81·20	82·68	−3·21***	(0·000)
Don't Know/Missing	5·44	5·75	5·74	6·12	−0·67***	(0·003)
Maternal BMI (in kg/m2)						
< 18.5	28·93	21·45	15·97	9·50	19·44***	(0·000)
18·5 to 25 (excluding 25)	62·85	62·69	59·73	54·41	8·45***	(0·000)
≥ 25	7·64	15·22	23·80	35·45	−27·80***	(0·000)
Flagged/Missing	0·57	0·64	0·50	0·65	−0·08	(0·294)
Maternal Anaemia status						
No	32·90	37·75	42·72	46·12	−13·22***	(0·000)
Yes	65·52	60·82	55·75	51·93	13·59***	(0·000)
Missing	1·58	1·43	1·53	1·95	−0·37***	(0·005)
Maternal Exposure to Mass Media (Newspaper/Television/Radio)						
No	80·79	51·83	31·11	20·39	60·39***	(0·000)
Yes	19·21	48·17	68·89	79·61	−60·39***	(0·000)
Iodized salt						
Not used	8·40	6·84	4·76	2·53	5·87***	(0·000)
Used	91·19	92·90	95·06	97·29	−6·10***	(0·000)
Other (No salt/No testing)	0·41	0·27	0·18	0·18	0·23***	(0·000)
Drinking Water Facility						
Unsafe	8·79	9·52	12·98	13·57	−4·78***	(0·000)
Safe	91·21	90·48	87·02	86·43	4·78***	(0·000)
Sanitary facility						
Not improved	56·26	28·34	8·69	1·50	54·75***	(0·000)
Improved	43·74	71·66	91·31	98·50	−54·75***	(0·000)
Household air quality						
Non-Solid fuels	10·85	41·70	73·57	92·40	−81·55***	(0·000)
Solid fuels in separate kitchen	24·65	22·10	13·14	4·32	20·34***	(0·000)
Solid fuels in non-separate kitchen	35·88	15·13	4·06	0·79	35·09***	(0·000)
Solid fuels with no information on kitchen	28·53	20·94	9·16	2·48	26·05***	(0·000)
Other	0·10	0·13	0·07	0·02	0·08***	(0·000)
Presence of water at hand-washing place						
No	21·19	11·83	6·13	1·91	19·87***	(0·000)
Yes	77·71	87·39	93·28	97·58	−19·87***	(0·000)
Don't Know/Missing	1·11	0·78	0·59	0·51	0·59***	(0·000)
Unweighted Number	59858	49642	41029	31701	91559	

***p < 0·01, **p < 0·05, *p < 0·1; Note: Sample weights were used to compute the summary statistics.

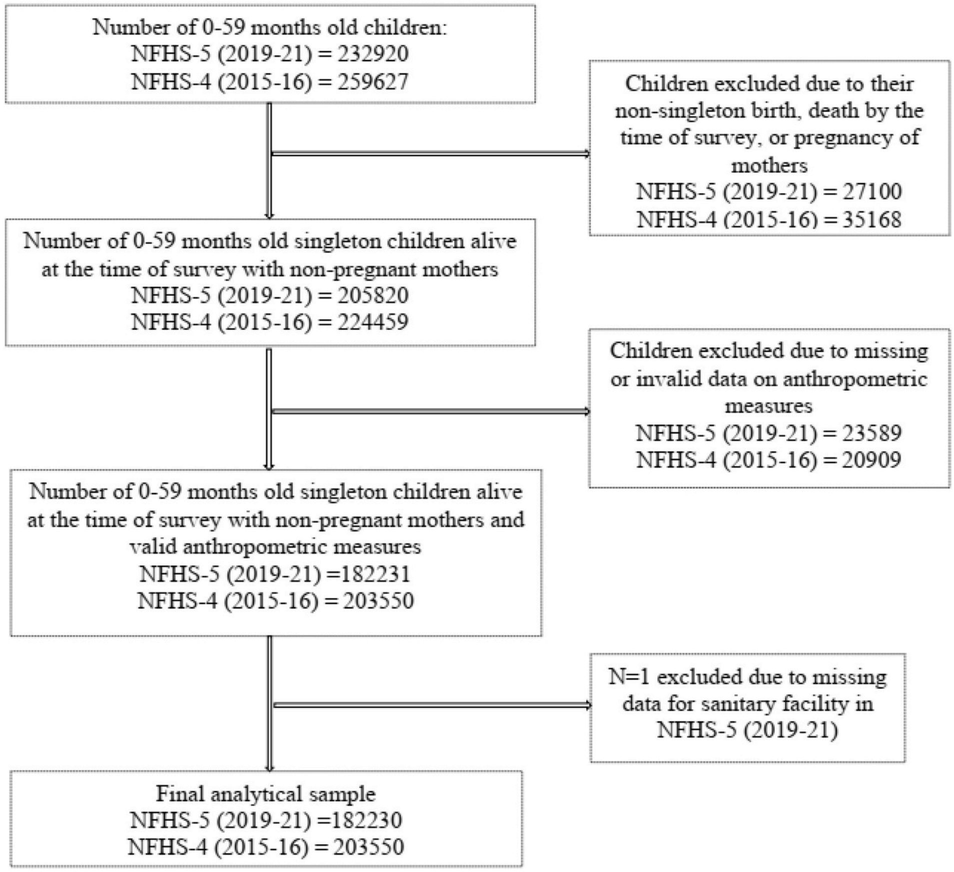

Fig. 1. Schematic representation of the 0–59 months old children from NFHS-5 and NFHS-4 included in the study.

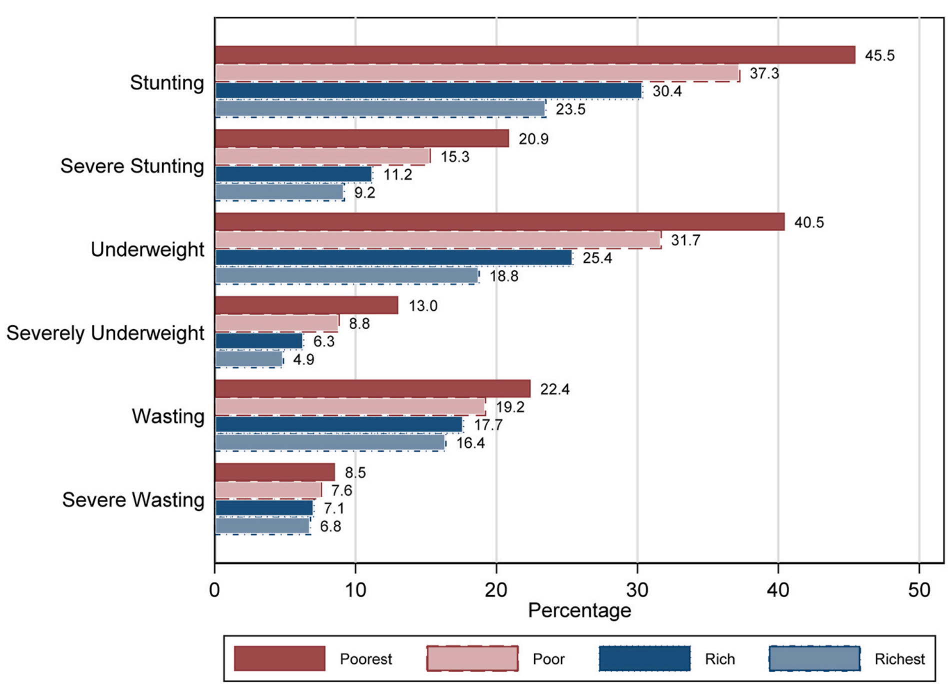

Fig. 2. Wealth inequality in anthropometric failure among children aged 0–59 months in India, 2019-21.

42% of severely stunted children, 39.8% of underweight children, 44.5% of severely underweight children, 34.6% of wasted children, and 33.4% of severely wasted children are in the poorest group. The proportion of children in the richest groups is 12.6%, 12.6%, 11.4%, 17.3%, and 18.1% among severely stunted, underweight, severely underweight, wasted, and severely wasted children, respectively.

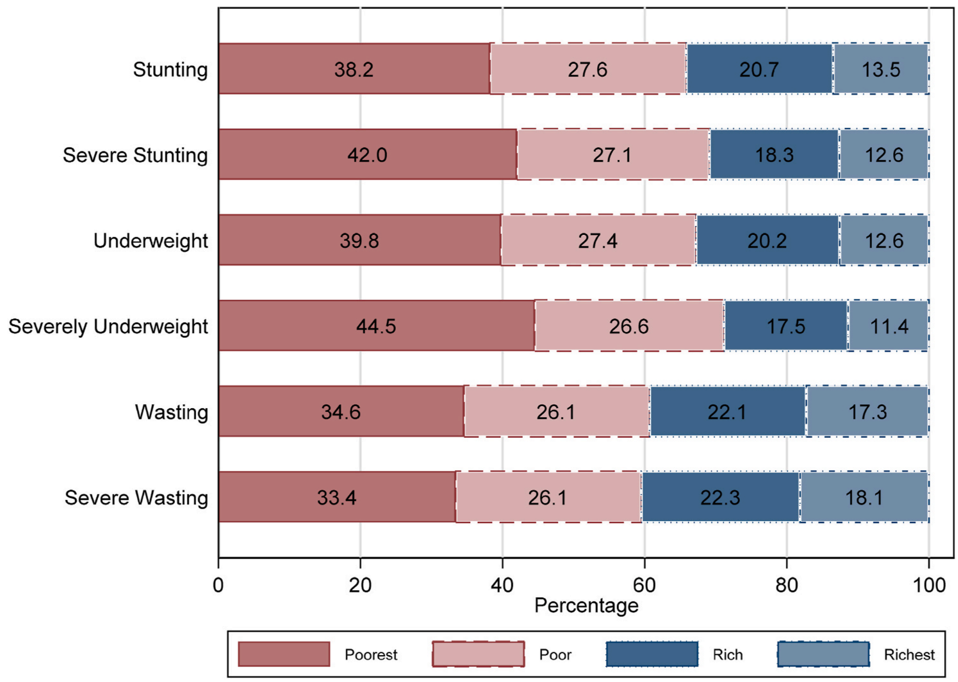

Fig. 3. Distribution of wealth status among 0–59 months aged children suffering from stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting in India, 2019-21.

3.4. Logistic regression analysis

Odds ratios from the logistic regression of each of the six outcomes are presented in Table 2. The first specification shows the raw wealth differences in outcomes (column 1). Next, we examine the extent to which these gaps can be explained by the differences in NMRF in the second specification (column 2) and all the risk factors (including both MRF as well as NMRF) in the third specification (column 3). We also estimate the attenuation in the wealth gradient due to MRF (column 4).

The findings based on the crude specification reflect large and significant differences in wealth outcomes. Specifically, children from the poorest backgrounds are more likely to be stunted (OR, 2.71; 95% CI, 2.58–2.85), severely stunted (OR, 2.60; 95% CI, 2.43–2.79), underweight (OR, 2.94; 95% CI, 2.78–3.11), severely underweight (OR, 2.92; 95% CI, 2.67–3.20), wasted (OR, 1.47; 95% CI, 1.37–1.58) and severely wasted (OR, 1.28; 95% CI, 1.16–1.41) than children from the richest background. The findings from the second specification indicate that the differences in the NMRF explain a significant proportion of the wealth gap. However, the wealth gap persists in five out of six outcome variables: stunting, severe stunting, underweight, severely underweight, and wasting.

After mutual adjustment for NMRF and MRF in the third specification, we observe further attenuation in the odds ratios of wealth dummies across all the outcome variables, i.e., stunting (at least 24%), severe stunting (at least 35%), underweight (at least 29%), severely underweight (at least 44%), wasting (at least 53%), and severe wasting (at least 100%). However, we continue to observe a significant wealth gap for stunting, severe stunting, underweight, and severely underweight. Compared with children from the richest background, children from rich, poor, and poorest backgrounds have higher odds of stunting (OR, 1.16; 95% CI, 1.09–1.23 for rich, OR, 1.29; 95% CI, 1.21–1.37 for poor, and OR, 1.41; 95% CI, 1.31–1.52 for poorest) and underweight (OR, 1.20; 95% CI, 1.13–1.27 for rich, OR, 1.35; 95% CI, 1.26–1.44 for poor, and OR, 1.54; 95% CI, 1.43–1.66 for poorest). Children from the poor and poorest backgrounds are associated with increased odds of severe stunting (OR, 1.22; 95% CI, 1.12–1.33 for the poor, and OR, 1.37; 95% CI, 1.24–1.51 for the poorest) and severely underweight (OR, 1.25; 95% CI, 1.11–1.39 for poor, and OR, 1.45; 95% CI, 1.28–1.64 for poorest) compared with the richest background. Compared with children from the richest background, children from the poorest backgrounds have higher odds of wasting (OR, 1.16; 95% CI, 1.06–1.27).

3.5. Decomposition analysis

The poor-rich gap in stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting is 14.4%, 8.0%, 14.0%, 5.4%, 3.8%, and 1.2%, respectively. We estimate the reduction in this poor-rich gap due to equalization of the distribution of MRF and NMRF and equalization of constants and the coefficients of MRF and NMRF (i.e., unexplained component) of children belonging to poor and rich households (Figs. 4–6). The negative percentage for a particular risk factor indicates the increase in the poor-rich gap due to equalizing that risk factor.

We observe that a significant share of the poor-rich gap in AF can be closed by equalizing the distribution of MRF of children in the two groups. Specifically, suppose the children from poor backgrounds have the same distribution of maternal BMI as rich. In that case, the poor-rich gap in stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting can reduce by 9.12%, 9.54%, 17.32%, 16.45%, 34.19%, and 31.01%, respectively. Equalization of the distribution of maternal exposure to mass media and sanitary facilities between poor and rich can reduce the poor-rich gap in stunting by 5.66% and 5.23%, in severe stunting by 5.76% and 5.07%, in underweight by 6.13% and 3.69%, in severely underweight by 6.68% and 5.93%, in wasting by 6.50% and 4.97%, in severe wasting by 17.15% and 13.52%, respectively.

A major component of the overall poor-rich gap in AF exists due to the unequal distribution of NMRF of children in the two groups. Specifically, unequal distribution of maternal height and maternal education accounts for 20.39% and 15.07% of the poor-rich gap in stunting, 20.78% and 19.95% in severe stunting, 17.41% and 13.13% in underweight, 16.67% and 15.33% in severely underweight, 20.98% and 8.02% in wasting, 36.38% and 8.73% in severe wasting, respectively. Moreover, a significant share of poor-rich gap in stunting (27.66%),

Table 2
Unadjusted (UOR) and Non-Modifiable Risk Factors Adjusted (NMAOR), Modifiable and Non-Modifiable Risk Factors Adjusted (MNMAOR) Odds Ratios (With 95% Confidence Intervals) and Percentage Change in the Odds Ratio of the socioeconomic status on stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting.

	(1) UOR	(2) NMAOR	(3) MNMAOR	(4) Change (%)
Panel A: Stunting				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·42*** (1·35–1·50)	1·21*** (1·14–1·29)	1·16*** (1·09–1·23)	−24
Quartile 2 (Poor)	1·93*** (1·84–2·03)	1·43*** (1·35–1·52)	1·29*** (1·21–1·37)	−33
Quartile 1 (Poorest)	2·71*** (2·58–2·85)	1·71*** (1·60–1·82)	1·41*** (1·31–1·52)	−42
Panel B: Severe Stunting				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·25*** (1·16–1·35)	1·08* (1·00–1·17)	1·03 (0·95–1·12)	−63
Quartile 2 (Poor)	1·78*** (1·66–1·91)	1·34*** (1·23–1·45)	1·22*** (1·12–1·33)	−35
Quartile 1 (Poorest)	2·60*** (2·43–2·79)	1·62*** (1·49–1·77)	1·37*** (1·24–1·51)	−40
Panel C: Underweight				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·48*** (1·39–1·56)	1·28*** (1·21–1·36)	1·20*** (1·13–1·27)	−29
Quartile 2 (Poor)	2·01*** (1·90–2·13)	1·54*** (1·45–1·65)	1·35*** (1·26–1·44)	−35
Quartile 1 (Poorest)	2·94*** (2·78–3·11)	1·95*** (1·82–2·09)	1·54*** (1·43–1·66)	−43
Panel D: Severely Underweight				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·31*** (1·19–1·45)	1·15** (1·03–1·28)	1·07 (0·96–1·19)	−53
Quartile 2 (Poor)	1·89*** (1·72–2·08)	1·45*** (1·30–1·62)	1·25*** (1·11–1·39)	−44
Quartile 1 (Poorest)	2·92*** (2·67–3·20)	1·87*** (1·67–2·10)	1·45*** (1·28–1·64)	−48
Panel E: Wasting				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·09*** (1·03–1·16)	1·06* (0·99–1·14)	1·01 (0·94–1·08)	−83
Quartile 2 (Poor)	1·21*** (1·13–1·30)	1·15*** (1·06–1·25)	1·05 (0·97–1·14)	−67
Quartile 1 (Poorest)	1·47*** (1·37–1·58)	1·34*** (1·22–1·47)	1·16*** (1·06–1·27)	−53
Panel F: Severe Wasting				
Quartile 4 (Richest)	1·00 Reference	1·00	1·00	
Quartile 3 (Rich)	1·04 (0·95–1·13)	1·02 (0·93–1·12)	0·98 (0·89–1·07)	−200
Quartile 2 (Poor)	1·12** (1·02–1·24)	1·07 (0·95–1·21)	0·98 (0·88–1·11)	−129
Quartile 1 (Poorest)	1·28*** (1·16–1·41)	1·15** (1·02–1·31)	1·00 (0·87–1·14)	−100
Non-Modifiable Risk Factors	No	Yes	Yes	
Modifiable Risk Factors	No	No	Yes	
N	182230	182230	182230	

***p < 0·01, **p < 0·05, *p < 0·1 Note: Confidence intervals in brackets were adjusted for the cluster survey design. Non-Modifiable risk factors include the child's age, gender, birth order, maternal education, maternal height, maternal age at birth, religion, caste, household size, and area of residence. Modifiable risk factors include the child's birthweight, antenatal care visits during pregnancy, skilled birth assistance at the delivery, breastfeeding initiation, vitamin A supplementation in the previous six months, drugs for intestinal parasites in the previous six months, oral rehydration therapy for children during diarrhea in past two weeks, received care for fever/cough in the past two weeks maternal BMI, maternal anemia status, maternal exposure to mass media, consumption of iodized salt, drinking water facility, sanitary facility, household air quality, and presence of water at the hand-washing place. In column 4, change was the degree to which odds ratios were attenuated after adjustment of both non-modifiable and modifiable risk factors that was calculated according to the formula {(MNMAOR-NMAOR)X100}/(NMAOR-1).

severe stunting (23.80%), underweight (23.36%), severely underweight (22.44%), wasting (12.65%), and severe wasting (4.85%) exists due to differences in the returns of MRF and NMRF and constants (i.e., unexplained component) between the poor and rich.

3.6. *Additional analysis on the sample from NFHS-4*

In the additional analysis, we focus on 203550 children aged 0–59 months interviewed from January 2015 to December 2016 to examine the differences in the poor-rich gap in AF and its risk factors between the two surveys (Figure 1 and Figure A1 in the Appendix). We continue to observe a clear negative wealth gradient with each measure of AF (Figure A2 in the Appendix). The distribution of wealth status reveals that more than 60% of the children with AF belong to the poorest and poor group (Figure A3 in the Appendix). Some differences are found in the magnitude of the attenuation of the wealth gradient due to MRF (Table A3 in the Appendix) and the contribution of the risk factors that can reduce the poor-rich gap in AF (Figure A4 in the Appendix). However, the overall finding on the importance of MRF remains the same in the NFHS-4 sample.

3.7. *Sensitivity analysis: 6–23 months old*

In our primary analytical sample of 0–59 months old children, we couldn't include the following risk factors: currently breastfeeding, minimum feeding frequency, and minimum diet diversity, as this information is recorded for 6–23 months old children. The inclusion of these additional MRF in the subsample analysis of 6–23 months old children has no substantial effect on the findings from the logistic regression (Table A3 in the Appendix) and decomposition analysis (Figure A5 in the Appendix).

4. Discussion

The poor-rich gap in stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting has remained persistently high with 17.6% and 14.4%, 10.3% and 8.0%, 16.9% and 14.0%, 7.4% and 5.4%, 3.7% and 3.8%, and 1.2% and 1.2% in 2015–16 and 2019–21, respectively. Using data from NFHS-5 and NFHS-4, this study provides a detailed view of the relationship between the poor-rich gap in child AF and its risk factors. We have several key findings from this study. First, analyses of wealth gradient in the proportion of stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting reveal a negative relationship with respect to wealth quartiles. Second, we find that at least 60% of the population burden of AF was among the poor and poorest wealth groups. The richest wealth group accounts for 13.5%–18.1% of the burden of AF. These findings are in line with the previous literature (Kanjilal et al., 2010; Karlsson et al., 2021; Khadse & Bansod, 2021; Kumar et al., 2015; Kumar & Paswan, 2021; Mokalla & Mendu, 2020; Mukhopadhyay & Chakraborty, 2020; Nguyen et al., 2021; Pathak & Singh, 2011; Shirisha et al., 2022; Singh et al., 2020; Subramanian et al., 2008; Subramanyam et al., 2010) documenting the wealth inequality in AF. Third, among children with similar NMRF and MRF, children from poor and poorest backgrounds have a higher prevalence of stunting, severe stunting, underweight, and severely underweight compared to children from the richest backgrounds. A significant proportion of the wealth gap in AF can be attributed to MRF. However, focusing only on MRF cannot eliminate this wealth gap.

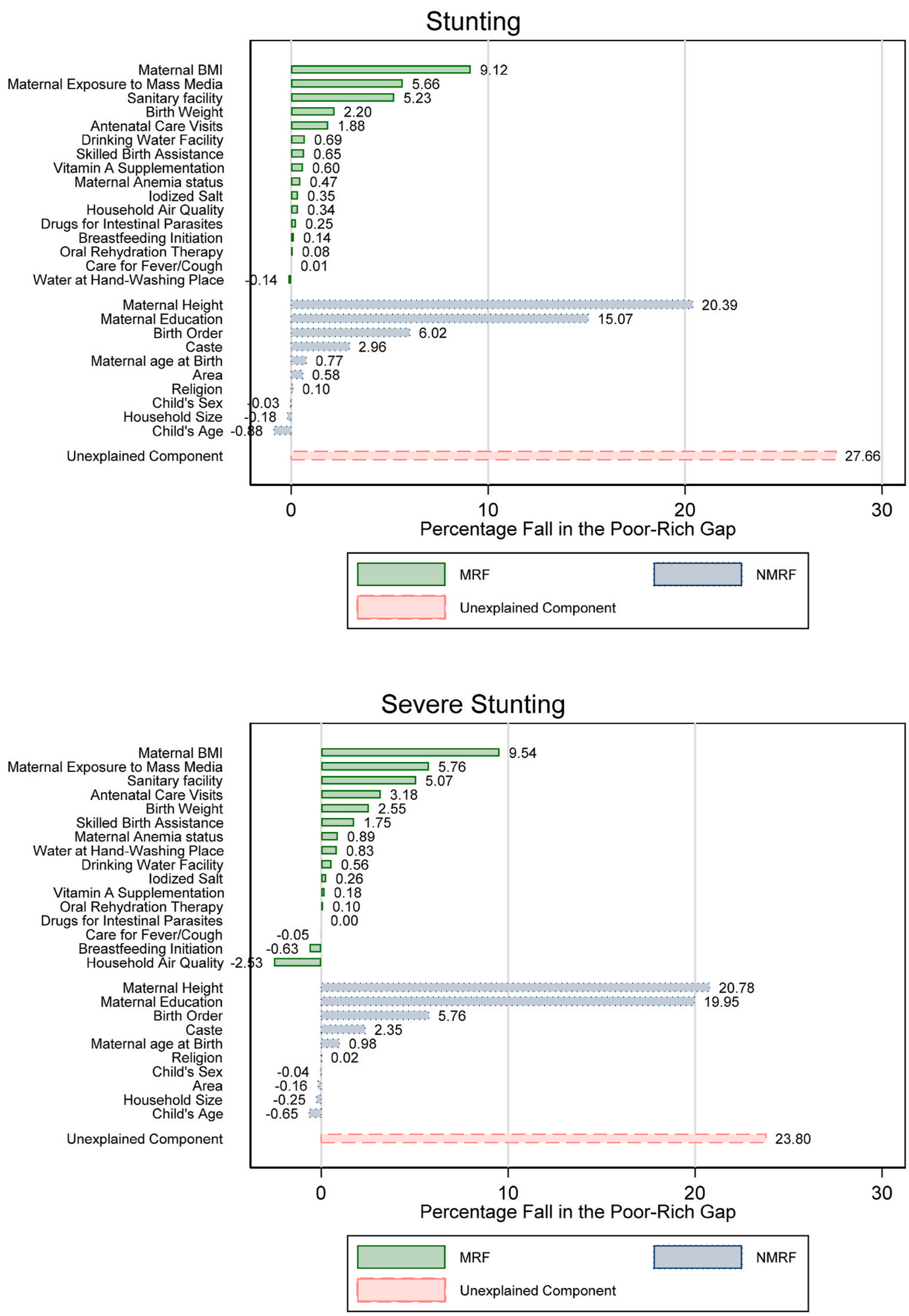

Fig. 4. Contribution of the risk factors in reducing the poor-rich gap in the prevalence of stunting and severe stunting among 0–59 months aged children.

Fourth, we identify the risk factors that can reduce the poor-rich gap in AF. Specifically, maternal BMI, maternal exposure to mass media, and the sanitary facility can reduce the poor-rich gap in stunting, severe stunting, underweight, severely underweight, wasting, and severe wasting by at least 9.12%, 3.69%, and 5.07%, respectively. At least 17% of the poor-rich gap in each measure of AF can be reduced by focusing on these three MRF alone. It highlights the significance of maternal BMI, maternal exposure to mass media, and access to proper sanitary facilities as key factors not only in addressing the overall AF (Corsi et al., 2016; Kim et al., 2017, 2019; Porwal et al., 2021) but also in bridging the poor-rich gap in AF. Child's birth weight, oral rehydration therapy, and maternal anemia status are some other MRF that can significantly reduce the poor-rich gap in each measure of AF. The unequal distribution of NMRF also accounts for a significant share of the poor-rich gap in AF. Maternal height, maternal education, and caste collectively account for at least 36% of the poor-rich gap in AF. Moreover, a significant share of the poor-rich gap in AF remains unexplained. Taken together, our findings suggest that it is crucial to adopt a two-dimensional strategy to narrow the poor-rich gap in AF. This approach should concentrate on both minimizing the unequal distribution of MRF and alleviating poverty. By implementing such a comprehensive plan, policymakers can effectively reduce the gap between the well-off and economically

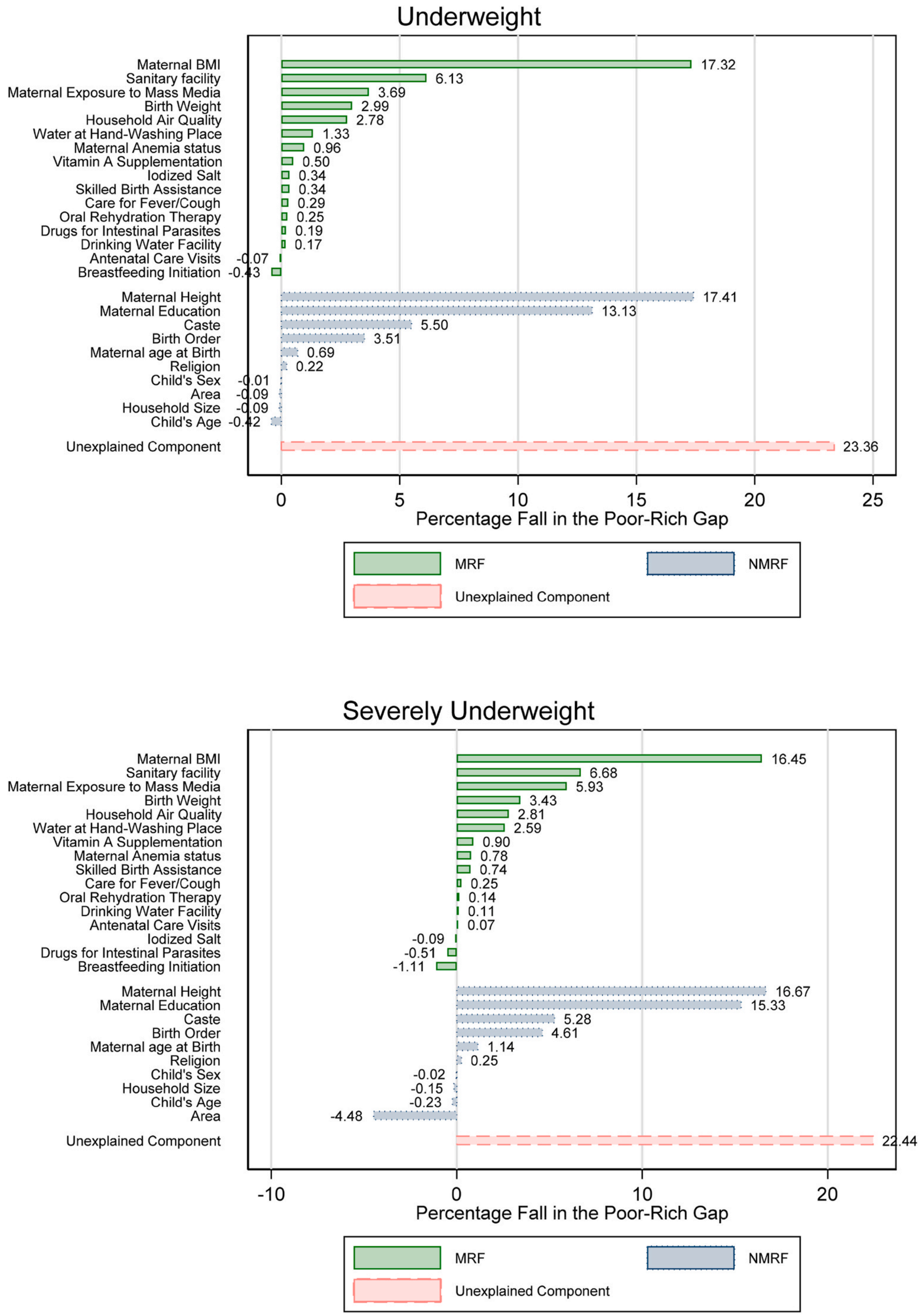

Fig. 5. Contribution of the risk factors in reducing the poor-rich gap in the prevalence of underweight and severely underweight among 0–59 months aged children.

disadvantaged in terms of AF.

One of the limitations of this study is the criterion to classify risk factors into MRF and NMRF. The likelihood of change in the variables included in NMRF is very low. However, variables such as maternal education, maternal height, maternal age at birth, household size, and area of residence can be modified slowly over time with appropriate interventions in place. The study's objective was to focus on those risk factors as the MRF, that could be changed in a short period through policy interventions.

5. Conclusion

The findings of this study suggest a two-pronged strategy to reduce the poor-rich gap in AF among children. The first strategy should aim to reduce the gap in the unequal distribution of the risk factors, as the unequal distributions of both MRF and NMRF are essential determinants of the poor-rich gap in AF among children. Focus on MRF, such as maternal BMI, maternal exposure to mass media, and the sanitary facility, can be the primary target of policy measures. To mitigate this unequal distribution, social safety nets focusing on child and maternal health, such as Integrated Child Development Services, Janani Suraksha Yojana, and the construction of toilets under the Swachh Bharat Mission

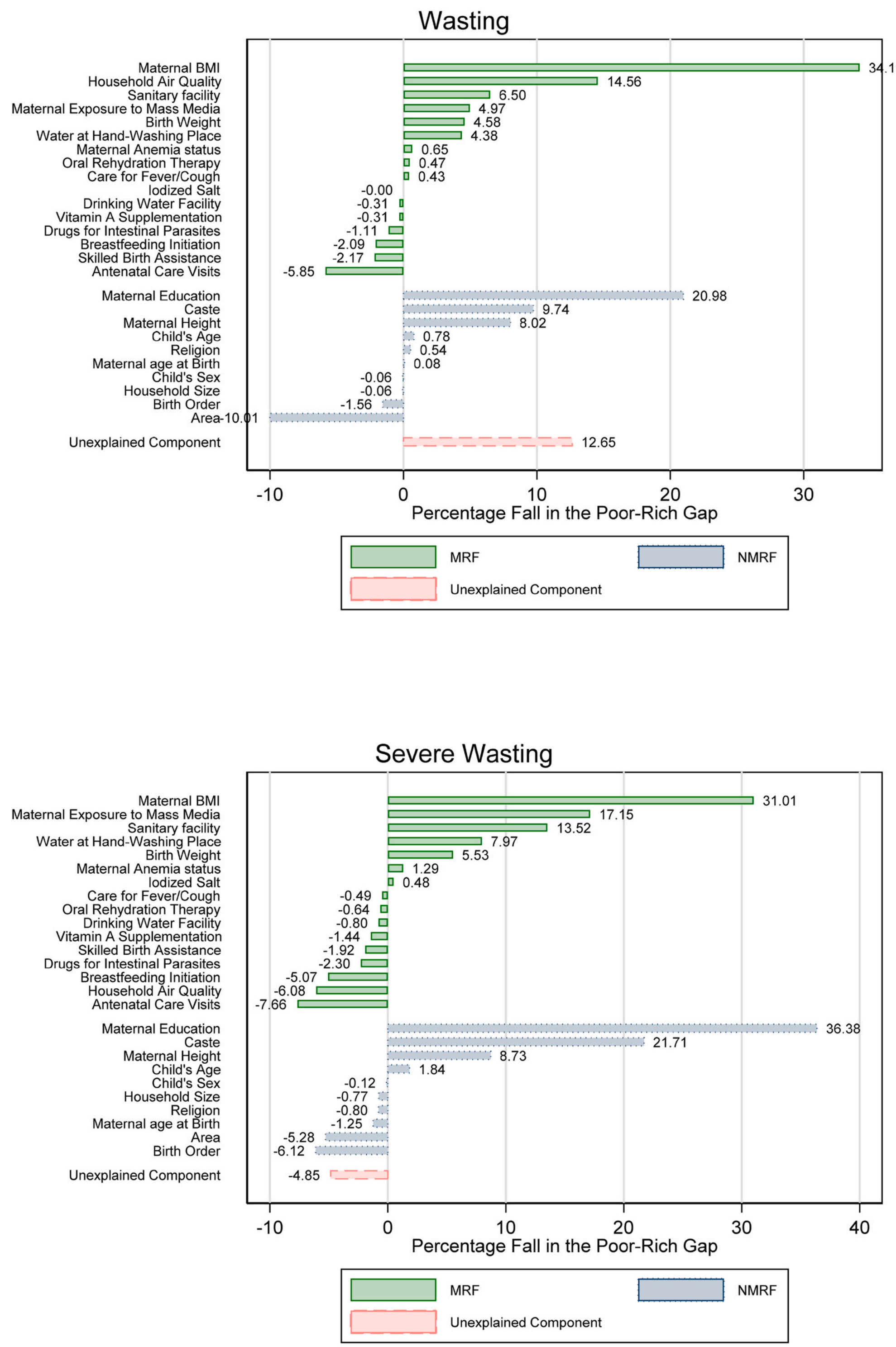

Fig. 6. Contribution of the risk factors in reducing the poor-rich gap in the prevalence of wasting and severe wasting among 0–59 months aged children.

should be implemented with a targeted approach focusing on the poorer groups. Second, it is also important to recognize that merely focusing on these risk factors might not eliminate the poor-rich gap. A sizeable share of the poor-rich gap exists due to unexplained components. Hence, the health programs targeting the poor will be partially effective in reducing the AF between the rich and the poor. These programs must be complemented with anti-poverty programs to effectively bridge the gap in AF between the rich and the poor.

Author contributions

Dhamija has the full access to all of the data in the study and takes responsibility for the data's integrity and the data analysis's accuracy.

Concept and design: Kapoor, Subramanian.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Dhamija.

Critical revision of the manuscript for important intellectual content: Kim, Kapoor, Subramanian.

Statistical analysis: Dhamija.

Supervision: Kapoor, Subramanian.

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Ethics statement

This project used publicly-accessible secondary data obtained from the DHS website (https://dhsprogram.com/data/available-datasets.cfm). The DHS data are not collected specifically for this study and no one on the study team has access to identifiers linked to the data. These activities do not meet the regulatory definition of human subjects research. As such, IRB review is not required.

Declaration of competing interest

The authors have declared that no competing interests exist.

Data availability

Data are available at the DHS website (https://dhsprogram.com/data/available-datasets.cfm).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101482.

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