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Abstract

Reduction of undernutrition has remained a priority among public health professionals and policy makers for decades. Though malnutrition disproportionately affects all age-groups, children belonging to under-five age are at the highest risk. In spite of various programmatic interventions, child undernutrition continues to be high in India. The state of Bihar has remained one of the backward states in India for decades in terms of human development indicators. Although the proportions of stunted, underweight and wasted children declined from 61 percent, 63 percent and 22 percent to 48 percent, 44 percent and 21 percent respectively between 1992-93 and 2015-16 according to the National Family Health Surveys, these percentages are still the highest among all the states in India. Numerically, 9.2 million children in Bihar are stunted. Notably, Bihar alone contributes around 15 percent of undernourished children in India. Against this backdrop, using four successive rounds of National Family Health Survey data spread over two decades, the present study aims to assess effects of various endowments as well as returns to those endowments in disparities in childhood stunting. The analysis was carried out by employing recentred function quantile regression modelling and counterfactual decomposition technique. The results show that although between 1992-93 and 1998-99 child's height-for-age Z-scores (HAZ) disparity at the bottom quantile of the distribution was largely accounted for differing levels of endowments, in the later periods such differences became statistically insignificant. At the higher quantiles, particularly between 50 – 75th quantile, although unequal endowments were somewhat responsible for HAZ disparities between 1992-93 and 1998-99, inadequate access to benefits from various development programmes was largely found accountable for HAZ disparities between 1998-99 and 2005-06. Such pattern was continued even between 2005-06 and 2015-16. We argue that child undernutrition in Bihar is not just only due to inequity in individual, maternal and household level endowments but also due to insufficient and inadequate access to or quality of different programmatic interventions. In addition to scaling up proven nutrition-specific interventions in alignment with other Indian states, Bihar must focus on nutrition-centric policy processes and their political underpinnings to reduce the menace of child undernutrition.

Investigating Correlates of Child Undernutrition in Bihar: Analyses of Successive Rounds of National Family Health Survey

Introduction

In the early 1990s, child undernutrition was ubiquitous and high across South Asian countries, and was contemplated as an 'enigma' (Ramalingaswami et al. 1996). It was comparable with many Sub-Saharan African counties during that period. Although Bangladesh and Nepal have made considerable progress in reduction of child undernutrition during last two decades or so (Nisbett et al. 2017; Cunningham et al. 2017), child undernutrition still continues to be high in India (International Institute for Population Sciences (IIPS) and ICF, 2017). Prevalence of stunting, underweight and wasting was observed to be 38, 36 and 21 percent at the all India level (ibid). UNICEF (2013) has observed that India alone contributed 38 percent of the stunted children in the world in 2011, while Headey (2013) estimated that number of undernourished children in India was higher than in all of Africa. Lamentation of Sen (2001) –"In the avoidance of endemic undernourishment and hunger, India has done worse than nearly every country in the world" – plausibly holds to date. It is needless to mention that a rapid reduction of child undernutrition in India is imperative to lessen global burden of malnutrition.

The high and persistent prevalence of child undernutrition in India may seem surprising in the era of consistent economic growth since the policy reform process gained momentum in the early 1990s. Between 1995 and 2010-11, per capita net state domestic product grew by 7.3 percent per year on average, signifying a substantial increase in real income. Despite such significant overall economic performance, the prevalence of child stunting and underweight has dropped by 27 and 33 percent (about 14 and 17 points) respectively over the 20 years or so (IIPS 1995; IIPS and Macro International 2016). If we compare with China, these rates of decline look modest; in China, childhood stunting dropped from 33 to 10 percent between 1992 and 2005,while child underweight was practically eliminated (Svedberg 2006). Svedberg (2006) has pointed out that India's progress in reducing child underweight since the early 1990s has been only marginally better than in Sub-Saharan Africa, a region with high and persistent child malnutrition, but economically stagnant (Table 1).

Table 1 : Child Stunting in different countries

	1992	**2005**
China	33%	10%
	1992	**2016**
India	52%	38%
	1990	**2016**
Sub-Saharan Africa	44%	39%

Source: Svedberg 2006

In a recent study Jose et al. (2018) emphasized that despite a moderate decline in child undernutrition during past 10 years in India, a large and graded socio-economic disparity in child undernutrition continues to exist. A systematic review on prevalence of child undernutrition in India has also concluded that burden of child undernutrition is still remarkably high in India and there is an urgent need to understand the risk factors in greater details (Ansuya et al. 2018).

Several studies were conducted in India using the multi sectoral conceptual framework developed by the UNICEF (1990) to understand the macro-, meso-, as well as micro – level factors causing undernutrition. According to the framework, basic causes of malnutrition in a society is related to the historical background of the society, political and ideological superstructure and, economic structure. These factors affect functioning of formal and non-formal institutions and other potential resources. Underlying causes of undernutrition could be unhealthy environment, inadequate or improper education, household food security, lack of care for children and women and scarcity of health services. Immediate causes mostly related to inadequate dietary intake and infectious diseases which severely affects health status, child growth and development, and resulted in malnutrition or even death. In other words, basic causes are the 'exogenous' determinants, which influence child nutrition through a set of proximate determinants – which can be viewed as 'endogenous' factors (Srinivasan et al. 2013).

Majority of the studies carried out in India and other developing countries have demonstrated that an array of household, individual, and contextual level factors have significant bearing on childhood undernutrition. Studies have shown that higher consumption expenditure in household lowers the risk of child malnutrition (Torlesse et al. 2003; Sari et al. 2010; Humphries 2017), while economic gradients viz. lack of resources and non-availability of food due to poverty and inequity contribute in maintaining vicious

cycle of poverty and malnutrition (Subramanian and Kawachi 2004; Subramanian et al. 2011; Gwatkin et al. 2007; Kumar et al. 2014; Harttgen et al. 2013). Strong and positive association of household sanitation on linear growth among children was observed by some studies (Spears 2013; Rah et al. 2015) Low body-mass index (BMI) among mothers could lead to intrauterine growth retardation of foetus and resulted into low birth-weight babies, who are, in turn, at high risk of malnutrition (Black et al. 2013; Rachmi et al., 2016; Geo-Horta et al., 2016).Significant positive effect of parental education on child growth was observed in low- and middle-income countries (Vollmer et al. 2016). Imai et al. (2014) argued that relative bargaining power of women in the household has statistically positive and significant effect on child's anthropometric outcomes. In a synthesis of literature, Cunningham et al. (2014) observed that although women's empowerment is generally linked with child anthropometry, findings are mixed. They have also argued that different women's empowerment domains may relate differently to child nutritional status and urged for future research. In a recent study, Menon et al. (2018) have observed that women's BMI, education, child's adequate diet, household asset, sanitation, age at marriage, antenatal care and household size together explains 71 percent of the observed differences in stunting prevalence across Indian districts. Khan and Mohanty (2018), using spatial econometric model, have concluded that mother's BMI and household's wealth are strong and significant predictors of all the three anthropometric outcomes, while women's educational attainment and breast feeding practices have significant association with stunting and underweight. Jose et al. (2018) have noted that about 83 percent of high stunting prevalence (higher than the national average) districts belong to eight states located in north-central (Uttar Pradesh, Bihar, Madhya Pradesh, and Jharkhand), western (Rajasthan, Gujarat, and Maharashtra), and eastern (Odisha) region. The study has also pointed out that women's undernutrition and poverty at the district-level have strong effects on child underweight. Thus, effects of endowments (or covariate *per se*) were found to be significant in India; however, they vary across space and nature of endowment.

Other studies addressed effect of macro-level determinants such as poverty, agricultural production, natural calamity, and intervention from governmental and non-governmental agencies etc. on child nutritional outcome. For example, Menon et al. (2008) found that State Hunger Index (comprised of calorie inadequacy, child underweight and child mortality) for Indian states has weak relationship with state per-capita income and economic growth. Heady et al. (2012) observed that relationship between nutritional outcomes and, economic and agricultural growth was found to be strong and positive

between 1992-2005 in some of the Indian states but very weakly in others. Bhagowalia et al. (2012) found that although household's livestock possession and irrigated agricultural land have positive significant effect on child nutrition, agricultural-child nutrition linkage in India found to be weak or unclear. Kumar et al. (2016) found that, in rural India, children exposed to a drought *in utero* or at birth have worse anthropometric outcome, and a higher probability of dying during infancy, which can be linked with household's financial distress and reduced income from agriculture during drought. Small-scale studies have found that though exposure to flood has negative significant influence on child wasting, it did not have any effect on stunting and moderate effect on underweight (Rodriguez-Llanes et al. 2016). Effect of Integrated Child Development Services (ICDS) was examined by various researchers (for example, Jain 2015; Kandpal 2011; Singh and Gupta 2016). These studies argued that there are significant gaps in programme implementation regarding coverage and regularity.

Further, some studies have also attempted to document disparities in returns to endowments (or strength of association *per se*) and their different dimensions, which potentially influence child nutritional outcome. For example, how quality of the governance, institutional strength in implementing public policies, reach of public services, bargaining power of the communities, and macro-level political economic context etc. can influence health and nutritional outcomes have been documented in these studies. In Indian context, disparity in institutional performance (measured in terms of quality of public services such as health, education and public distribution system) was observed between northern and north-central states, and southern states(Bajpai 2014; Barik and Thorat, 2015 & Sanneving et al., 2013). Besley and Burgess (2002) argued that states with higher community voice and political accountability have performed better in poverty reduction even in case of equivalent growth in income. Harriss and Kohli (2009) investigated influence of inter-state political and institutional factors on child undernutrition and differentiated between the politics of "clientelism" and "programmatic" politics. They argued that such political spectrum could impinge on worse and better child anthropometric outcomes respectively. Considerable differences in strength of association between observed covariates and nutritional outcomes across Indian states was also highlighted by Heady et al. (2012) and Menon et al. (2008).

Majority of literature reviewed above have either tried to identify some of the key observable characteristics (or covariates or endowments) that help in explaining variation

in child anthropometric outcomes in developing countries including India or have emphasized differential strength of relationship (or coefficients or returns to endowments) might also influence childhood nutritional outcomes. Only a few studies have attempted to quantify the contribution of socio-demographic, economic and ecological variables, individually or at the aggregate (covariate effects) and contribution of the strength of relationship (or coefficient effects) together in the South Asian context. To find out differentials in child undernutrition in Nepal and Bangladesh, studies highlighted that rural-urban disparities in child nutrition are primarily attributable to the difference in the levels of critical endowments such as household affluence, maternal as well as spouse's education, while differences in the strength of association (or returns to endowments) between determinants and nutrition outcomes are of relatively small in magnitude (Srinivasan et al. 2013). However, studies conducted in India found that large disparities in child nutritional outcomes across states are modestly explained by the differences in critical endowments, while returns to endowments or implementation of nutrition-relevant policies and programmes pay an important role in explaining such disparity (Cavatorta et al. 2015).

India and its states have witnessed substantial changes in endowments (covariates) as well as returns to endowments (coefficients) during past two decades. For example, head-count poverty ratio has declined from 46 percent during 1990s to 21percent during 2011-12, while female literacy rate has improved by 26.2 percentage-points (from 39.3 to 65.5 percent). Other developmental indicators such as infant mortality rate (IMR) and maternal mortality ratio (MMR) have decreased by 50 and 65 percent respectively during 1990 to 2012-13, while life expectancy at birth has improved by 7.9 years (from 60 year to 67.9 year) during 1990-94 to 2010-14.

Integrated Child Development Services (ICDS), which was the first ever vertical nutrition-centric programme initiated by the Government of India in 1975, was the fall out of National Policy for Children in 1974. In addition to the expanding coverage of ICDS, numerous policies and programmes which had direct bearing on nutrition had formulated and implemented during past 20 years in India and its states (for an excellent review, see Vir et al. 2014). It started with National Nutrition Policy (NNP), which was first implemented in 1993 and viewed undernutrition "as a part of a larger set of processes that produces and consumes agricultural commodities on farms, transforms them into food in the marketing sector, and sells the food to customers to satisfy nutritional, aesthetic, and

social needs" (India–MRHD 1993). The NNP was followed by the launch of the National Plan of Action on Nutrition in 1995 (India–MoWCD 1995), which identified the roles of 14 different sectors of government. State-level actions were expected to be undertaken, depending on resources allocated by states and their departments. However, the National Health Policy (NHP), 2002, did not provide adequate recognition to the problem of undernutrition and its correlation with morbidity and mortality in general, and infant mortality rate (IMR) or maternal mortality ratio (MMR), in particular (Chaudhary 2011). There were successive revision and implementation of various nutrition-centric policies such as control of anaemia among mothers and children, 1971, 1991, 2005-06. Further, in 2005, the MoWCD released the National Plan of Action for Children (NPAC), which was preceded by two earlier versions in 1974 and 1992. Policy for Elimination of Vitamin A Deficiency through the Vitamin A Supplementation Program, 1970, 1991, 2006; while National Guidelines on Infant and Young Child Feeding were implemented in 2004 and revised in 2006.

National Rural Health Mission (NRHM) was implemented in 2006. Schemes such as *Janani Suraksha Yojona* (JSY) was implemented for safe delivery and better maternal and child health out comes. Vir et al. (2014) have noted that despite the articulation of the NNP early on in India, the overall issue of undernutrition received very little attention in the post-NNP phase, except for increased attention to the supplementary feeding component of the ICDS Scheme. Many states have also come up with many state-specific schemes and emphasized multi sectoral nutrition intervention. For example, Maharashtra (*Rajmata Jijaju Mother-Child Health and Nutrition Mission*), Madhya Pradesh (*Atal Bal Mission*), and Karnataka have implemented nutrition missions and placed special emphasis on nutrition surveillance, district planning, and district-level monitoring with the goal of reducing undernutrition at a desirable rate.

The National Nutrition Mission launched in March 2018 by the Government of India places nutrition at the centre stage in the national development agenda. The said mission envisioned nutrition as a foundation for human development, particularly among the economically marginalized and socially excluded, by reducing susceptibility to morbidity, disability and mortality burden, which in turn enhances the cumulative lifelong learning capabilities and productivity during adulthood. National Health Policy (2017) has also envisaged importance of vigorous reduction of childhood undernutrition for economic development and overall well-being.

Among other important policies and programmes implemented during this period, which could have indirect effect on child nutrition areenactment of Mahatma Gandhi National Rural Employment Guarantee Act (2006) to ensure livelihood generation at the household level and National Food Security Act (2013) to bring sizeable number of socio-economically marginalized communities under the coverage of public distribution system (PDS). Being flagship programme of federal government, every state in India has implemented these policies with varying capacity and thus resulted differently across states.

The state of Bihar, located in the eastern part of India, has the highest prevalence of childhood undernutrition in India for several past decades. The proportion of childhood stunting has decline by 21 percent (or by 13 percentage-points) during last twenty years –implying an annual average decline of just one percent. Proportion of underweight has decreased by 30 percent (or by 19 percentage-points), while proportion of wasted children lessened only by 4.5 percent (or by one percentage point) during the same period. Currently the state of Bihar has 48 percent, 44 percent and 21 percent stunted, underweight and wasted children respectively (IIPS 1995; IIPS and ICF 2017). Numerically, about 9.2, 8.4, 4.0 million children in Bihar are stunted, underweight and wasted respectively. Notably, Bihar alone contributes around 15 percent of undernourished children in India. Out of 38 districts, 36 districts in Bihar are among 201 districts in India, where prevalence of stunting is the highest. More importantly, out of 100 districts, where prevalence of stunting is the highest, one-quarter belonging to Bihar. It was observed that malnutrition (maternal and child malnutrition together) continued to be the largest risk factor driving the most death and disability since 1990 (ICMR, PHFI and IHME 2017).The slender decline of child undernutrition during past twenty years plausibly indicates implementation of nutrition-centric programmes was inadequate in this state. Changes in the basic socio-demographic and economic indicators are given in Table 2. To note, the state of Bihar has undergone territorial changes following Bihar Reorganization Act (2000) (Government of India, 2000) and a separate state of Jharkhand was created from the districts of south Bihar.

Table 2: Some important demographic and health indicators of Bihar in 1991 and 2015-16

Demographic and Health Indicators	1991	2015-16
Population('000s)	8,63,38,853[a]	**10,40,99,452f**
Population Density (person/km^2)	685[a]	1102[h]
Sex ratio (female/1000 male)	907[a]	916[h]
% population aged 6+ that is literate	38.5[a]	63.8[h]
% female population aged 6+ that is literate	22.9[a]	53.3[h]
Child (0-6 years) sex ratio	953[a]	908[h]
life expectancy at birth (in years)	57.5[b]	68.1[i]
Infant mortality rate	69[c]	42[j]
Total fertility rate	4.4[a]	3.3[i]
Maternal mortality ratio	452[d]	165[j]
% mothers who had at least 3 ANC for last birth	30.7[e]	14.4[k]
% skilled attendance at delivery	19.0[e]	70.0[k]
% institutional delivery	13.0[e]	63.8[k]
Head count poverty ratio	45.9%[f]	43%[l]
Economic growth (GDP)	4.6[g]	10.3[m]
Singulate Mean age at marriage	18.0[e]	19.5[n]

Sources: [a] Census of India, 2001; [b] SRS 1988-92; [c] NIPCCD (National Institute of Public Cooperation and Child Development 2014; [d] SRS 2000, figure pertain to 1998; [e] NFHS 1 (1992-93); [f] World Bank 1993; g Economic and Political Weekly 2000;[h]Census 2011; [i] SRS 2016; [j] SRS 2014-16 (Jharkhand included); [k] NFHS 4 (2015-16); [l] World Bank 2016; [m] Economic survey in Bihar 2016-17; [n] IIPS 2016

In the present study, we intend to find out changing relative contribution of different factors, which affect child undernutrition, particularly stunting, during the last two decades in the state of Bihar. We contribute to the literature of childhood stunting by applying a recently developed advanced econometric method that allows a more nuanced approach to disentangle the effects of endowments (or covariates) and returns to endowments (or coefficients). The Quantile Regression-based Counterfactual Decomposition (QR-CD) methods allow the covariate and coefficient effects to vary along the entire distribution of nutrition outcomes. The study examines the changing contribution of the factors affecting child's HAZ scores in Bihar between 1992-93 and 2015-16. We would also like to enquire whether changing contribution of covariate and coefficient effects are different at the lower tail of the HAZ distribution, where severe stunting is likely to be prevalent, compared to the middle and higher tail during the study period. Such insights would be of utmost value in a policy atmosphere where targeting most vulnerable is considered imperative. Our primary hypothesis is that the period-wise changes across the HAZ distribution arises from covariate, rather than coefficient effects. We are, of course, particularly interested in disparities in the lower tail of the distribution.

A secondary hypothesis is that, even if a covariate or a coefficient dominates, there are important differences across the HAZ distribution in the relative contributions of covariate and coefficient effects to period-wise changes. The rationale behind application of QR-CD approach would be strengthened if the second hypothesis holds.

Materials and Methods

Data and Variables

Data for this study are obtained from the four rounds of NFHS, which were carried out between 1992-93 and 2015-2016, and conducted by International Institute for Population Sciences (IIPS), Mumbai, ORC Macro and Macro International Inc. NFHS is an Indian variant of Demographic and Health Surveys (DHS) which collects and disseminate information on fertility, mortality, family planning, and important aspects of reproductive health, nutrition and healthcare based on a nationally representative household surveys for 90 countries. The data set is available in the public domain subject to a prescribed registration and approval process. Requisite permission in accessing and usage of data set was obtained from the DHSPROGRAM archive (www.dhsprogram.com). During 1992-93, in undivided Bihar, the survey collected information from 88,562 households and interviewed 89,777 ever-married women (in the age group 13-49) in all the states and union territories in India. In addition, the survey collected information on indicators pertaining to maternal and child health care of 48,959 children born during the four years preceding the survey. It is imperative to note that although the state of Bihar was reorganized in 2000, we have culled out the data of second round (1998-99) for the districts representing present-day Bihar using district codes to compare with the third round (2005-06). During 1998-99, a total of 89,199 ever-married women were interviewed and data on 32,393 children born during three years preceding the survey were collected residing in 91,196 households. Information of 124,385 ever-married women, 51,555 children born during three years preceding the survey from 109,041 households were collected in 2005-06. For Bihar, the state-level sample of NFHS-4 comprises of 7,464 ever-married women, 3,679 children born during five years preceding the survey. NFHS also collected information on various socio-demographic and economic indicators on mother, child and households.

Height-for-age Z scores (HAZ) has been used as an indicator of child nutrition. Stunting

has been defined as HAZ less than minus two standard deviation (-2SD) of the WHO International Reference Standard (WHO 2010). Stunting is considered as a standard indicator of child undernutrition and health status as it reflects chronic undernutrition caused by long-term deprivation. It may be noted that we had to consider the children of age group 0 – 36 months for comparing childhood stunting over the four rounds of NFHS. Out of 2,419 children (0-36 months of age) complete information on HAZ score was available for 1,821 children in the first round of NFHS. In the last three rounds, out of 2,948, 1,368 and 2,294 children of the said age group, complete information on HAZ score was available for 2029, 1,188, and 2,184 children respectively. HAZ has been used as outcome variable in all our regression models. Although we started with reduced form of conceptual framework of UNICEF as mentioned earlier and previous literature, we need to further refined our covariate set since decomposition of observed HAZ differences into covariate and coefficient effects require well-specified regressions models which should include key relevant covariates (Cavatorta et al. 2015). Our final regression models include following covariates representing child, maternal, household and spatial characteristics.

We include current age of the child (in months), square of the age, sex of the child (male/female), size of the child at birth (more than average, average, small) as a proxy for birth weight, initiation of early breastfeeding (no, yes), and number of siblings as child characteristics. Receipt of any services from ICDS during 12 months preceding the survey was included while comparing NFHS 3 and 4 because such information was available for these rounds. Maternal characteristics comprises age of the mother at first birth (in years), maternal education, work status (working/not-working), degree of media exposure (additive index of three binary variables – reading newspaper at least one a week, watching television at least once a week, listening radio at least once a week). Institutional delivery (no, yes) was considered as a proxy of contact with health personnel by mother. Maternal height and maternal BMI, and anaemia (no, mild, moderate and severe) were included for analyses of second, third and fourth rounds of NFHS because such information were not collected in the first round. Similarly, normalized factor scores of variables indicating household decision making, freedom of movement etc. were incorporated as maternal level variable in second, third and fourth rounds of NFHS (see endnote 1).

Household wealth index, religious category (Hindu, Muslims/others), membership to social group (scheduled castes (SC), scheduled tribes (ST), Others) were incorporated as

household level variables. It may be mentioned here that instead of household consumption expenditure and income, household wealth index as calculated by DHS is based on possession of household durable assets, availability of safe drinking water and sanitation, and hand holding. For construction of index, the variables were first broken into sets of dichotomous variables and indicator weights are assigned using PCA as suggested by Filmer and Pritchett (2001). In addition to the variables representing child, maternal and household characteristics, place of residence (rural/urban) was also included in the regression models.

Econometric analysis

To assess the differentials in HAZ scores over the study period, first, the distribution of the HAZ scores of Bihar's children were estimated separately in each survey period using kernel smoothing techniques. From the kernel density estimates of HAZ scores, period-wise differentials were computed at each quantile and the raw difference in HAZ scores across distribution was provided.

One of the primary objectives of the present study was to decompose the period-wise differences in child's HAZ scores in covariate effect, i.e. the differences in HAZ scores arising out of the differences in levels of characteristics or composition of the children in the survey-period; and the coefficient effect, i.e. the differences in HAZ scores were caused by the differences in the returns to those characteristics or structure, across the entire HAZ distribution. It is worth mentioning that majority of the earlier studies have largely modelled the nutrition outcomes (such as HAZ scores) at the mean/median level by using ordinary least square (OLS), or the prevalence of stunting, underweight or wasting by using log it or probit regression approaches. The problem with these approaches is related to the fact that changes in covariates and the effect of covariates is constrained to be same along the entire distribution of outcome variable. Further, decompositions based on OLS would apply only to the period-wise mean differences in HAZ scores; however, not to other distributional characteristics, such as quantiles.

In the present study, we have used a quantile regression (QR) approach to investigate how child's HAZ outcomes are related to individual, maternal, household and spatial characteristics over the years. To note, QR model allowed effects of covariates to vary across the entire distribution of child's HAZ scores. QR model also permitted us to understand how the effects of different covariates in the lowest quantile of HAZ scores

may vary from those in other quantiles. For instance, the association between increase in women's workforce participation may be very different in the lower and the higher tails of HAZ scores. Simple segmentation of HAZ into different subsets, for instance, deciles, and run OLS on these segments separately is not advisable since it introduces selectivity bias (Koenker and Hallock 2001). Logit/probit type models in explaining stunting status, though could be an option, these models, first, constraint the effect of explanatory variables to be same across the distribution of the outcomes, and secondly, these models sacrifice statistical information in grouping continuously distributed variables (such as HAZ) into categories. QR models offer the most robust approach to flexibly model the shifts in HAZ distribution associated with changes to covariates (Srinivasan et al. 2013).

Koenker and Bassett (1978) developed QR method. But the limitation of this model is that it can estimate only the conditional quantile effects of changes in covariates. In the present study, we were interested to estimate the effect of policy intervention, for instance, mother's education in a population of individuals with different characteristics (i.e. unconditional effects) rather than in the impact for sub-groups with specific values of covariates (i.e. conditional effects). We have employed unconditional Recentred Influence Function (RIF) Quantile Regression (RIFREG) developed by Firpo et al. (2009) to assess the unconditional quantile effects of changes in covariates. The method consists of employing a regression of a transformation – the recentered influence function (RIF) – of the dependent variable (Y) on the explanatory variables (X). Advantage of this method is that it allows estimating the contribution of each explanatory variable for the components of the HAZ decomposition and thus extends the Blinder and Oaxaca decomposition to other distributional statistics than the mean (Fortin et al., 2011).

To estimate the unconditional quantile regression, first we have derived the RIF of the response variable (HAZ score, in our case). The RIF for the q_{th} quantile is given by the following expression:

$$RIF\,(Y, q_\tau) = q_\tau + \frac{\tau - I(Y \le q_\tau)}{f_Y(q_\tau)} \quad (1)$$

Where $f_Y(q_\tau)$ is the marginal density function of Y at the point q_τ estimated by kernel methods; q_τ is the sample quantile; $I(Y \leqslant q_\tau)$ is an indicator function indicating whether the value of the outcome variable is below q_τ. RIF provides a linear approximation to a non-linear functional ($v(Y)$) (such as median) of the Y distribution and thus allow computing partial effects for single covariates (Firpo et al. 2009). Firpo et al. (2009) have also shown

that by estimating OLS of the new dependent transformed variable on the covariates (X), the RIF quantile regression may be implemented. In our case, considering two periods (t_1 and t_2), RIF regressions for HAZ score in both periods are estimated as:

$$E[RIF(Y_{i\in g};q_\tau) \mid X_{i\in g}] = X_{i,g}\beta_{\tau,g} g = t_1, t_2 \qquad (2)$$

Coefficients $\beta_{\tau,g}$ represents the approximate marginal effects of the predictor variables on the HAZ quantile q_τ for children age 0-35 months in periods $g = t_1, t_2$.

Once we estimate the parameter $\beta_{\tau,g}$ for each year in our sample, we applied a Oaxaca-Blinder decomposition using RIF unconditional quantile estimates for any given quantile by following equation-

$$\widehat{q_\tau}(HAZ_{t\_2}) - \widehat{q_\tau}(HAZ_{t\_1}) = \left|X_{t\_2}(\widehat{\beta_C} - \widehat{\beta_{t\_2}}) + \bar{R}^{\widehat{Coeff}}\right| + \left|(X_{t\_1}\widehat{\beta_{t\_1}} - X_{t\_2}\widehat{\beta_C}) + \bar{R}^{\widehat{Cov}}\right|$$

Where t_2 is the final year and t_1 is the initial year. In our application, we set up the initial years as 1992-93, 1998-99, and 2005-06 and the final years as 1998-99, 2005-06, and 2015-16 respectively. As typical in Oaxaca-Blinder decomposition, the term $\widehat{q_\tau}(HAZ_{t\_2}) - \widehat{q_\tau}(HAZ_{t\_1})$ represents the raw differences in t_2 and t_1 HAZ scores at the τth quantile and X represents the covariate averages. The term $\overline{X_{t\_2}}(\widehat{\beta_C} - \widehat{\beta_R})$ refers to the coefficient effect and $(X_{t\_1}\widehat{\beta_{t\_1}} - X_{t\_2}\widehat{\beta_C})$ represents the differences between t_2 and t_1 scores attributable to the differences in characteristics of endowments and hence represents the covariate effect. $\bar{R}^{\widehat{Coeff}}$ and $\bar{R}^{\widehat{Cov}}$ are errors related to the estimation of coefficient and covariate effects.

To note, we have tried our best to minimize endogeneity problems, and is consistent with previous literature (Srinivasan et al. 2013; Cavatorta et al. 2015), though endogeneity could persist and can lead to difficulties in parameter interpretation. However, as O'Donnell et al. (2009) noted that objective of the counterfactual decomposition is not solely causal identification, but to explain variations in child's HAZ and decide the relative values of covariate and coefficient effects. One should cautiously interpret the coefficients of variables that are potentially endogenous; however, the decomposition itself remains valid.

Results

Descriptive statistics

Table 3 revealed percentile of HAZ scores after carrying out kernel smoothing for the four successive rounds of NFHS. HAZ scores of first and second rounds of NFHS are not strictly comparable because of territorial changes as mentioned earlier.The HAZ values were also compared with the HAZ values of overall India. Without loss of generality, one can note that absolute increase in overall HAZ scores was the highest between second and third rounds of NFHS (i.e. between 1998-99 and 2005-06) followed by third and fourth rounds i.e. between 2005-06 and 2015-16. Child's HAZ scores largely remained at the same level between 1992-93 and 1998-99. Absolute increase of child's HAZ scores was remarkable for the bottom quantiles between 1998-99 and 2005-06 nationally and in Bihar, in particular. In Bihar, there was even decline of HAZ scores at the top quantile. However, between 2005-06 and 2015-16, absolute increase in the HAZ scores was observed in the top quantile nationally as well as in Bihar. In other words, nutritionally better-off children gained more compared to the severely undernourished children and such inequity persists.

Table 3: Percentile of HAZ score in NFHS 1, NFHS 2, NFHS 3 and NFHS 4 in Bihar and India

Bihar	NFHS 1	NFHS 2	NFHS 3	NFHS 4	Absolute increase btw NFHS 1 and NFHS 2	Absolute increase btw NFHS 2 and NFHS 3	Absolute increase btw NFHS 3 and NFHS 4
10	-4.92	-4.89	-4.03	-3.74	0.03	0.86	0.29
25	-3.85	-3.75	-2.95	-2.81	0.10	0.80	0.14
50	-2.49	-2.46	-1.93	-1.80	0.03	0.54	0.13
75	-1.09	-1.08	-0.84	-0.61	0.01	0.24	0.23
90	0.12	0.36	0.19	0.65	0.24	-0.17	0.46
Overall	-2.36	-2.28	-1.89	-1.63	0.07	0.40	0.26
India	**NFHS 1**	**NFHS 2**	**NFHS 3**	**NFHS 4**	**Absolute increase btw NFHS 1 and NFHS 2**	**Absolute increase btw NFHS 2 and NFHS 3**	**Absolute increase btw NFHS 3 and NFHS 4**
10	-4.26	-4.19	-3.72	-3.49	0.07	0.47	0.24
25	-3.16	-3.10	-2.70	-2.48	0.06	0.40	0.22
50	-2.00	-1.96	-1.63	-1.43	0.04	0.33	0.20
75	-0.85	-0.82	-0.51	-0.27	0.03	0.31	0.24
90	0.32	0.31	0.64	0.99	-0.01	0.33	0.35
Overall	-1.94	-1.91	-1.55	-1.30	0.03	0.36	0.25

Source: Computed by the authors from unit-level data of NFHS rounds

Table 4 depicted socio-demographic and economic characteristics of the samples in four rounds of NFHS. Mean age of the children was found to be somewhat higher in the third and fourth rounds compared to the previous rounds. Although proportion of girls in the sample was found to be marginally higher in the first round, proportion of boys was found to be higher in all other rounds. It has also been observed that the proportions of small as well as more than average size of babies were more in the third round compared to the other rounds. Initiation of early breastfeeding (within one hour of birth) has improved dramatically – more than 14-times – between 2005-06 and 2015-16.

Although number of siblings of the index child has been declined in the recent past, it still indicates high fertility in the state of Bihar. Benefit received from ICDS services increased by more than 7-fold between 2005-06 and 2015-16. Similar is the case for institutional delivery of mothers. Mothers in the sample are more likely to bear their first child after age of 20 years. It may also be noted that BMI of mothers has improved between 2005-06 and 2015-16, while rate of decline of anaemia was substantial between 1998-99 and 2005-06 compared to 2005-06 and 2015-16. As expected, no significant change in mother's height has been observed during the study period. Mean years of schooling has improved marginally during past 20 years or so. One may note that though workforce participation rate among mothers was consistent around 20 percent during 1992-93 and 2005-06, it has declined by half between 2005-06 and 2015-16. Degree of media exposure as computed by regular exposure to newspaper, TV and radio was found to have increased marginally over the years. As far as socio-religious affiliation is concern, majority of the respondents in the sample was Hindu and non-SC/ST. It is surprising to find out that proportion of economically marginalized segment of the population has increased not only between 1998-99 and 2005-06 but also in between 2005-06 and 2015-16, in spite of the state's higher economic growth during these periods, particularly after 2005. This possibly indicates that the indicators used in NFHS, which represents household wealth are not robust enough to capture the consumption pattern of households in the recent past. Being the least urbanised state of the country(among the major states), overwhelming proportion of the sample belong to the rural areas of Bihar.

Table 4: Sample Characteristics of Child age 0-35 months according to Background characteristics in Bihar

	NFHS 1	NFHS 2	NFHS 3	NFHS 4
Child HAZ (Mean)	**-2.36 (0.05)**	**-2.29 (0.05)**	**-1.89 (0.05)**	**-1.63 (0.04)**
Age of Child in Month (mean)	16.26	16.35	17.45	17.71
Age2 (mean)	357.20	378.48	405.54	414.71
Child Sex				
Male	49.5	52.1	53.45	51.8
Female	50.5	47.9	46.55	48.2
Birth Size				
Normal	71.9	69.5	47.23	69.34
Average and above	11.0	14.5	31.5	17.42
Small	17.1	16.1	21.27	13.24
Early Breastfeeding				
No	98.2	95.6	97.39	63.39
Yes	1.8	4.4	2.61	36.61
No. of Sibling (mean)	1.88	1.96	2.06	1.62
Benefitted ICDS services				
No	–	–	92.06	39.04
Yes	–	–	7.94	60.96
Mother's Characteristics				
Institutional Delivery				
No	87.6	84.9	77.98	30.84
Yes	12.4	15.1	22.02	69.16
Age of mother at first birth (mean)	**18.55**	18.28	18.51	20.42
BMI of mother (mean)	**–**	19.34	19.30	20.06
Mother's anaemia				
No	–	71.09	80.08	83.1
Yes	–	28.91	19.2	16.9
Mother's height (mean)	–	149.6	150.01	149.5
Mother's Education (mean)	2.02	2.01	2.93	3.98
Working mother				
No	78.1	80.6	79.9	89.20
Yes	21.9	19.7	20.1	10.20
Media exposure	0.47 (0-3)	0.43 (0-3)	0.60 (0-3)	1.31(0-3)
Religion				
Hindu	78.2	80.4	81.57	79.24
Muslim/Others	21.8	17.6	18.43	20.76
Caste				
SC	9.3	23.72	19.6	19.9

ST	8.5	1.3	0.9	3.7
Others	82.2	75.0	79.6	76.4
Wealth index				
Poorest	20.5	18.2	31.7	55.5
Poorer	25.9	20.4	33.3	24.8
Middle	16.9	23.3	16.6	11.6
Richer	13.8	23.2	12.5	6.3
Richest	22.9	14.9	5.8	1.8
Place of residence				
Urban	13.1	6.2	11.1	10.8
Rural	86.9	93.8	88.9	89.2
Total	1821	2029	1188	2184

Source: Computed by the authors from unit-level data of NFHS rounds

Table 5 describes mean HAZ scores according to various socio-demographic and economic characteristics. Girls were less likely to be stunted across periods. As expected, small size children were more likely to have lesser HAZ scores compared to average or above average children. Although children who breastfed early after birth were higher than mean HAZ during 1992-93, but such differences diminished in the recent period. It seems that children with poorer HAZ outcomes were more likely to receive any benefit from ICDS services. Better nourished mothers were more likely to have children with higher HAZ scores compared to undernourished mothers. Anaemic mothers were more likely to have children with lower HAZ compared to non-anaemic mother during second and third round; however, such association weakened in the recent past. Positive association of mother's completed years of schooling and child's HAZ scores was observed throughout the study period. Working mothers were more likely to have lower HAZ children during first two rounds of NFHS; however, the direction of association became opposite during last two rounds. Although differences of child's HAZ scores across religion was marginal, caste differentials in child's HAZ scores were observed, particularly during last two rounds of NFHS. As expected, children belong to affluent households were more likely to have higher HAZ scores compared to their poorer counterparts. Urban children were found to be have better HAZ scores compared to their rural counterparts.

Table 5: Sample mean HAZ score by background characteristics in Bihar

Background Characteristics	NFHS 1	NFHS 2	NFHS 3	NFHS 4
Age of Child	–	–	–	–
Age2	–	–	–	–
Child Sex				
Male	-2.480	-2.316	-1.908	-1.715
Female	-2.234	-2.252	-1.860	-1.534
Birth Size				
Normal	-2.399	-2.245	-1.853	-1.647
Average and above	-2.117	-2.205	-1.815	-1.346
Small	-2.334	-2.524	-2.062	-1.865
Early Breastfeeding				
No	-2.366	-2.237	-1.878	-1.574
Yes	-1.743	-2.184	-1.858	-1.574
No. of Sibling	–	–	–	–
Benefitted ICDS services				
No	–	–	-1.870	-1.432
yes	–	–	-2.111	-1.744
Mother's Characteristics				
Institutional Delivery				
No	-2.440	-2.340	-2.021	-1.729
Yes	-1.874	-1.967	-1.534	-1.589
Age of mother at first birth				
less than 18	-2.337	-2.403	-2.042	-1.757
18 to 24	-2.437	-2.119	-1.733	-1.620
25 and above	-1.710	-2.281	-1.249	-1.319
BMI of mother				
< 18.5	–	-2.484	-2.174	-1.777
18.5 to 23.5	–	-2.185	-1.768	-1.606
above 23.5		-1.891	-0.938	-1.325
Mother's anaemia				
No	–	-2.228	-1.741	-1.652
Yes	–	-2.426	-1.930	-1.617
Mother's height				
Mother's Education				
Illiterate	-2.493	-2.349	-2.123	-1.801
1-5	-2.373	-2.426	-1.755	-1.669
6 and above	-1.787	-1.982	-1.355	-1.356
Working mother	-2.228	-2.273	-2.251	-1.786

Empowerment	–	–	–	–
Media exposure	–	–	–	–
Religion				
Hindu	-2.367	-2.278	-1.858	-1.616
Muslim/Others	-2.305	-2.315	-1.999	-1.687
Caste				
SC	-2.565	-2.372	-2.431	-1.754
ST	-2.216	-2.147	-2.115	-1.643
Others	-2.341	-2.259	-1.765	-1.373
Wealth index				
Poorest	-2.590	-2.215	-2.168	-1.775
Poorer	-2.590	-2.238	-2.147	-1.659
Middle	-2.667	-2.327	-1.815	-1.411
Richer	-2.452	-2.316	-1.515	-0.951
Richest	-2.355	-2.085	-1.052	-0.709
Place of residence				
Urban	-2.085	-2.279	-1.624	-1.357
Rural	-2.422	-2.285	-1.997	-1.663

Source: Computed by the authors from unit-level data of NFHS rounds

Unconditional RIF quantile regression results

The estimates derived from unconditional RIF quantile regressions (QR) separately for all the survey periods were shown in Tables 6-8. Simple OLS regression analyses were also carried out and results given in the Appendix Tables A1 and A2. Our findings suggest that among demographic characteristics, age and sex of the child, size of the baby at birth, initiation of early breastfeeding and number of siblings – all have significant association with child's HAZ outcomes; however, the degree and nature of relationship vary across quantile and period of survey. We observed that child age has negative and significant influence with child's HAZ scores across quantiles. If we move from the lower tail to the upper tail, this effect increases, indicating that children starting with better nutritional status stand to lose more through faltering as they grow older. Although such observation holds for second and third rounds of NFHS, said observation confirms up to 75 percent quantile for first and fourth rounds of NFHS. Girls were found to have significantly better HAZ outcomes compared to boys across quantiles; however, strength of association varies across quantile and period of survey. Children with smaller birth size and belong to lowest 10 percent quantile were significantly more likely to have lower HAZ scores during first

round of NFHS, while smaller birth size children belong to 75 percent quantile were shown to have recovered from growth faltering according to the second round of survey. In third and fourth rounds, size of the birth of children did not have any significant effect on HAZ scores. Early initiation of breastfeeding found to have positive and significant effect on HAZ scores in NFHS 1, while such effect weakened during the last three rounds. Higher sibling size has negative significant influence on child's HAZ scores, particularly those belong to the lower quantiles during third and fourth rounds of survey. Receipt of any benefit from ICDS found to be negatively associated with child's HAZ scores and such effect increases when we go from lower tail to higher tail of the HAZ distribution during the latest round of survey.

Table 6: Unconditional Re-centred Influence Function (RIF) quantile regression results for NFHS 1 (1992-93)) in Bihar

	NFHS 1				
	10	25	50	75	90
Age of Child	-0.073***	-0.103***	-0.171***	-0.173***	-0.086***
Age2	0.001***	0.001***	0.003***	0.003***	0.001***
Female	0.234***	0.306***	0.344***	0.367***	0.578***
Birth Size					
Normal					
Average and above	0.054	-0.102	0.077	0.485***	0.332***
Small	-0.185***	-0.003	0.066	0.002	0.088
Early Breastfeeding (Yes)	0.82***	1.063***	0.447***	0.422***	-0.242
No. of Sibling	-0.003	0.007	-0.017*	-0.013	0.036**
Mother's Characteristics					
Institutional Delivery (yes)	0.398***	0.888***	0.398***	0.135**	-0.192**
Age of mother at first birth	-0.021***	0.005	-0.004	0.02***	0.051***
Mother's Education	0.019***	0.003	0.025***	0.03***	0.025**
Working mother	-0.228***	-0.551***	-0.371***	-0.24***	-0.357***
Media exposure	-0.016	0.011	0.157***	0.172***	0.241***
Religion					
Hindu					
Muslim/Others	-0.115***	-0.141***	-0.073*	-0.115***	0.075
Caste					
SC					
ST	0.48***	1.018***	0.360***	0.179**	-0.435***
Others	0.355***	0.765***	0.168***	-0.095	-0.533***
Wealth index	-0.004	0.137***	0.086***	0.053***	0.193***

Place of residence					
Urban					
Rural	0.241***	0.523***	0.027	-0.282***	-0.131
Constant	-4.321***	-3.87***	-1.037***	0.336**	0.426
R square	0.0423	0.0938	0.1361	0.1318	0.0456
Adj. R square	0.0414	0.0929	0.1352	0.1310	0.0446

****p<0.001; **p<0.01; *p<0.05, Source:* *Computed by the authors from unit-level data of NFHS 1*

Table 7: Unconditional Re-centred Influence Function (RIF) quantile regression results for NFHS 2 (1998-99) in Bihar

	NFHS 2				
	10	25	50	75	90
Age of Child	0.025	-0.104*	-0.237***	-0.303***	-0.419**
Age2	-0.003	0.000	0.004**	0.006***	0.010*
Female	0.442	0.625**	1.089***	0.412	0.480
Birth Size					
Normal					
Average and above	0.218	0.580	0.833*	0.944	2.332
Small	-0.505	0.416	0.476	1.127*	-0.291
Early Breastfeeding (Yes)	-1.281	-1.137	-0.117	-0.064	-2.467**
No. of Sibling	-0.089	-0.014	0.109	0.146	0.158
Mother's Characteristics					
Institutional Delivery (yes)	0.472	1.680***	2.231**	1.943	4.823
Age of mother at first birth	0.061	0.018	0.045	0.000	-0.006
BMI of mother	0.000	0.000	0.001***	0.001	0.003
Mother's anaemia					
Yes	0.258	-0.274	-0.998***	-1.256***	-2.049**
Mother's height	0.006**	0.003	0.005*	0.006*	-0.003
Mother's Education	-0.003	-0.047	-0.100	-0.187**	-0.213
Working mother	-1.160**	-1.520***	-0.868	-0.331	0.354
Empowerment	-0.096	0.019	-0.252**	-0.193	-0.316
media exposure	0.020	-0.247	-0.341	-0.394	-1.629*
Religion					
Hindu					
Muslim/Others	-0.468	0.481	0.912	0.802	2.375
Caste					
SC					
ST	0.126	-1.027	-0.097	0.325	0.369
Others	0.030	-0.637*	-0.100	-0.249	0.407

Wealth index	-0.028	-0.192	-0.053	-0.008	-0.086
Place of residence					
Urban					
Rural	-1.262*	0.304	1.695*	0.144	-1.302
Constant	-11.677***	-6.495	-12.044***	-10.286*	2.286
R square	0.211	0.247	0.3207	0.2267	0.174
Adj. R square	0.127	0.167	0.2482	0.1443	0.0859

****p < 0.001; **p < 0.01; *p < 0.05;* Source: Computed by the authors from unit-level data of NFHS 2*

Table 8: Unconditional Re-centred Influence Function (RIF) quantile regression results for NFHS 3 (2005-06) and NFHS 4 (2015-16) in Bihar

	NFHS 3					NFHS 4				
	10	25	50	75	90	10	25	50	75	90
Age of Child	-0.021	-0.100***	-0.148***	-0.153***	-0.215***	-0.095***	-0.106***	-0.171***	-0.197***	-0.124***
Age2	-0.001	0.001*	0.002***	0.002**	0.004***	0.002***	0.002***	0.003***	0.004***	0.002**
Female	0.172	-0.020	0.024	0.139	0.177	0.355***	0.237**	0.167*	0.065	0.193
Birth Size										
Normal										
Average and above	0.064	0.037	0.089	0.276	-0.007	0.109	0.142	0.189	0.237	0.226
Small	-0.227	-0.102	-0.187	-0.109	-0.106	-0.256	-0.245	-0.203	0.166	0.432
Early Breastfeeding (yes)	0.538	0.715**	0.326	0.449	0.102	0.105	-0.017	0.05	0.038	0.047
No. of Sibling	-0.112**	-0.075**	-0.052*	-0.013	0.012	-0.117**	-0.039	0.025	-0.018	-0.036
Benefitted ICDS services (yes)	-0.187	-0.15	0.156	0.158	0.362	-0.069	-0.245**	-0.259**	-0.183	-0.619***
Mother's Characteristics										
Institutional Delivery	-0.206	-0.224	-0.085	-0.016	-0.235	0.09	0.224*	-0.098	-0.235	-0.041
Age of mother at first birth	-0.022	-0.009	0.009	-0.017	0.004	0.000	0.000	0.005	0.009	0.066**
BMI of mother	0.001*	0.001***	0.001***	0.001***	0.001***	0.001***	0.000***	0.001***	0.000	0.000
Mother's anaemia										
Yes	-0.275	-0.292**	-0.120	-0.171	-0.088	-0.200	0.007	0.118	-0.047	-0.027
Mother's height	0.004**	0.006***	0.005***	0.005***	0.008***	0.006***	0.004***	0.006***	0.006***	0.005***
Mother's Education	0.017	0.019	0.025	0.045	0.014	0.025	0.014	0.015	-0.033*	0.001
Working mother	0.283	0.199	-0.125	-0.084	0.380*	-0.241	-0.316*	-0.051	-0.210	0.231
Empowerment	-0.097	-0.073	0.011	0.059	0.011	0.003	0.007	0.036	0.037	0.081
media exposure	0.090	0.148	0.131	-0.037	-0.162	-0.033	-0.019	-0.005	0.034	0.001
Religion										
Hindu										

Muslim/Others	0.187	-0.015	0.108	0.286	-0.290	0.035	-0.099	-0.118	-0.407**	-0.410
Caste										
SC										
ST	1.489***	0.427	0.150	-0.094	-0.429	0.249	0.023	0.087	-0.065	-0.029
Others	0.069	0.259	0.319**	0.529***	0.309*	0.305	0.146	0.369**	0.160	-0.041
Wealth index	0.000**	0.000**	0.000**	0.000**	0.000	0.000	0.000	0.000**	0.000**	0.000
Place of residence										
Urban										
Rural	0.207	0.023	0.006	0.265	0.085	-0.177	-0.089	-0.132	-0.173	0.101
Constant	-9.868***	-12.311***	-9.598***	-9.526***	-11.783***	-12.537***	-8.243***	-9.426***	-7.241***	-6.973***
R square	0.090	0.171	0.209	0.176	0.124	0.061	0.094	0.177	0.115	0.062
Adj. R square	0.072	0.155	0.193	0.159	0.107	0.049	0.083	0.167	0.104	0.050

****p<0.001; **p<0.01; *p<0.05;** *Source: Computed by the authors from unit-level data of NFHS 3 and NFHS 4*

As found in case of child characteristics, a number of maternal characteristics were also found to have profound association with child's HAZ outcomes. Institutional delivery of mother, which is an important indicator for contact with health personnel, has positive and significant influence on child's HAZ scores across quantiles, particularly in the lower and middle quantile in varying degree except during the third round of the survey. Significant positive effect of higher age of mother's first birth on child's HAZ outcomes was found in the higher quantiles during the first and the latest rounds of survey, but not in other rounds. Notably, significant positive influence of maternal education on child's HAZ scores decreased with rounds. Working mothers are significantly more likely to have children with lower HAZ scores compared to their non-working counterparts across quantiles during first round of the survey; however, such association holds only in lower quantiles during second and fourth rounds. Mother's exposure to any mass media found to have positive significant influence in the middle and upper quantile of HAZ scores during the first round, though weakened in other rounds. Maternal height and BMI both have small but significant effect in enhancing child's HAZ scores across quantiles, such association strengthen during the last two rounds of survey.

Degree of maternal empowerment found to have positive significant effect on child's HAZ scores during second round of the survey; however, such relationship weakened during last two rounds.

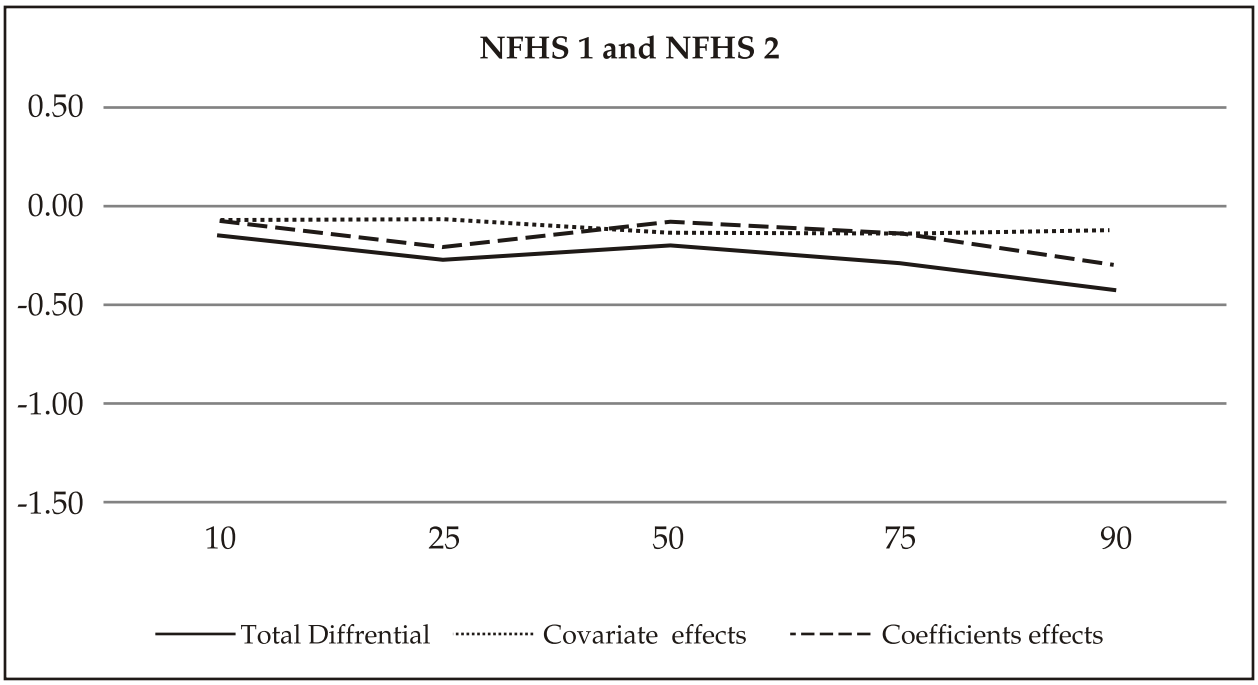
Among household characteristics, religion and caste affiliations and household wealth were found to have significant association with child's HAZ scores, though strength of relationship varies across quantiles and survey period. Differentials with respect to

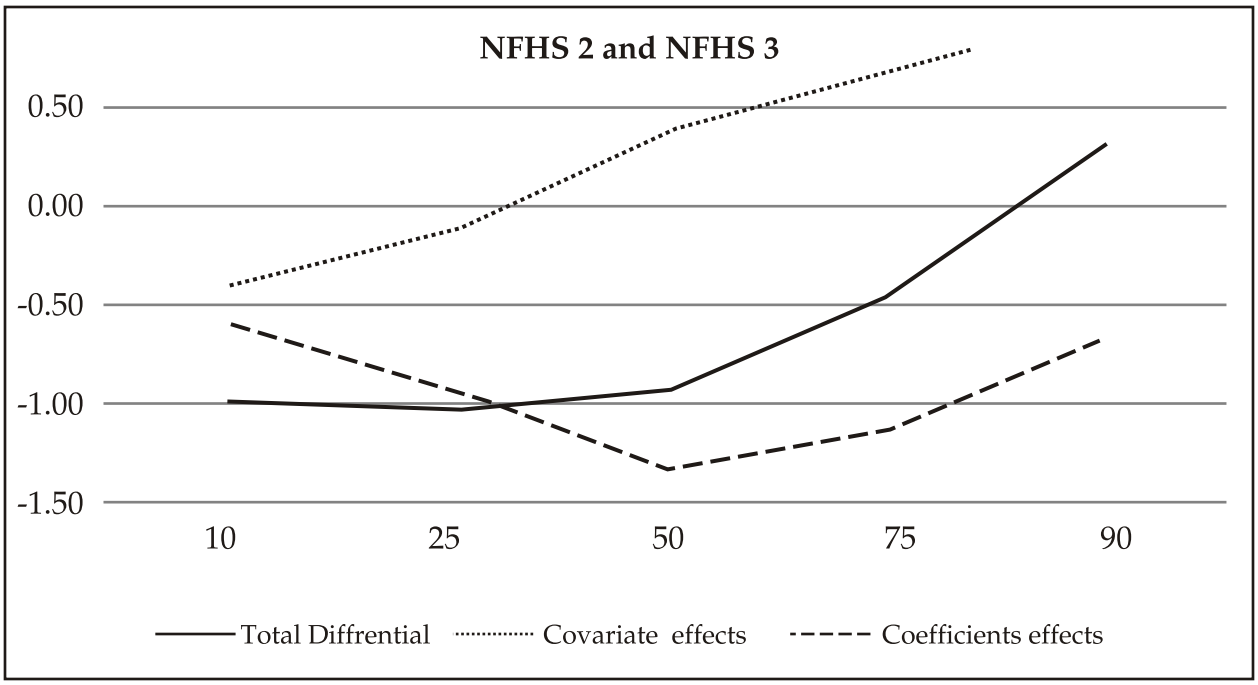
religion and caste were found in child's HAZ scores during first round of the survey; however, the relationship weakened thereafter. Significant positive influence of household affluence on child's HAZ outcomes was found during first and third round of survey and observation suggests the effect is higher among those belonging to higher quantiles. The results also revealed that rural-urban differentials in child's HAZ outcomes diminished over the period in Bihar.

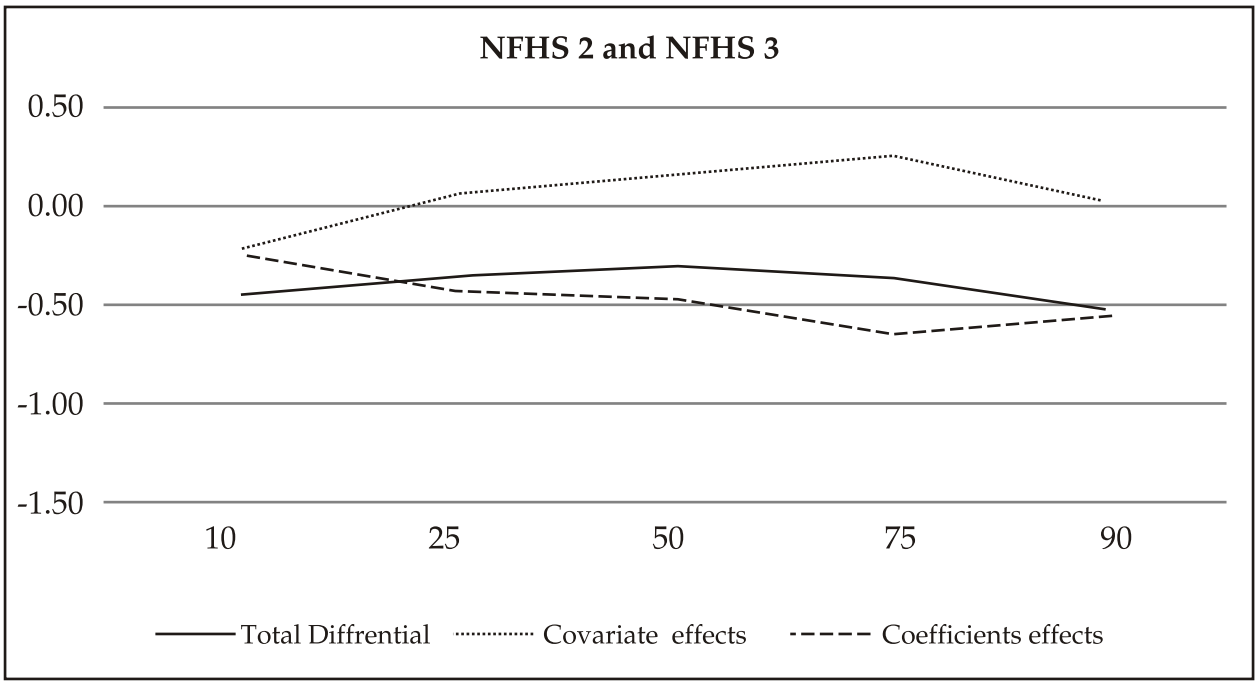
Quartile regression Oaxaca Blinder counterfactual decomposition (QR-CD)

Figures 1 shows the cumulative distribution functions for child's HAZ scores during the survey periods for Bihar. These figures also depict in aggregate the results of QR-CD analysis. The estimated QR-CD results at the aggregate level of child, maternal, household and spatial characteristics have presented in the Tables 9-11, while a detailed break-down of contribution of these characteristics have given in the Tables 12-14. OLS regression estimates and subsequent regression-decompositions from these estimates of various periods were given in Appendix Tables A1-A5.

Figure 1







Source: Computed by the authors from unit-level data of NFHS rounds

Before interpreting the results, it should be kept in mind that the negative sign of the observed raw gap in HAZ scores between two successive periods reflects the fact that raw HAZ scores of the later period was lower than the previous period in all quantiles, except at the highest quantile between second and third rounds of NFHS. Additionally, it must also be kept in mind that the direction of effect of contribution of characteristics as shown

in the Tables 9-14 – negative figures imply a contribution to *increase* in the disparity in HAZ scores over time, while positive figures show a contribution to *diminish* it. A careful look to these tables reveals some pattern of covariate effects and coefficient effects across quantiles and over the periods.

Table 9: Oaxaca Blinder decomposition of HAZ scores of NFHS 1 and NFHS 2 in Bihar

	10	25	50	75	90
NFHS 1 HAZ score	-4.935***	-3.870***	-2.511***	-1.160***	0.098
NFHS 2 HAZ score	-4.812***	-3.659***	-2.339***	-0.930***	0.455***
Observed Raw gap in HAZ scores	**-0.124**	**-0.211*** **	**-0.172****	**-0.230****	**-0.358*** **
Covariate effect	-0.059*	-0.050	-0.108**	-0.114***	-0.106
(% contribution)	47.7	23.7	62.9	49.6	29.7
Coefficient Effect	-0.065	-0.161	-0.064	-0.116	-0.251*
(%contribution)	52.3	76.3	37.1	50.4	70.3

	Covariate effect					Co-efficient effect				
	10	**25**	**50**	**75**	**90**	**10**	**25**	**50**	**75**	**90**
Aggregate effect	-0.059*	-0.05	-0.108**	-0.114***	-0.106	-0.065	-0.161*	-0.064	-0.116	-0.251*
Child Characteristics	-0.193***	-0.260***	-0.261***	-0.255***	-0.088	0.389	0.195	0.134	-0.818**	0.342
(%)	142.1	270.8	112.7	95.6	36.5	-949.8	-263.9	-192.1	534.7	-559.9
Mother's Characteristics	-0.032**	-0.037**	-0.033*	-0.010	0.021	-0.204	-0.240	-0.116	0.117	-0.067
(%)	23.6	38.4	14.1	3.6	-8.8	498.0	324.5	166.3	-76.4	110.1
Household's Characteristics	0.105*	0.235***	0.064	-0.021	-0.186	-0.102	-0.059	-0.162	-0.021	0.126
(%)	-77.5	-244.6	-27.4	7.8	77.2	247.9	79.6	231.6	13.6	-206.4
Spatial Characteristics	-0.016	-0.034**	-0.002	0.019	0.012	0.419	-0.110	-0.184	-0.081	-0.631
(%)	11.9	35.8	0.9	-7.1	-4.8	-1022.3	148.0	262.3	52.9	1033.8
Constant						-0.543	0.139	0.258	0.649	0.169
Residuals	0.077	0.047	0.124	0.153	0.135	-0.024	-0.087	0.006	0.037	-0.19
Total	-0.136	-0.096	-0.232**	-0.267***	-0.241	-0.041	-0.074	-0.07	-0.153	-0.061

****p<0.001; **p<0.01; *p<0.05;** *Source: Computed by the authors from unit-level data of NFHS 1 and NFHS 2*

Table 10: Oaxaca Blinder decomposition of HAZ scores of NFHS 2 and NFHS 3 in Bihar

	10	25	50	75	90
NFHS 2 HAZ score	-5.036***	4.043***	-2.908***	-1.294***	0.474
NFHS 3 HAZ score	-4.064***	-3.027***	-1.983***	-0.854***	0.153
Observed Raw gap in HAZ scores	**-0.972*** **	**-1.016*** **	**-0.925*** **	**-0.440***	**0.321**
Covariate effect	-0.384	-0.112	0.393	0.680	0.991
(% contribution)	39.5	11.0	-42.5	-154.5	309.3
Coefficient Effect	-0.588	-0.905**	-1.317***	-1.121**	-0.671
(%contribution)	60.5	89.0	142.5	254.5	-209.3

	Covariate effect					Co-efficient effect				
	10	**25**	**50**	**75**	**90**	**10**	**25**	**50**	**75**	**90**
Aggregate effect	-0.384	-0.112	0.393	0.68	0.991	-0.588	-0.905**	-1.317***	-1.121**	-0.671
Child Characteristics	0.034	-0.032	-0.207	-0.415	-1.136**	-1.702***	-1.667***	-0.775***	-0.897***	-1.777***
(%)	-2.2	2.2	90.1	-418.8	397.3	-136.4	-150.9	181.0	-1008.0	-265.7
Mother's Characteristics	-1.941*	-1.409	-0.349	0.630	1.811	9.36***	22.151***	6.782***	6.046***	13.241***
(%)	123.4	98.8	151.9	636.3	-633.4	750.1	2004.7	-1584.5	6792.7	1979.2
Household's Characteristics	0.114	-0.300	-0.151	-0.058	-0.352	-0.102	-1.856***	-0.184	-0.373**	0.020
(%)	-7.2	21.0	65.8	-58.1	123.0	-8.1	-167.9	43.0	-419.0	2.9
Spatial Characteristics	0.220	0.314	0.478	-0.058	-0.610	0.214	0.163	0.192	0.284	0.232
(%)	-14.0	-22.0	-207.8	-59.1	213.1	17.2	14.8	-44.9	318.8	34.7
Constant						-6.524*	-17.687***	-6.443***	-4.971***	11.046***
Residuals	1.189	1.315	0.623	0.581	1.278	-1.836	-2.009	-0.889	-1.209	-1.34
Total	-1.573	-1.427	-0.23	0.099	-0.286	1.248***	1.105***	-0.428***	0.089	0.669***

****p<0.001; **p<0.01; *p<0.05;* *Source: Computed by the authors from unit-level data of NFHS 2 and NFHS 3*

Table 11: Oaxaca Blinder decomposition of HAZ scores of NFHS 3 and NFHS 4 in Bihar

	10	25	50	75	90
NFHS 2 HAZ score	-4.041***	-3.016***	-1.975***	-0.843***	0.166**
NFHS 3 HAZ score	-3.593***	-2.654***	-1.664***	-0.463	0.699***
Observed Raw gap in HAZ scores	**-0.448*** **	**-0.361*** **	**-0.311*** **	**-0.380*** **	**-0.533*** **
Covariate effect	-0.206	0.061	0.168	0.261	0.026
(% contribution)	45.9	-17.0	-53.9	-68.7***	-4.9
Coefficient Effect	-0.243	-0.423**	-0.479***	-0.642	-0.559**
(%contribution)	54.1	117.0	153.9	168.7	104.9

	Covariate effect					Co-efficient effect				
	10	**25**	**50**	**75**	**90**	**10**	**25**	**50**	**75**	**90**
Aggregate effect	-0.206	0.061	0.168	0.266	0.029	-0.243	-0.423**	-0.479***	-0.646***	-0.562
Child Characteristics	0.424	0.220	-0.412	1.088***	0.940**	0.429*	0.849***	3.344***	0.650**	1.349***
(%)	140.5	-21.2	16.1	25.4	107.5	2873.0	256.0	247.2	-52.1	-449.1
Mother's Characteristics	0.456*	-0.463	-1.319	1.041***	-0.160	6.123***	-2.277	-18.339***	10.574***	2.242
(%)	151.2	44.6	51.5	24.3	-18.3	41039.2	-687.0	-1355.7	-847.8	-746.3
Household's Characteristics	-0.582	-0.789	-0.849	2.145***	-0.200	-0.935***	-0.958**	-1.711*	0.733*	-0.016
(%)	-192.9	76.1	33.2	50.1	-22.9	-6268.0	-289.0	-126.5	-58.7	5.3
Spatial Characteristics	0.004	-0.005	0.020	0.008	0.014	0.076	-0.246	0.906**	0.163	0.816***
(%)	1.2	0.5	-0.8	0.2	1.6	510.8	-74.3	66.9	-13.1	-271.5
Constant						-5.678**	2.965	17.154**	13.367***	-4.692
Residuals	-0.507	1.099	2.728	-4.015	-0.846	-0.258	-0.754	-1.831	0.601	-0.262
Total	0.302	-1.037	-2.560	4.281***	0.874	0.015	0.332	1.353	-1.247***	-0.300

****p<0.001; **p<0.01; *p<0.05;** *Source: Computed by the authors from unit-level data of NFHS 3 and NFHS 4*

It may be observed that between the periods 1992-93 and 1998-99 covariate (or endowments) effects contributed significantly to enhance disparities in child HAZ outcomes, at the 10th, 50th and 75th quantiles, while coefficient (returns to endowments) effects dominates over covariate effect in enhancing disparities in child's HAZ outcomes at 90th quantile (Table 8). Lower panel of the Table 9 suggested that child characteristics (or child endowments) alone contributed 36.5 percent at 90th quantile to 270.8 percent at 25th quantile while explaining disparities in child's HAZ outcomes. Effect of mother's characteristics (or mother's endowments) in explaining such disparity was found to be relatively small and varies between -8.8 percent at 90th quantile to 38.4 percent at 25th quantile, while effects of household characteristics have tried to reduce covariate effects, particularly in 10th and 25th quantiles. Table 12 indicated that among child endowments, effect of child's age was the highest in all the quantiles in increasing disparity, while such effect was noticeable at 10th and 25th

quantiles for early initiation of breastfeeding. Among mother characteristics, delivery in institutions was found to have significant effect in enhancing disparity, particularly between lower tails of the HAZ distribution.

Notwithstanding to above findings, the directions of covariate and coefficient effects reversed significantly between the periods 1998-99 and 2005-06, and 2005-06 and 2015-16 (Tables 10 and 11). During both the periods, coefficient effects (or returns to endowments) significantly surpassed covariate effects (or endowments) in most of quantiles except 10th quantile. Between 1998-99 and 2005-06, coefficient effects enhanced disparities in child's HAZ outcomes by 89 – 254.5 percent between 25th and 75th quantiles (Table 10), while such effects vary between 117 – 168.7 percent between the same quantile(Table 11). Additionally, between the said period, coefficient effects enhanced disparity in child's HAZ outcomes even at the 90th quantile. If we notice the lower panels of the Tables 10 and 11, we found that between 1998-99 and 2005-06, coefficients of child characteristics significantly increased disparities in child's HAZ scores across, while coefficient effects of mother's characteristics have tried to reduce it except 25th and 50th quantiles. Further, coefficient effects of the household attributes have tried to increase disparities in HAZ outcomes significantly at 25th and 75th quantiles between 1998-99 and 2005-06 and 10th to 50th quantiles between 2005-06 and 2015-16. Additionally, during the last period, positive and significant covariate effects were observed at the higher tails of HAZ distribution.

Table 12: Oaxaca Blinder decomposition of HAZ scores of NFHS 1 and NFHS 2 in Bihar

	Covariate effect					Co-efficient effect				
	10	25	50	75	90	10	25	50	75	90
Aggregate effect	-0.059*	-0.050	-0.108**	-0.114***	-0.106	-0.065	-0.161*	-0.064	-0.116	-0.251*
Child age in Months	-0.129***	-0.176***	-0.323***	-0.304***	-0.198**	-0.121	0.497	0.083	-1.297**	0.356
(%)	94.4	182.6	139.0	113.7	82.1	296.6	-670.6	-118.3	845.5	-584.9
Age2	0.032	0.029	0.104***	0.098***	0.038	0.427	-0.194	-0.052	0.423	-0.173
(%)	-23.4	-30.3	-44.6	-36.5	-15.7	-1047.3	261.8	74.3	-276.0	283.3
Female	0.014*	0.018**	0.022**	0.022**	0.044**	0.030	-0.088	0.043	0.001	0.040
(%)	-10.1	-18.2	-9.4	-8.1	-18.4	-73.5	118.0	-61.0	-0.5	-66.2
Birth Size										
Normal										
Average and above	-0.002	0.003	-0.003	-0.016**	-0.015	-0.034	0.008	-0.006	0.021	0.010
(%)	1.3	-3.5	1.2	6.1	6.1	82.9	-11.1	9.2	-13.5	-16.6
Small	-0.003	0.000	0.001	0.000	0.002	0.037	0.027	0.009	0.002	0.113*
(%)	1.9	0.0	-0.4	0.0	-0.7	-90.3	-36.4	-12.2	-1.2	-185.6
Early Breastfeeding (Yes)	-0.106*	-0.134**	-0.062	-0.055	0.041	0.011	0.010	0.000	0.037	0.013
(%)	77.7	139.0	26.8	20.4	-17.0	-26.3	-14.1	-0.1	-24.1	-21.1

No. of Sibling	0.000	0.000	0.000	0.000	0.000	0.040	-0.066	0.059	-0.005	-0.019
(%)	0.00	0.01	-0.01	-0.01	0.04	-97.95	89.04	-84.49	3.08	30.62
Mother's Characteristics										
Institutional Delivery (yes)	-0.015*	-0.032***	-0.016*	-0.005	0.009	0.025	-0.018	0.040	0.024	0.100*
(%)	10.9	33.7	6.9	1.9	-3.9	-61.3	24.6	-56.7	-15.3	-163.8
Age of mother at first birth	-0.010	0.002	-0.002	0.009	0.031	-0.279	-0.278	-0.032	0.049	-0.151
(%)	7.2	-2.3	0.9	-3.5	-13.0	683.6	375.3	46.1	-32.2	247.6
Mother's Education	-0.005	-0.001	-0.007	-0.008	-0.009	0.025	0.041	0.018	-0.019	-0.043
(%)	3.9	0.7	3.1	3.1	3.7	-61.7	-55.5	-25.4	12.3	71.2
Working mother	-0.002	-0.006	-0.004	-0.003	-0.005	0.032	0.023	-0.077*	0.029	0.064
(%)	1.8	5.9	1.8	1.0	2.0	-77.5	-31.4	110.1	-18.7	-105.0
Media exposure	0.000	0.000	-0.003	-0.003	-0.006	-0.007	-0.008	-0.065	0.034	-0.037
(%)	-0.2	0.2	1.3	1.2	2.3	18.1	10.7	92.6	-22.3	60.3
Religion										
Hindu										
Muslim/Others	-0.007	-0.009	-0.005	-0.007	0.006	-0.021	0.004	0.019	0.082	0.108
(%)	5.3	8.9	2.1	2.7	-2.6	52.4	-4.8	-26.7	-53.7	-177.1
Caste										
SC										
ST	0.021*	0.045***	0.017	0.008	-0.025	-0.005	-0.004	-0.007	-0.010	0.008
(%)	-15.7	-46.2	-7.5	-3.0	10.5	12.7	5.0	9.9	6.5	-12.5
Others	0.091*	0.192***	0.047	-0.024	-0.179*	-0.074	-0.046	-0.204	-0.116	-0.020
(%)	-67.1	-199.5	-20.1	9.1	74.3	181.9	62.1	292.3	75.7	33.4
Wealth index	0.000	0.007	0.005	0.003	0.013	-0.001	-0.013	0.030	0.023	0.031
(%)	0.2	-6.8	-2.0	-1.0	-5.2	2.5	17.1	-43.3	-15.0	-50.5
Place of residence										
Urban										
Rural	-0.016	-0.034**	-0.002	0.019	0.012	0.419	-0.110	-0.184	-0.081	-0.631
(%)	11.9	35.7	0.9	-7.1	-4.8	-1028.7	147.7	262.9	52.8	1035.0
Constant						-0.543	0.139	0.258	0.649	0.169
Residuals	0.077	0.047	0.124	0.153	0.135	-0.024	-0.087	0.006	0.037	-0.190
Total	-0.136	-0.096	-0.232**	-0.267***	-0.241	-0.041	-0.074	-0.070	-0.153	-0.061

***$p<0.001$; **$p<0.01$; *$p<0.05$; *Source: Computed by the authors from unit-level data of NFHS 1 and NFHS 2*

Table 13: Oaxaca Blinder decomposition of HAZ scores of NFHS 2 and NFHS 3 in Bihar

	Covariate effect					Co-efficient effect				
	10	25	50	75	90	10	25	50	75	90
Aggregate effect	-0.384	-0.112	0.393	0.680	0.991	-0.588	-0.905**	-1.317***	-1.121**	-0.671
Child age in Months	-0.004	0.060	0.144	0.154	0.191	-1.256	-1.393**	-1.570***	-1.733***	-4.301***
(%)	0.3	-4.2	-62.5	154.8	-66.8	-100.6	-126.2	366.4	-1956.9	-642.6
Age2	0.131	-0.073	-0.300	-0.353	-0.479	-0.039	1.223***	0.506**	0.515**	2.071***
(%)	-8.3	5.1	130.4	-355.5	167.5	-3.1	110.7	-118.1	581.2	309.5
Female	0.092	0.172**	0.174**	0.132	0.118	0.074	-0.082	-0.008	0.117**	0.154**
(%)	-5.8	-12.0	-75.8	132.6	-41.3	5.9	-7.4	1.8	132.0	23.0
Birth Size										
Normal										
Average and above	-0.093	-0.186	-0.338**	-0.485**	-0.818*	-0.025	-0.401***	0.086**	0.139***	0.040
(%)	5.9	13.0	146.9	-488.6	285.7	-2.0	-36.3	-20.1	156.5	5.9
Small	-0.006	0.015	0.070	0.146	-0.056	-0.106*	-0.646***	0.050*	-0.002	0.027
(%)	0.4	-1.1	-30.6	147.0	19.4	-8.5	-58.5	-11.7	-2.7	4.1
Early Breastfeeding (Yes)	-0.051	-0.034	0.002	-0.046	-0.126	0.015	-0.041	-0.009	0.009	0.002
(%)	3.3	2.4	-1.0	-45.9	44.1	1.2	-3.7	2.1	10.7	0.2
No. of Sibling	-0.034	0.015	0.040	0.038	0.033	-0.365***	-0.327***	0.170***	0.059	0.229***
(%)	2.2	-1.0	-17.2	38.2	-11.5	-29.2	-29.6	-39.7	66.1	34.2
Mother's Characteristics										
Institutional Delivery (yes)	-0.487	-0.884**	-1.064***	-0.874*	-2.486**	-0.048	-0.514***	-0.042	-0.048	-0.040
(%)	31.0	62.0	462.6	-880.1	868.7	-3.8	-46.5	9.9	-54.0	-5.9
Age of mother at first birth	-0.016	-0.007	-0.040	0.039	-0.001	-0.773	1.568***	-0.236	-0.359	0.293
(%)	1.0	0.5	17.3	38.9	0.3	-61.9	141.9	55.2	-405.6	43.8
BMI of mother	0.002	-0.002	0.000	-0.007	-0.018	1.440	5.112***	1.139***	1.469***	1.046*
(%)	-0.1	0.2	0.2	-7.0	6.3	115.3	462.8	-265.7	1659.2	156.3
Mother's anaemia										
Yes	0.048	0.343	0.614**	0.878**	1.616	-0.349*	-0.165	-0.127	-0.022	0.001
(%)	-3.1	-24.0	-267.0	883.5	-564.8	-27.9	-14.9	29.7	-24.9	0.2
Mother's height	-0.058	-0.051	-0.005	-0.079	0.033	8.563***	15.272***	5.641***	4.671***	11.333***
(%)	3.7	3.6	2.2	-79.5	-11.4	686.0	1382.6	-1316.6	5274.9	1693.1
Mother's Education	-0.071	0.276	0.058	0.563	0.670	-0.011	-0.325***	-0.012	0.021	-0.027
(%)	4.5	-19.3	-25.1	566.5	-234.2	-0.9	-29.5	2.8	23.5	-4.0
Working mother	-1.161	-1.384	-0.530	-0.326	0.338	0.360	1.104***	0.195*	0.088	0.321**
(%)	73.8	97.0	230.5	-328.3	-118.1	28.9	99.9	-45.4	99.8	48.0
Empowerment	-0.002	0.057	0.073	0.149	0.217	0.012	-0.141***	-0.012	-0.010	-0.010
(%)	0.1	-4.0	-32.0	149.9	-76.0	1.0	-12.7	2.9	-11.7	-1.5

Media exposure	-0.196	0.244	0.544	0.288	1.442	0.168	0.241**	0.238***	0.236***	0.324***
(%)	12.5	-17.1	-236.9	290.3	-503.8	13.4	21.9	-55.5	266.4	48.3
Religion										
Hindu										
Muslim/Others	0.028	-0.007	-0.132*	-0.175	-0.318	0.007	-0.080**	0.078***	0.091***	-0.053
(%)	-1.8	0.5	57.5	-175.7	111.0	0.5	-7.3	-18.2	103.1	-7.9
Caste										
SC										
ST	0.005	-0.020	0.014	-0.045	0.018	0.017	-0.007	-0.007	-0.011	-0.012
(%)	-0.3	1.4	-6.1	-45.1	-6.1	1.3	-0.6	1.5	-12.2	-1.8
Others	0.115	0.068	0.159	0.130	-0.240	0.301	-0.674***	0.195	-0.073	0.251
(%)	-7.3	-4.7	-69.2	130.8	84.0	24.1	-61.0	-45.4	-82.9	37.5
Wealth index	-0.035	-0.340	-0.1925	0.032	0.189	-0.426**	-1.095***	-0.450***	-0.380***	-0.167
(%)	2.2	23.9	83.7	32.1	-66.0	-34.1	-99.1	105.0	-429.1	-24.9
Place of residence										
Urban										
Rural	0.220	0.314	0.477984	-0.058	-0.610	0.214	0.163	0.192	0.284	0.232
(%)	-14.0	-22.0	-207.8	-58.9	213.0	17.2	14.8	-44.8	320.4	34.7
Constant					-6.524*	-17.687***	-6.443***	-4.971***	-11.046***	
Residuals	1.189	1.315	0.623	0.581	1.278	-1.836	-2.009	-0.889	-1.209	-1.340
Total	-1.573	-1.427	-0.230	0.099	-0.286	1.248***	1.105***	-0.428***	0.089	0.669***

****p<0.001; **p<0.01; *p<0.05;** *Source: Computed by the authors from unit-level data of NFHS 2 and NFHS 3*

Table14: Oaxaca Blinder decomposition of HAZ scores of NFHS 3 and NFHS 4 in Bihar

	Covariate effect					Co-efficient effect				
	10	25	50	75	90	10	25	50	75	90
Aggregate effect	-0.206	0.061	0.168	0.266	0.029	-0.243	-0.423**	-0.479***	-0.646***	-0.562
Child age in Months	-0.106***	-0.263***	-1.026***	-0.509***	-0.608***	-0.781**	-0.069	3.122***	-0.519	1.593***
(%)	-35.2	25.4	40.1	-11.9	-69.5	-5236.4	-20.7	230.8	41.6	-530.1
Age2	0.022	0.111*	0.503***	0.388***	0.493***	0.551**	0.195	-0.537	0.075	-0.973***
(%)	7.3	-10.7	-19.7	9.1	56.4	3694.6	58.8	-39.7	-6.0	324.0
Female	-0.001	-0.005	-0.026	0.008	-0.006	0.124***	0.096	-0.314***	0.133*	0.001
(%)	-0.4	0.5	1.0	0.2	-0.7	829.3	29.1	-23.2	-10.7	-0.4
Birth Size										
Normal										
Average and above	0.006	-0.028*	-0.009	-0.009	-0.040**	0.014	0.074**	0.043	0.074**	0.100**
(%)	2.0	2.7	0.4	-0.2	-4.6	96.6	22.4	3.2	-6.0	-33.3
Small	-0.038***	-0.118***	-0.195***	-0.052***	0.041**	0.011	0.112***	0.195***	0.084***	0.003
(%)	-12.7	11.3	7.6	-1.2	4.7	72.5	33.8	14.4	-6.8	-1.1
Early Breastfeeding (Yes)	0.231**	0.109	-0.167	0.615***	0.068	0.192**	0.022	-0.069	0.411***	0.069
(%)	76.7	-10.5	6.5	14.4	7.7	1287.5	6.7	-5.1	-33.0	-23.1
No. of Sibling	-0.071***	-0.069***	-0.146***	-0.013	-0.030*	0.066	0.179**	0.530***	-0.001	0.034
(%)	-23.6	6.7	5.7	-0.3	-3.4	441.6	54.0	39.2	0.1	-11.5
Benefitted ICDS services	0.381***	0.483**	0.653	0.660***	1.121***	0.252*	0.239	0.374	0.392**	0.522**
(%)	126.4	-46.5	-25.5	15.4	128.2	1687.2	72.0	27.6	-31.4	-173.6
Mother's Characteristics										
Institutional Delivery (yes)	-0.034	-0.802***	-1.317***	0.392***	0.086	0.062	-0.694***	-1.364***	0.253	0.082
(%)	-11.4	77.3	51.4	9.2	9.8	415.8	-209.5	-100.8	-20.3	-27.3
Age of mother at first birth	0.152***	-0.013	-0.077	0.295***	-0.009	1.340***	-0.136	-0.607	2.734***	1.166
(%)	50.3	1.2	3.0	6.9	-1.0	8980.2	-40.9	-44.9	-219.3	-388.1
BMI of mother	0.021	-0.068**	-0.311***	-0.080***	-0.033	1.470**	0.219	-3.125***	-0.435	0.173
(%)	7.1	6.6	12.1	-1.9	-3.8	9850.3	65.9	-231.0	34.9	-57.5
Mother's anaemia										
Yes	-0.020**	0.044***	0.184***	-0.050***	-0.030*	-0.006	-0.169*	-0.653***	0.195*	0.091
(%)	-6.8	-4.3	-7.2	-1.2	-3.4	-37.6	-51.0	-48.3	-15.7	-30.2
Mother's height	-0.006	-0.012	-0.027	-0.003	-0.008	2.556	-2.430	-12.737***	7.506***	0.629
(%)	-1.8	1.2	1.0	-0.1	-0.9	17128.9	-732.9	-941.6	-601.9	-209.3
Mother's Education	0.099***	0.124***	0.227***	0.100***	-0.101***	0.229***	0.265***	0.417***	0.004	-0.141
(%)	33.0	-12.0	-8.9	2.3	-11.5	1533.2	79.9	30.8	-0.3	47.1
Working mother	0.089***	0.128***	-0.026	0.019	-0.008	0.382*	0.554**	-0.260	-0.013	0.157

(%)	29.6	-12.3	1.0	0.4	-0.9	2558.2	167.1	-19.2	1.1	-52.2
Empowerment	0.018	-0.008	0.041	0.057***	-0.070***	-0.001	0.001	-0.003	-0.006	0.002
(%)	6.0	0.8	-1.6	1.3	-8.0	-8.7	0.2	-0.2	0.5	-0.6
Media exposure	0.137**	0.144	-0.013	0.310***	0.088	0.092	0.114	-0.006	0.334***	0.084
(%)	45.3	-13.9	0.5	7.2	10.1	618.9	34.3	-0.4	-26.8	-28.0
Religion										
Hindu										
Muslim/Others	-0.018*	0.011	0.019	-0.055**	-0.035*	0.115**	-0.082	-0.128	0.245***	0.125*
(%)	-5.9	-1.0	-0.7	-1.3	-4.0	770.7	-24.7	-9.5	-19.7	-41.6
Caste										
SC										
ST	-2.036***	-1.713***	-3.193***	0.831**	0.058	-1.150***	-1.044***	-1.970***	0.470*	0.002
(%)	-674.7	165.1	124.7	19.4	6.7	-7705.5	-315.1	-145.6	-37.7	-0.7
Others	1.510***	0.968	2.434	1.425**	-0.138	-0.256***	-0.159	-0.414	-0.254**	0.012
(%)	500.6	-93.3	-95.1	33.3	-15.8	-1714.8	-48.1	-30.6	20.4	-4.1
Wealth index	-0.039**	-0.055**	-0.110**	-0.056***	0.020	0.355***	0.328**	0.801**	0.271*	-0.155
(%)	-12.9	5.3	4.3	-1.3	2.3	2381.6	98.9	59.2	-21.7	51.7
Place of residence										
Urban										
Rural	0.004	-0.005	0.020	0.008	0.014	0.076	-0.246	0.906**	0.163	0.816***
(%)	1.2	0.5	-0.8	0.2	1.6	510.8	-74.3	66.9	-13.1	-271.5
Constant						-5.678**	2.965	17.154**	-13.367***	-4.692
Residuals	-0.507	1.099	2.728	-4.015	-0.846	-0.258	-0.754	-1.831	0.601	-0.262
Total	0.302	-1.037	-2.560	4.281***	0.874	0.015	0.332	1.353	-1.247***	-0.300

****p<0.001; **p<0.01; *p<0.05;* *Source: Computed by the authors from unit-level data of NFHS 3 and NFHS 4*

If we look covariate effects and coefficient effects during the period of 1998-99 and 2005-06 in more disaggregated manner, we found that coefficient effects of mother's height and BMI and media exposure have tried to reduce disparities in child HAZ outcomes across quantiles, while coefficient effects of other variables remained mixed across quantiles (Table 13). During the same period, covariate effects of institutional delivery have contributed significantly in increasing disparities in child HAZ outcomes. Moreover, coefficient effects of household wealth were found to be significantly contributed in increasing disparities in child HAZ outcomes. Between 2005-06 and 2015-16, both covariate and coefficient effects of the receipt of ICDS services were found to be significantly associated with reduction of HAZ disparities among children (Table 14). Both of these effects were found to be significantly positive in reducing disparity, particularly at

the lower tail of the HAZ distribution, for early initiation of breastfeeding, increased age of mothers, and for working mothers. Except for the 90th quantile, covariate and coefficient effects of educational attainment of mothers have helped in reducing child's HAZ disparities. Covariate effects of child age were found to be associated with increased disparities in HAZ outcomes across quantiles, while such association holds for the lowest quantile for coefficient effects. For child's size at birth and household wealth, it was observed that covariate effects tended to enhance disparities in child HAZ outcomes, while coefficient effects likely to reduce such disparities. Compared to SCs, covariate as well as coefficient effects would significantly likely to increase disparities among STs up to 50th quantile. Such inequity was also found if we compared SCs with Non-SC/STs.

Discussion

The QR-based decomposition methods provided specific insight into the drivers of disparities across child's HAZ distribution. The understanding of factors resulted in disparities in the lower quantiles of HAZ scores would be useful in designing interventions aimed at the vulnerable households having with children of the highest levels of stunting. In order to assess the contribution of the 'returns' to different types of interventions in reducing child HAZ disparities during last 20 years or so, such quantification of the contribution of different socio-demographic, economic and cultural determinants seemed to be imperative.

Our study indicates that although between 1992-93 and 1998-99 child's HAZ disparity at the bottom quantile of the distribution was largely accounted for differing levels of endowments, in the later periods such differences became statistically insignificant. In other words, between 1992-93 and 1998-99, at the lowest quantile, reducing disparity in childhood stunting was a matter of equalizing endowments; however, between 1998-99 and 2005-06, and 2005-06 and 2015-16, both – unequal endowments as well as uneven access to the benefits of implementation of government sponsored schemes – were largely responsible for childhood HAZ disparity. At the higher quantiles, particularly between 50 – 75th quantile, although unequal endowments were responsible for HAZ disparities between 1992-93 and 1998-99, inadequate access to benefits from programme implementation was largely found accountable for HAZ disparities between 1998-99 and 2005-06 and such scenario continued till 2015-16.

From the QR-CD estimates between 2005-06 and 2015-16, it is important to note that there are limited number of equalizing endowments which can have significant influence in reducing disparities in child HAZ outcomes for the bottom quintiles, though at the aggregate level influences of endowments were statistically insignificant. According to our estimates, much of the reduction of disparities at the lowest quantile can be achieved by focussing on regularity of ICDS services, early initiation of breastfeeding, reduction of sibling size (proxy for family size), increasing mother's age at first birth, mass media exposure, educational attainment and employability. Additionally, access to the programmes pertaining to initiation of early breastfeeding, securing access to ICDS services, reduction of early childbearing, improving mother's nutritional status, ensuring educational attainment and employability of women, and creation of household wealth found to be imperative to the households having the highest level of stunting. Further,

access to the programmes pertaining to bridging gender-gaps during childhood could also be beneficial for reduction of childhood stunting. Because coefficient effects indicate all-inclusive returns to endowments, arguably,not only the 'reach' of these programmes, but also 'quality' of these programmes also could enhance child nutritional status considerably. Although earlier studies have also demonstrated the influence of these characteristics to lowering stunting (Dewey 2016; McGovern et al. 2017), these studies could not able to quantify the contribution of reach of various policies and programmes in reducing stunting.

In addition to the implementation of centrally sponsored schemes such as ICDS, the government of Bihar has initiated a number of programmes in the recent past which has indirect influenceto the reduction of child undernutrition. Currently 18 centrally sponsored schemes and 30 state-specific nutrition-sensitive schemes are being implemented by 16 departments. It would have been more meaningful and easier to monitor if all these schemes can be possibly brought under a single umbrella of a State Nutrition Mission. How a State's Nutrition Mission can successfully reduce the menace of child undernutrition has been well-documented for the state of Maharashtra in India (Nisbett and Barnett 2017). The key factors identified in the policy processes in the success of Maharashtra include the way the issue was framed and available evidences helped catalyse a political response; forming State Nutrition Mission as response from government structures, and system-wide capacity was combined with leadership in an innovative fashion in utilizing available resources (ibid).

Nonetheless, the Draft State Plan of Action for Children 2017 proposed 11 strategies and actions for all-round development for children. These include effective implementation of schemes, programmesand laws; mapping vulnerable households and linking those households with appropriate development schemes; raising community awareness on the nutritional issues through institutional interventions; institutional strengthening through capacity building of staff, improved infrastructure and outreach; strengthening child-relevant resources and facilitating uptake of principal schemes and services etc. In the Imperative – 2 of the aforesaid state plans for action, 'breaking the intergenerational cycle of malnutrition' was emphasized. Apart from provisioning of essential services, support and provisions for nutritional attainment in a life-cycle approach, provision of take-home ration, safe health and hygiene practices, identifying and focussing on lower performing districts to ensure better outreach plans and services etc. The State Plan of Action for

Children must also accommodate the issue of intersectoral coordination in implementation of these programmes in order to harness better dividend of these schemes.

Some limitations of the study may be highlighted. First, NFHS sampling frame of 1998-99 does not allow to culling out districts from the states because district as a unit of stratification was not included in the sampling frame. However, because of unavailability of any other comparable dataset, we compelled to segregate districts of undivided Bihar. This may under- or over-estimate the QR-CD results. Secondly, CD exercise can provide reliable estimates only if the primary quantile regression includes all the important factors of child nutrition and is well-specified (Srinivasan et al. 2013). To note, our choice of determinants has been constrained by the coverage of NFHS, we have included key variables considered by the previous literature (Srinivasan et al. 2013; Cavatorta et al. 2015; Menon et al. 2018). However, in such situation, the issue of endogeneity cannot be entirely ruled out, though we have tested for it. Finally, the 'coefficient effects' in such comparisons lump several potential effects together and not informative about specific factors or actions (Cavatorta et al. 2015); thus, interpretations of coefficient effects are speculative. Nonetheless, this research helps to highlight important dimensions to child nutritional improvement during last two decades.

Inconspicuous presence of nutrition, particularly child nutrition in Millennium Development Goals (MDG) framework with an imperfect measure of child undernutrition (i.e. underweight) was criticised by many researchers across world (for example, Cavatorta et al. 2015). However, the issue has gained considerable momentum in the Sustainable Development Goals (SDGs) as it confirms that the countries will mobilise efforts to eradicate all forms of poverty, fight inequalities, while ensuring that no one is left behind. Although the ambition to 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture' is captured in SDG 2, at least 12 of the 17 Goals contain indicators are highly relevant to nutrition because of the fact that **w**ithout adequate and sustained investments in good nutrition, the SDGs will not be realised. Our results suggest that child undernutrition in Bihar is not just from a lack of sufficient and adequately nutritious and safe food, but from a host of intertwined factors linking healthcare, women's education and work, household wealth (including water, sanitation and hygiene) and more. In addition to scaling up proven nutrition-specific interventions in other Indian states, the state of Bihar, must focus on policy processes and their political underpinnings reduce the risk of child undernutrition.

Endnote 1: Women's empowerment indicators were created from factor scores of the factor analyses using different variables indicating women's household decision making power, freedom of movement etc. For NFHS 2, 1998-99, following variables were included: who decides how to spend money, who decides obtaining health care, who decides what to cook, permission need to go to market, and permission needed to visit relatives or friends. Women's work for cash in the past 12 months was also incorporated. In NFHS 3, 2005-06, final say on how to spend money, final say on own health care, final say on household purchases, final say on visit relatives or friends, Work for cash in the past 12 months, having bank account were considered to create such index. In NFHS 4, 2015-16, the variables such as who decides on own health care, who decides on how to spend money, who decides on household purchases, who decides on visit relatives or friends, owning house/land, Work for cash in the past 12 months, having bank account, and having mobile were included in the analysis.

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Appendix Tables A1-A5

Table A1: Linear regression results for NFHS 1 (1992-1993), NFHS 2 (1998-99), NFHS 3 (2005-06) and NFHS 4 (2015-16) in Bihar

	NFHS 1	NFHS 2
Age of Child	-0.133***	-0.200***
Age2	0.002***	0.003***
Female	0.366***	0.652***
Birth Size		
Normal		
Average and above	0.110**	0.955***
Small	0.013	0.213*
Early Breastfeeding (Yes)	0.498***	-0.778***
No. of Sibling	-0.005	0.066***
Mother's Characteristics		
Institutional Delivery (yes)	0.369***	1.937***
Age of mother at first birth	0.015***	-0.003
BMI of mother	-	0.001***
Mother's anaemia		
Yes	-	-0.720***
Mother's height	-	0.003***
Mother's Education	0.028***	-0.079***
Working mother	-0.362***	-0.481*
Empowerment	-	-0.129***
media exposure	0.106***	-0.546***
Religion		
Hindu		
Muslim/Others	-0.089***	0.756***
Caste		
SC		
ST	0.279***	-0.055
Others	0.078	-0.104
Wealth index	0.068***	-0.067
Place of residence		
Urban		
Rural	0.101**	-0.067
Constant	-1.566***	-6.348***
R square	0.1562	0.3047
Adj. R square	0.1554	0.2983

****p<0.001; **p<0.01; *p<0.05;* *Source: Computed by the authors from unit-level data of NFHS 1 and NFHS 2*

Table A2: Linear regression results for NFHS 1 (1992-1993), NFHS 2 (1998-99), NFHS 3 (2005-06) and NFHS 4 (2015-16) in Bihar

	NFHS 1	NFHS 2
Age of Child	-0.129***	-0.136***
Age2	0.002***	0.002***
Female	0.059	0.214***
Birth Size		
Normal		
Average and above	**0.055**	0.176*
Small	*-0.143*	-0.041
Early Breastfeeding (Yes)	0.362	0.031
No. of Sibling	-0.035	-0.027
Benefitted ICDS services	0.008	-0.288***
Mother's Characteristics		
Institutional Delivery (yes)	-0.125	0.030
Age of mother at first birth	-0.009	0.014
BMI of mother	**0.001*** **	0.000***
Mother's anaemia		
Yes	-0.224**	-0.031
Mother's height	0.005***	0.005***
Mother's Education	0.022	0.010
Working mother	**0.12**	-0.062
Empowerment	-0.009	0.041
media exposure	0.097	-0.010
Religion		
Hindu		
Muslim/Others	0.077	-0.148
Caste		
SC		
ST	0.555	0.052
Others	0.327***	0.250*
Wealth index	0.000***	0.000
Place of residence		
Urban		
Rural	**0.056**	-0.032
Constant	-9.99***	-8.721***
R square	0.275	0.160
Adj. R square	0.261	0.149

****p<0.001; **p<0.01; *p<0.05;* *Source: Computed by the authors from unit-level data of NFHS 3 and NFHS 4*

Table A3. Oaxaca–Blinder decomposition of mean HAZ gap between NFHS 1 and NFHS 2 in Bihar

NFHS 1 HAZ score				-2.397***
NFHS 2 HAZ score				-2.203***
Observed Raw gap in HAZ scores				-0.194***
Covariate effect				-0.107***
(% contribution)				55.2
Coefficient Effect				-0.087
(%contribution)				44.8
	Covariate Effects	**Share (%)**	**Coefficients Effects**	**Share (%)**
Child age in Months	-0.117**	109.6	0.770**	-886.9
Age2	0.031	-28.9	-0.313	360.4
Female	0.011*	-8.3	0.122**	-141.1
Birth Size				
Normal				
Average and above	-0.002	1.518	0.004	-5.2
Small	0.000	-0.109	0.089***	-102.0
Early Breastfeeding (Yes)	-0.020	14.461	0.015	-17.0
No. of Sibling	0.000	0.073	0.024	-27.6
Mother's Characteristics				
Institutional Delivery (yes)	-0.009	6.942	0.040	-45.6
Age of mother at first birth	0.003	-2.518	-0.271	311.7
Mother's Education	-0.006	4.642	-0.005	5.3
Working mother	-0.006	4.547	-0.064**	73.2
media exposure	-0.002	1.536	-0.007	8.3
Religion				
Hindu				
Muslim/Others	-0.003	2.111	-0.026	30.5
Caste				
SC				
ST	0.008	-5.736	0.020	-23.3
Others	0.008	-5.795	0.052	-59.7
Wealth index	0.002	-1.475	-0.018	20.9
Place of residence				
Urban				
Rural	-0.005	3.307342	0.174	-200.5
Constant			-0.694	798.7

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; Source: Computed by the authors from unit-level data of NFHS 1 and NFHS 2

Table A4. Oaxaca–Blinder decomposition of mean HAZ gap between NFHS 2 and NFHS 3 in Bihar

NFHS 2 HAZ score				-2.471**
NFHS 3 HAZ score				-1.945***
Observed Raw gap in HAZ scores				-0.526***
Covariate effect				0.226
(% contribution)				-42.9
Coefficient Effect				-0.752**
(%contribution)				142.9
	Covariate Effects	**Share (%)**	**Coefficients Effects**	**Share (%)**
Age of Child	0.366**	162.2	-1.202	159.9
Age2	-0.194	-85.9	0.585	-77.8
Female	-0.008	-3.7	0.277**	-36.8
Birth Size				
Normal				
Average and above	-0.143**	-63.4	0.288**	-38.3
Small	-0.004	-1.8	0.076	-10.1
Early Breastfeeding (Yes)	-0.017	-7.7	-0.030	4.1
No. of Sibling	0.018	7.9	0.210	-27.9
Mother's Characteristics				
Institutional Delivery (yes)	-0.303***	-134.5	0.454***	-60.4
Age of mother at first birth	0.002	0.9	0.127	-16.9
BMI of mother	0.007	3.0	-0.574	76.4
Mother's anaemia				
Yes	0.308**	136.7	-0.365	48.6
Mother's height	-0.022	-9.6	-3.167	421.4
Mother's Education	0.139	61.6	-0.245	32.6
Working mother	-0.084	-37.2	-0.478	63.6
Empowerment	-0.007	-3.0	0.042	-5.5
Media exposure	0.233	103.3	-0.356*	47.3
Religion				
Hindu				
Muslim/Others	-0.052	-22.9	0.131	-17.5
Caste				
SC				
ST	-0.002	-0.7	-0.005	0.6
Others	0.031	13.9	-0.351	46.7
Wealth index	-0.038	-16.7	0.235*	-31.2
Place of residence				
Urban				
Rural	-0.005	-2.4	-0.102	13.6
Constant			3.700	-492.4

****p<0.001; **p<0.01; *p<0.05 ;** *Source: Computed by the authors from unit-level data of NFHS 2 and NFHS 3*

Table A5. Oaxaca–Blinder decomposition of mean HAZ gap between NFHS 3 and NFHS 4 in Bihar

NFHS 3 HAZ score				-1.933***
NFHS 4 HAZ score				-1.509***
Observed Raw gap in HAZ scores				-0.424***
Covariate effect				0.130
(% contribution)				-30.6
Coefficient Effect				-0.554***
(%contribution)				130.6
	Covariate Effects	**Share (%)**	**Coefficients Effects**	**Share (%)**
Age of Child	-0.234***	-180.6	0.129	-23.2
Age2	0.158***	121.9	-0.237	42.8
Female	-0.003	-2.5	-0.072	12.9
Birth Size				
Normal				
Average and above	0.025	19.4	-0.038	6.9
Small	-0.003	-2.5	-0.022	3.9
Early Breastfeeding (Yes)	-0.011	-8.2	0.009	-1.6
No. of Sibling	-0.014	-10.9	-0.017	3.0
Benefitted ICDS services	0.158***		0.023	-4.2
Mother's Characteristics				
Institutional Delivery (yes)	-0.014	-10.8	-0.034	-4.2
Age of mother at first birth	-0.031***	-23.7	-0.421	6.1
BMI of mother	-0.038***	-29.1	1.058**	76.0
Mother's anaemia				
Yes	-0.003	-2.0	-0.141	-191.1
Mother's height	0.014	11.2	0.133	25.4
Mother's Education	-0.015	-11.5	0.031	-24.0
Working mother	0.006	4.4	0.146	-5.5
Empowerment	-0.013	-10.3	0.018	-26.3
Media exposure	0.007	5.6	0.059	-3.3
Religion				
Hindu				
Muslim/Others	0.003	2.0	0.042	-10.6
Caste				
SC				
ST	-0.031	-24.2	0.004	-7.6
Others	0.162*	124.6	0.062	-0.7
Wealth index	0.007	5.1	-0.096	-11.2
Place of residence				
Urban				
Rural	0.000	0.0	0.079	-14.3
Constant			-1.269	229.0

****p<0.001; **p<0.01; *p<0.05;* *Source: Computed by the authors from unit-level data of NFHS 3 and NFHS 4*

The Centre for Health Policy (CHP) at the Asian Development Research Institute (ADRI) has been set up with support from the Bill & Melinda Gates Foundation to strengthen the health sector in Bihar with a multidimensional and multi-disciplinary approach. Its aim is to engage in rigorous analysis of the health system and inform policy makers to fine-tune interventions for even stronger outcomes.

- Research and Analytical Studies

  It constitutes the core of CHP's activities. The areas of research include health infrastructure and delivery with emphasis on equity, health outcomes such as IMR, MMR, TFR and its predictors, health financing, private-public partnerships, regulatory framework and its implementation, and other issues which might emerge.

- Informing Policymakers on Strengthening the Existing Health System

  CHP aims to be the trusted partner of the state Government in providing evidence-based inputs in making the health system stronger, resilient and equitable.

- Sustainable Health Solutions

  CHP recognizes the need for establishing a strong health system which will be self-sustaining. It means immunity to natural disasters/calamities, financial uncertainties and other unanticipated factors. These pillars may be interrelated; CHP will provide a framework of synergy among actors working on these pillars.

- Collaboration

  CHP engages in collaboration with an extensive network of academic and policy research institutions both in India and abroad in health and the broader social sciences.