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Economic Shocks and Child Wasting

Derek Headey

Marie Ruel

Poverty, Health, and Nutrition Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Derek Headey (d.headey@cgiar.org) is a Senior Research Fellow in the Poverty, Health, and Nutrition Division of the International Food Policy Research Institute (IFPRI), based in Yangon, Myanmar.

Marie Ruel (m.ruel@cgiar.org) is the Division Director of IFPRI's Poverty, Health, and Nutrition Division, Washington, DC.

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Abstract

In developing countries macroeconomic volatility is common, and severe negative economic shocks can substantially increase poverty and food insecurity. Less well understood are the implications of these contractions for child acute malnutrition (wasting), a major risk factor for under-5 mortality. This study explores the nutritional impacts of growth shocks over 1990-2018 by linking wasting outcomes collected for 1.256 million children from 52 countries to lagged annual changes in national income. Difference-in-difference estimates suggest that a 10% annual decline in national income increases moderate/severe (WHZ<-2) and severe wasting (WHZ<-3) by 14 and 22 percent. An exploration of possible mechanisms suggests negative economic shocks increase risks of diarrhea, fever, and maternal underweight prevalence, and reduce child dietary diversity. Applying these results to the predicted economic impacts of COVID-19 suggests that millions of pre-school children are at increased risk of wasting and wasting-related morbidity and mortality unless urgent preventative action is taken.

Key words: Economic growth; child malnutrition; wasting; COVID-19; child mortality.

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1. Introduction

Macroeconomic volatility is far more common in developing countries for a variety of economic, political and environmental reasons. However, the economic impacts of the COVID-19 pandemic have been exceptional, forcing governments throughout the world to shut down large parts of their domestic and international economies, thereby transforming a health crisis into a complex economic crisis of exceptional scale and scope. Estimates from The International Monetary Fund (IMF)[1] – which are arguably too optimistic[2] – suggest that the economies of low and middle income countries (LMICs) will decline by 4% on average in 2020 and almost 90% of these countries will experience negative growth, while The World Bank projects a 2.5% contraction in developing countries.[3] A global general equilibrium model from The International Food Policy Research Institute (IFPRI) estimates that 140 million people will fall into $1.90/day poverty in 2020,[4] while the World Food Programme estimates that the number of people facing severe food shortages will double in 2020.[5]

Although young children are typically immune to the direct effects of the COVID-19 virus, the indirect effects of economic recession and health system disruptions pose grave risks for child nutrition, morbidity and mortality, particularly children under 5 years of age. In the short term, nutritional insults often manifest in the form of acute weight loss, typically measured as low weight-for-height z scores (WHZ) that are used to classify different levels of severity of wasting. Wasting is usually the result of both severe reductions in food intake and recent or repeated episodes of infectious diseases, and the well-documented dynamic interaction between poor diets and infections. Infants and young children are at the greatest risk of wasting – and of mortality due to wasting – because of their immature immune system and their high nutrient requirements for growth and development. Although less prevalent than stunting – an indicator of chronic undernutrition – wasting is a much stronger predictor of child mortality. A pooled analysis of ten prospective cohort studies estimated that severe wasting had a hazard ratio of 11.6 compared to 5.5 for severe stunting (height-for-age Z-scores < -3), while moderately wasted children (-2>WHZ>-3) were 3.4 times and mildly wasted children (-1>WHZ>-3) 1.6 times as likely to die before their fifth birthday compared to non-wasted children.[6]

Despite the serious risks that wasting poses for morbidity and mortality in young children, the underlying economic causes of wasting are under-researched compared to the many studies linking longer term economic growth to stunting,[7-13] or the numerous studies estimating the impacts of economic shocks on child mortality.[9] Moreover, while LMICs have made significant progress in the past few decades in reducing stunting, progress in reducing wasting is uneven at best, despite improved programmatic approaches to treating and preventing wasting.[14] Globally, around 50 million under-5 children were estimated to be moderately (WHZ<-2) or severely (WHZ<-3) wasted in 2019, although levels and trends in wasting are difficult to assess due to high seasonal variability. The vast majority of wasted children reside in South Asia and sub-Saharan Africa, particularly the Sahel and Horn of Africa, where prevalence of wasting remains remarkably high and – in India, at least – seemingly unaffected by longer term economic growth.[15]

In this study we explore the impacts of short-term economic growth and recession on the risks of child wasting. While many features of the current COVID-19 social and economic crisis are unique, it is critical to understand whether the economic shocks currently being experienced in LMICs are likely to significantly increase risks of wasting and wasting-related mortality in addition to the serious impacts of health system disruptions caused by pandemics.[16-18] To do so we use an extensive set of 177 Demographic Health Surveys (DHS)[19] that collected information on 1.256 million children in 52 countries over three decades (1990-2018). We link these child and household level data to national level macroeconomic estimates of short- and medium-term changes in Gross National Income per capita (hereafter GNI). With some modifications we follow the empirical strategies of previous papers[20,21] that combine macroeconomic data with multiple rounds of DHS data to examine the mortality effects of economic shocks: fixed effects estimators that control for region-specific time trends to derive difference-in-difference (DiD) estimates that net out the biasing effects of many potential confounding factors.

We show that episodes of rapid negative economic growth increase wasting in the subsequent calendar year, and by a significant margin: a 10% decline in GNI per capita predicts a 14 percent increase in moderate/severe wasting in children under-5 and a 22% increase in severe wasting. Our findings also support the hypothesis that increases in child wasting are associated with rises in infections (proxied by diarrhea and fever) and poor dietary diversity, while the control variables in our models shed light on some of other channels through which complex crises can further exacerbate child wasting, especially health service disruptions.

These findings raise serious concerns for the nutritional security of vulnerable children in LMICs in 2020 and beyond. Unless protected urgently and holistically, children in LMICs could well be neglected victims of an economic pandemic affecting poor populations throughout the developing world, with no immediate end in sight.

2. Data

To explore the impact of macroeconomic shocks on child wasting we combine a large multi-country child-level DHS dataset with national level macroeconomic data. The DHS are well suited for this kind of analysis because of their high degree of standardization and coverage of a wide range of LMICs, their collection of a rich array of nutrition, health, demographic and socioeconomic data, their representativeness at both national and subnational levels, and their repeated application within countries over different periods of time. Our dataset comprises 177 DHS rounds that collected data on child weight in multiple rounds for children 0-59 months of age in 52 LMICs between 1990 and 2018 (See Appendix Table A1). We note that DHS has excellent coverage of sub-Saharan Africa and South Asia, the two regions with the highest rates of wasting, but is under-represented in South-East Asia where wasting rates are also relatively high. Even so, the surveys are representative of approximately 400 million under-5 children.

DHS data were used to calculate WHZ score relative to WHO reference weight-for-height measures of healthy breastfed children in multiple countries.[22] We then defined three standard measures of wasting: any wasting (WHZ<-1), moderate/severe wasting (WHZ<-2) and severe wasting (WHZ<-3).

Our key explanatory variable is the lagged annual change in GNI from the UN National Accounts Database,[23] although we also test robustness to a World Bank source for this same indicator.[24] We used GNI because this national income measure excludes public and private investment components of Gross Domestic Product (GDP), which are less likely to be related to household incomes. We used the lagged measure for two reasons. First, the lag ensures that growth shocks always precede the measurement of wasting, since measurement could take place early in the calendar year, whereas an economic collapse might emerge later in the year (as was the case in the 2008 financial crisis). Second, when faced with major income shocks households can use various coping mechanisms to protect essential food and health expenditures in the short run, suggesting there may be a lag between the onset of a shock and any impacts on child weight measures.

The remaining variables in our analysis are control variables specified to minimize the bias of confounding factors or to explore non-income channels linking COVID-19 to increased wasting risk. To use a comparable measure of wealth across a wide range of countries we develop a simple classification of ownership of five assets: improved flooring, electricity, TV, fridge and car/motorbike. We classify household into three levels of ownership: no assets, some assets, all five assets. We control for maternal education, three proxies designed to capture the continuum of maternal and child health care (antenatal care (% mothers who attended ≥ 4 visits in previous pregnancy), medical facility births and vaccinations (% children fully immunized for age), improved sanitation and water supplies, household demographics (teenage births, high fertility rates ≥ 4 children), child sex and rural location. In addition to these DHS controls we also followed a previous cross-country DHS study on growth shocks by testing sensitivity to

two additional national-level controls that could influence economic growth but independently affect child health: climate, as captured by the one-year lag of total annual rainfall and average monthly temperature;[25] and conflict, captured by battle-related deaths per 100,000 people.[24]

Finally, we used child morbidity symptoms and dietary indicators, as well as low maternal body mass index (BMI<18.5) to explore whether disease, dietary or maternal nutrition mechanisms might explain the impacts of growth shocks on child wasting. For morbidity symptoms we use the DHS measure of whether a child was reported to have had diarrhea or fever-only in the past two weeks. For diets we use the standard minimum dietary diversity (MDD) indicator corresponding to a child having consumed at least four of seven food groups in the previous 24 hours measured for children 6-35 months. We also use the individual food groups to test sensitivity of their consumption to GNI growth.

3. Methods

Our analysis of these data was conducted in three stages.

First, we estimate a new set of weights to make the regressions more representative of under-5 children in the DHS countries in our analysis. In a typical single-country analysis one need only use the DHS survey weights for each household to render statistics nationally representative, but in a multi-country analysis a more complex approach is needed, especially when the main explanatory variable of interest is itself measured at the country-year level. This is because: (a) countries differ in terms of their total population of under-5 children; (b) different countries have different numbers of rounds and survey sizes do not reflect population sizes; and (c) different rounds within a country can have very different sample sizes. Were we not to construct explicit weights to reflect these facts then the regression coefficients for GNIpc growth would remain implicitly weighted by the number of observations in each individual survey, resulting in some GNIpc growth episodes being over-weighted or under-weighted relative to their country's population of under-5 children.

To address this, we construct a three-step weighting metric. First, we used United Nations[26] statistics on the population of children < 5years of age to create a country-level population weight. India, for example, accounts for 20% of all child-level observations in our sample, but India contains 34% of all under-5 children in our DHS sample of countries (Appendix Table A2). Second, we re-weight observations within rounds to correct for imbalances in sample sizes. To continue the Indian example, its 2015-16 DHS round has 232,761 child observations while its 2005-06 round has 42,615 (Appendix Table A1), so the new weight corrects this imbalance to apply equal weight to both rounds. Finally, we use the standard DHS survey weights to ensure representativeness within surveys.

In the second step of our analysis we use different descriptive analysis techniques to explore patterns and trends in the data by mapping moderate/severe wasting, using non-parametric regressions to plot wasting by child age and region, and examining the distribution of GNI growth shocks across DHS rounds.

Third, we used a DiD linear probability model to test the impacts of lagged GNI growth shocks conditional upon long run wasting prevalence. By interacting lagged GNI shocks with the average wasting prevalence across surveys we allow the effect of changes in GNI to be linearly proportional a country long-run wasting prevalence. This is biologically appropriate (as populations in which wasting is more prevalent should be more vulnerable to negative shocks) but also mathematically appropriate since a WHZ distribution that is distributed more closely to the various wasting thresholds should see larger absolute changes in wasting. This specification also has a benefit for interpretation since the coefficient represents the elasticity of wasting prevalence with respect to economic growth.

The remaining variables are control variables. The key benefit of the DiD model is that it nets out the numerous time-invariant factors that influence wasting as well as common trends over time, such as improvements and expansions in programs aimed at preventing and treated acute malnutrition. This

approach is similar to a previous study examining the impacts of growth shocks on retrospective mortality measures from the DHS,[21] although the application to wasting poses some additional challenges highlighted below.

The first is that wasting is seasonal and seasonal variations in wasting are region-specific. In South Asia the available evidence suggests that wasting sharply increases in the monsoon,[27-29] whereas in some parts of the Sahel and Horn of Africa it is reported to increase in drier seasons.[30,31] Second, and relatedly, wasting may have quite different etiologies in different regions. For example, low birth weight is more prevalent in South Asia than in sub-Saharan Africa despite similar poverty levels.[32] Moreover, DHS evidence suggests that there may be difference in long term wasting trends across regions; wasting rates have also been stubbornly immune to longer term economic growth in South Asia, but have declined notably in some West African countries, such as Ghana.

To control for these complex differences in the trends and timing of wasting, we first created a more refined series of regional dummy variables that account for the diversity of wasting prevalence within sub-Saharan Africa: the Sahel and Horn of Africa (where wasting is highly prevalent), Western and Central Africa (where wasting is moderately prevalent), and Eastern and Southern Africa (where wasting is rare, despite high rates of stunting and general poverty). The remaining regions are more standard: South Asia, South-East Asia, Middle East and North Africa, Eastern Europe and Central Asia and Latin America and the Caribbean. We then interacted these regional dummy variables with three kinds of temporal effects: 5-year time brackets to flexibly control for secular changes in wasting in different regions; month of child measurement dummies to control for seasonality of wasting; and child age dummies (in months) to control for differences in the region-specific progression of wasting in early life.

With the control variables outlined above (excluding time subscripts for simplicity), the DiD linear probability models take the form:

$$(1) \quad w_{i,c,r} = \beta_0 + \beta_n \overline{w}_{c,r} g^n_{c,r} + \boldsymbol{\beta}_X \boldsymbol{X}_{i,c,r} + \boldsymbol{\beta}_C \boldsymbol{C} + \boldsymbol{\beta}_A \boldsymbol{A.R} + \boldsymbol{\beta}_S \boldsymbol{S.R} + \boldsymbol{\beta}_T \boldsymbol{T.R} + \varepsilon_{i,c,r}$$

This equation states that wasting risks (w) for child i in country c and region r modelled as a function of lagged negative (g^n) interacted with average wasting prevalence across all rounds ($\overline{w}$). We note that $\overline{w}$ refers to each of the specific wasting indicators described above, depending on which is specified on the left-hand side of equation (1), and also that g^n is re-scaled to the unit of a 10 percent change in GNI. The remaining variables include a vector of control variables from the DHS ($\boldsymbol{X}$), country fixed effects ($\boldsymbol{C}$), and three types of region-specific temporal effects (child age effects ($\boldsymbol{A.R}$), seasonality effects ($\boldsymbol{S.R}$) and trend effects ($\boldsymbol{T.R}$)). Standard errors (ε) are clustered at the DHS cluster level for the calculation of 95% confidence intervals (CIs) in all tables, although the graphs report 90% CIs to reflect one-sided tests of the null hypothesis that the growth elasticities are significantly below zero. All analysis was conducted in STATA™ Version 16.

Although all our regressions follow the basic structure of equation (1) we conduct several sample restrictions and specification modifications.

First, we explore the influence on key results of excluding various sets of control variables, as well to exclusion of extreme growth outliers. Our assumption is that many DHS controls are pre-determined and not influenced by recent growth shocks, including household assets, parental education, sanitation and water sources, but access to health services might indeed be seriously affected by shocks.

Second, we explore variation in wasting impacts by child age since previous research has shown that wasting prevalence is higher in young children (e.g. <2 years) and that wasting risks in younger children appear are more sensitive to various nutritional insults.[33]

Third, we introduce interactions with urban and girl dummies to test for differential impacts of growth shocks on boys and girls and rural and urban children since previous research on the health and nutrition

impacts of economic shocks suggests impacts may differ by gender[33-35] and that urban populations are typically more vulnerable to economic crises than rural populations.[36-38]

Finally, we explore potential mechanisms linking GNI shocks to wasting, including symptoms of common childhood infections such as diarrhea and fevers, as well as child dietary diversity and its individual food group components. These regressions follow the same structure as equation (1), but with disease or dietary diversity as dependent variables, while growth shocks are modelled contemporaneously rather than lagged under the assumption that diseases and dietary responses to growth shocks are more rapid than wasting responses. We then estimate wasting regressions with disease symptoms and dietary diversity as explanatory variables to further test the validity of these mechanisms.

4. Descriptive Results

Table 1 reports descriptive statistics for the key variables used in our analysis. The sample size of 1.256 million children is determined by availability of WHZ and DHS control variables for all children 0-59 months (diarrhea and fever were available for a slightly smaller sample, while child MDD was available only in more recent DHS surveys for children 6-36m). The listing of all 177 surveys and their wasting and lagged GNI growth rates are reported in Table A1, while Table A2 reports total sample sizes by country.

The mean prevalence of moderate/severe wasting among all children 0-59m was 11%, but any form of wasting was 28%, while severe wasting was 4% (Table 1). Wasting prevalence is often substantially higher for younger children, however. Figure 1 reports moderate/severe wasting prevalence for children 0-35m for the most recent DHS round in all surveyed countries (including those not in our data) according to established national thresholds of low/very low (<5%), medium (5-10%), high (10-15%) and very high (>15%).[39] Wasting prevalence is very high in South Asia, especially India (23.4%) and Bangladesh and moderately high in other Asian countries. In sub-Saharan Africa wasting prevalence is very high in Sahelian. Wasting prevalence is high in Ethiopia and medium in Kenya. Wasting is typically medium (5-10%) in West and Central Africa, but generally relatively low in Eastern and Southern Africa. Outside of sub-Saharan Africa and South Asia wasting prevalence is generally low.

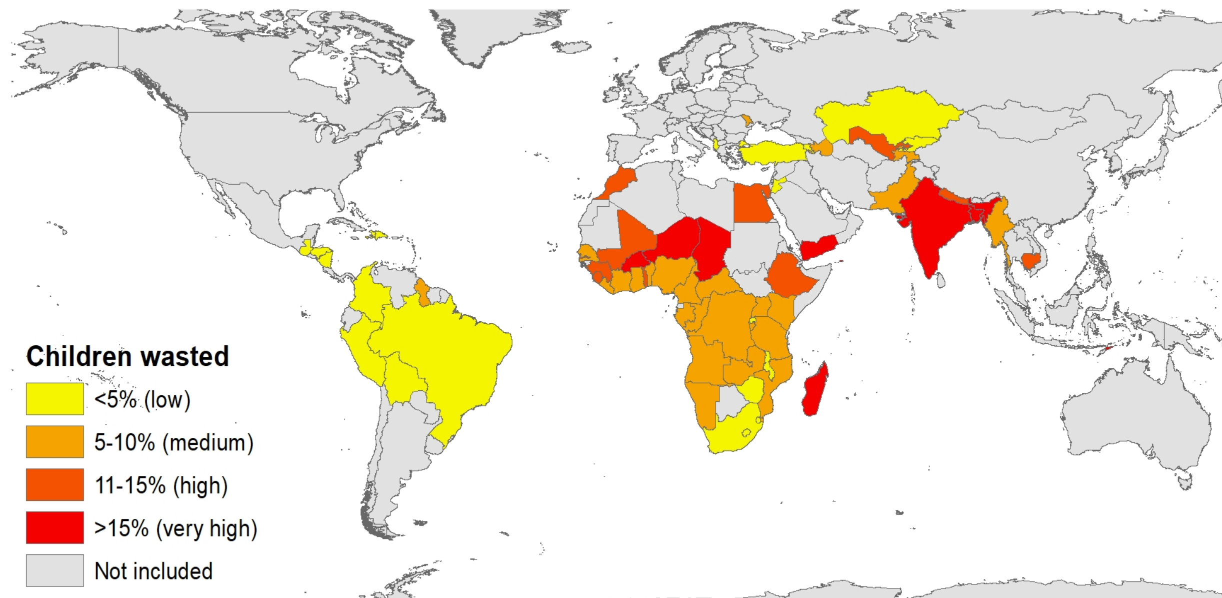
Figure 2 estimates moderate/severe wasting prevalence by child age for each region in sub-Saharan Africa and Asia using local polynomial estimates that allow for flexible curvature. We find strikingly distinct differences in the progression of wasting between Asian and Africa children. In South Asia and South-East Asia peak wasting prevalence occurs at birth, consistent with previously observed differences in birth weight and maternal weight gain across the two regions.[40] Across all South Asian surveys, the results suggest that 27.5% of South Asian children were born moderately/severely wasted, but wasting prevalence declines to 16% by 36 months. South-East Asian children follow a similar trajectory, but with just 17% of children born wasted. In sub-Saharan Africa these cohorts of children follow a very different pattern: they are commonly born wasted (21% in the Sahel); wasting rates are then typically steady for the first few months of life, perhaps because of some protection of predominant breastfeeding (the Sahel is an exception, however); wasting rates then increase up until 10-12 months of age where they peak before declining. In the Sahel these dynamics are noticeably accentuated: 21% are born wasted, but by 11 months wasting prevalence reaches 30% and thereafter declines to 10% by 36 months.

Table 1. Descriptive statistics for key variables

Variable	N	Mean	Std. Dev.	Min	Max
Nutrition outcomes					
Any Wasting (WHZ<-1)	1,256,076	0.28	0.45	0.00	1.00
Moderate/severe wasting (WHZ<-2)	1,256,076	0.11	0.31	0.00	1.00
Severe Wasting (WHZ<-3)	1,256,076	0.04	0.20	0.00	1.00
National-level indicators					
Growth in GNI per capita (%) (UN), lag 1 year	1,256,076	3.19	5.31	-28.75	52.31
Growth in GNI per capita (%) (WB), lag 1 year	1,125,338	3.01	4.13	-17.45	20.71
Total annual rainfall (mm), lag 1 year	1,256,076	1096.06	628.17	19.38	3508.74
Average temperature (C), lag 1 year	1,256,076	23.89	3.90	3.79	29.32
Battle-related deaths per 100,000 people	1,256,076	0.49	2.34	0.00	24.65
Individual, mother, household indicators					
Household owns no DHS assets	1,256,076	0.34	0.47	0.00	1.00
Household owns some (< 5 y) assets	1,256,076	0.58	0.49	0.00	1.00
Household owns all 5 assets	1,256,076	0.07	0.25	0.00	1.00
Mother has 9 or more years of schooling	1,256,076	0.27	0.44	0.00	1.00
Household has piped water	1,256,076	0.40	0.49	0.00	1.00
Household has flush toilet	1,256,076	0.30	0.46	0.00	1.00
Child born in medical facility	1,256,076	0.60	0.49	0.00	1.00
Mother received 4 or more ANC visits	1,256,076	0.55	0.50	0.00	1.00
Child received all vaccinations	1,256,076	0.47	0.50	0.00	1.00
Teenage mother (at birth)	1,256,076	0.18	0.38	0.00	1.00
Mother has 4 or more children	1,256,076	0.39	0.49	0.00	1.00
Household is rural	1,256,076	0.67	0.47	0.00	1.00
Child is girl	1,256,076	0.49	0.50	0.00	1.00
Wasting mechanisms					
Child had diarrhea in past 2 weeks	1,230,393	0.15	0.35	0.00	1.00
Child had fever in past 2 weeks	1,230,393	0.09	0.28	0.00	1.00
Mother has low BMI (<18.5)	884,436	0.12	0.32	0.00	1.00
Child meets minimum dietary diversity (MDD)	323,014	0.32	0.47	0.00	1.00
Starchy staples in past 24 hours	323,014	0.72	0.45	0.00	1.00
Legumes/nuts in past 24 hours	323,014	0.24	0.42	0.00	1.00
Dairy in past 24 hours	323,014	0.42	0.49	0.00	1.00
Flesh foods in past 24 hours	323,014	0.34	0.48	0.00	1.00
Eggs in past 24 hours	323,014	0.20	0.40	0.00	1.00
Vitamin A-rich fruits/vegetables in past 24 hours	323,014	0.43	0.49	0.00	1.00
Other fruits/vegetables in past 24 hours	323,014	0.27	0.44	0.00	1.00

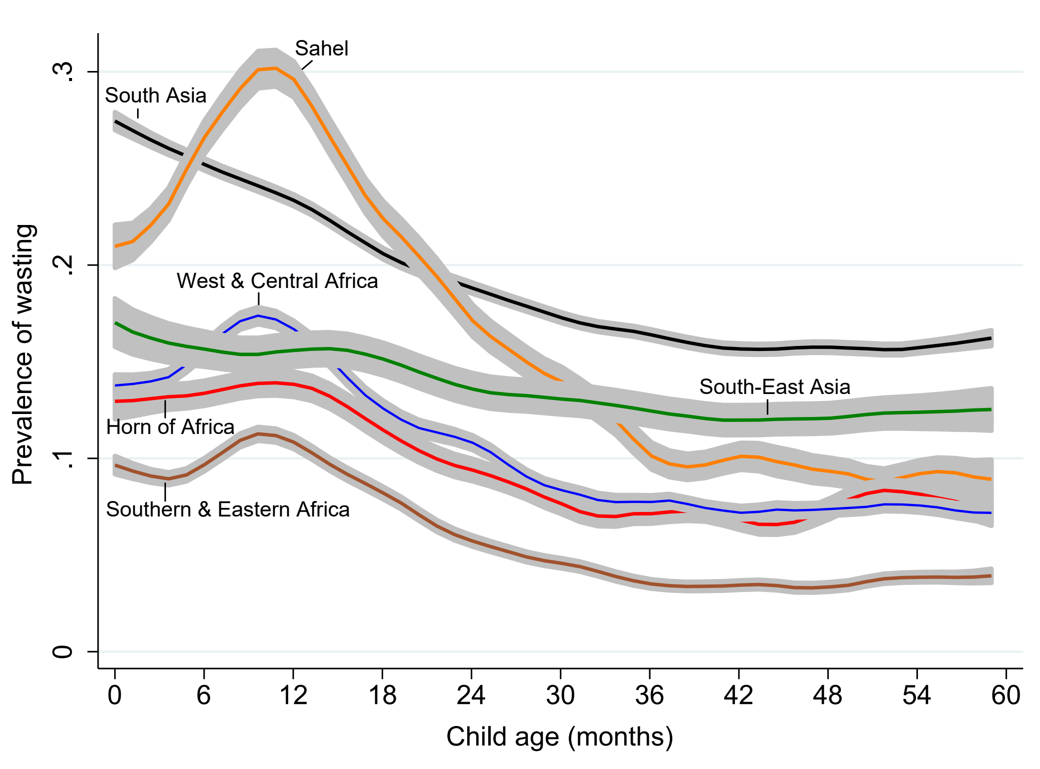
Source: Authors' estimates. See text for details on sources. UN=United Nations; WB=World Bank.

Figure 1. Prevalence of moderate/severe wasting among children 0-35 months of age



Source: Authors' construction from survey-weighted estimates for children 0-35m of age in 67 countries. Data pertain to the most recent DHS round.

Figure 2. Local polynomial estimates of moderate/severe wasting (WHZ< -2) prevalence against child age for various regions in Asia and sub-Saharan Africa (95% confidence intervals)



Source: Authors' estimates from DHS data using the *lpolyci* command in STATA™. Sample sizes are as follows: South Asia = 402990; South-East Asia = 27,614; Sahel = 80,717; West and Central Africa = 248,204; Horn of Africa = 68,608; Southern and Eastern Africa = 228,818.

The remaining indicators reported in Table 1 show means and spreads for some of the key explanatory variables, as well as indicators of possible mechanisms linking growth shocks to wasting impacts, while Appendix Figure A1 reports a histogram showing the frequency distribution of lagged annual changes in GNI for the 210 surveys in our sample. The lagged average annual growth rate was positive (3.2%) but there was large variation in growth rates across survey years, and just under one quarter of these DHS surveys were preceded by negative GNI growth in the preceding year, mostly in sub-Saharan Africa. Table 1 also indicates that the DHS sample of children are mostly found in poor countries with mean GDP per capita varying between $213 and $9,364. Moreover, 34% of the sample owned none of the five listed assets and just 7% owned all five assets; education, health and demographic indicators are consistent with low levels of development. Diarrhea and fever were also common in the two weeks prior to the interview, 12% of mothers had low BMI, and less than one third of children 6-35m achieved minimum dietary diversity (a proxy for dietary quality).

5. Multivariate regression results

Main results

Our main DiD findings are reported in Table 2, which shows results from a linear probability model for any wasting (WHZ<-1), moderate/severe wasting (WHZ<-2) and severe wasting (WHZ<-3) for the

aggregate sample of 1.256 million children 0-59 months of age. The model follows equation (1) in controlling for country fixed effects and various region-specific temporal effects (not reported). The principal finding is that the GNI growth elasticities for wasting are negative and highly statistically significant. In absolute magnitude, the growth elasticity increases with the severity of wasting; a 10% increase in GNI is associated with a 7% reduction in mild wasting, 14% reduction in moderate/severe wasting, and 22% reduction in severe wasting. The effects are large, however, suggesting that wasting is highly responsive to short run economic growth.

In Table 3 we demonstrate the magnitude of the predicted impacts for the example of India. Prior to COVID19 India already had very high rates of mild wasting (27.3%), moderate wasting (12.2%) and severe wasting (8.0%) by international standards, and it has a vast population of almost 117 million children < 5 years of age. Were the COVID-19 crisis to result in a 10% decline in GNI, our model suggests that 3.946 million children would be newly wasted: 542,975 mildly wasted, 1.322 million moderately wasted, and 2.081 million severely wasted, with greatly elevated risk of mortality. We note that an assumption of a 10% decline in GNI is close to the estimate of a 9.5% decline in India's GDP in 2020 relative to a counterfactual GNI in 2020 without COVID-19, derived from a global economic model.[4]

Coefficients on the control variables also shed light on some of the non-income risk factors for wasting. As expected, asset wealth is a very strong predictor of stunting risk: households that own all five assets have children 2.8 points less likely to be moderately/severely wasted. The risk of wasting is also substantially reduced for children with more educated mothers, piped water (a modest association), flush toilets (a stronger association), and greater use of antenatal care, neonatal care and postnatal care. Demographic effects are modest although girls are significantly less likely to be wasted than boys, ceteris paribus. Amongst these it is clear that magnified interruptions to healthcare during COVID-19 could compound the adverse effects on wasting from economic shocks.[41]

Table 2. Difference-in-difference linear probability models of wasting risks (children 0-59 months)

	(1) N=1,256,076 Any wasting (WHZ < -1)	(2) N=1,256,076 Moderate/severe wasting (WHZ < -2)	(3) N=1,256,076 Severe wasting (WHZ < -3)
Growth elasticity ($w.g^n$)	-0.071*** (-0.092, -0.050)	-0.144*** (-0.185, -0.103)	-0.222*** (-0.293, -0.151)
Household has some assets vs none	-0.019*** (-0.027, -0.011)	-0.015*** (-0.021, -0.009)	-0.009*** (-0.013, -0.005)
Household has all 5 assets vs none	-0.051*** (-0.065, -0.036)	-0.028*** (-0.038, -0.018)	-0.012*** (-0.018, -0.005)
Mother 9+ years of schooling	-0.034*** (-0.042, -0.027)	-0.025*** (-0.031, -0.019)	-0.013*** (-0.016, -0.010)
Household has piped water	0.000 (-0.007, 0.008)	0.006** (0.001, 0.012)	0.004** (0.001, 0.008)
Household has flush toilet	-0.036*** (-0.045, -0.027)	-0.026*** (-0.032, -0.020)	-0.009*** (-0.013, -0.005)
Child born in medical facility	-0.027*** (-0.033, -0.020)	-0.014*** (-0.019, -0.009)	-0.004*** (-0.007, -0.001)
4 or more ANC visits	-0.015*** (-0.021, -0.009)	-0.011*** (-0.016, -0.007)	-0.006*** (-0.009, -0.003)
Received all vaccinations	-0.013*** (-0.019, -0.007)	-0.015*** (-0.019, -0.011)	-0.011*** (-0.014, -0.008)
Teenage pregnancy	0.001 (-0.007, 0.008)	-0.003 (-0.009, 0.002)	-0.003 (-0.006, 0.001)
Mother has 4 or more children	0.002 (-0.005, 0.008)	0.003 (-0.002, 0.008)	0.001 (-0.002, 0.004)
Rural community	-0.007* (-0.015, 0.001)	-0.007** (-0.012, -0.001)	-0.005*** (-0.009, -0.002)
Female child	-0.018*** (-0.023, -0.013)	-0.018*** (-0.022, -0.014)	-0.010*** (-0.013, -0.008)
Country fixed effects?	Yes	Yes	Yes
Region-specific trends, seasonality and age dynamics?	Yes	Yes	Yes
R-squared	0.119	0.068	0.033

Notes: 95% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses, with significance levels as follows: *** p<0.01, ** p<0.05, * p<0.10. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics and trend effects. Regressions are weighted to be representative of the < 5 year population of children of all countries included in this DHS dataset.

Table 3. Estimating the potential increase in different degrees of wasting in India based on an assumed 10% decline in GNI per capita due to the COVID19 crisis

		Specific categories of wasting			
	Any wasting (WHZ<-1)	Mild wasting (-2<WHZ<-1)	Moderate wasting (-3<WHZ<-2)	Severe wasting (WHZ<-3)	All children < 5 years
Pre-COVID19 wasting prevalence	47.56%	27.33%	12.20%	8.02%	
Pre-COVID wasting numbers	55,584,165	31,948,744	14,261,193	9,374,227	116,879,507
Change due to 10% decline in GNI	3.38%	0.46%	1.13%	1.78%	
Post-COVID wasting prevalence	50.93%	27.80%	13.33%	9.80%	
Newly wasted Indian children	3,946,476	542,975	1,322,422	2,081,078	

Source: Authors' estimates based on the results in Table 2. Specifically, we apply the estimates elasticities for a 10% GNI to any wasting, moderate/severe wasting and severe wasting, then deduct the number of severely wasted children from the severe/moderate category to obtain an estimate for moderately wasted, and deduct moderate/severe wasted children from any wasting to obtain estimates for mild wasting.

Additional results report robustness of these core results to variations in specifications and samples. Appendix Figure A2 reports sensitivity of the estimates to different specifications, starting with a very basic DiD with no controls and sequentially adding different sets of DHS-based controls, then the addition of national level lagged changes in rainfall, temperature and battle deaths, removal of unusually high or low GNI growth rates and replacement of the UN-based GNI growth measure with a measure from the World Bank. The estimated elasticities are statistically significant and below zero in all 21 regressions, and even the magnitudes remain largely unchanged. The main exception is that the World Bank-based GNI growth measure produces elasticities that are substantially larger in absolute magnitude but less precisely estimated from a smaller sample of surveys (however, the change in elasticity is not due to the change in sample size).

While Table 2 reported results for a pooled sample of children < 5 years , Figure A3 reports the variation in growth elasticities of wasting for different age ranges. Somewhat consistent with Figure 2, we find that the estimated elasticities for any wasting and moderate/severe wasting show some tendency to peak in the 6-11m range but the differences are modest and not statistically significant, and most elasticities seem relatively constant over different age ranges.

Appendix Table A3 reports tests for differential impacts across urban and rural children and boys and girls. We find no statistically significant differences by gender, although we find that the growth elasticity for any wasting is significant larger in absolute magnitude in urban areas (-10.07 for urban children compared to -6.00 for rural children). A similar pattern holds for moderate/severe wasting, although the interaction term is only significant at the 13% level. These results are broadly consistent with macroeconomic shocks often having more adverse impacts on the urban poor.[36-38]

Table 4 explores potential mechanisms linking growth shocks to changes in wasting (Appendix Table A4 reports results that include control variables). Both poor diets and disease can lead to wasting (although wasting can lead to disease also), but poor maternal nutrition could also affect neonatal weight or have more complex indirect effects, and also might proxy for general household food and nutrition insecurity. We also note that DHS morbidity symptoms and diet indicators are crude proxies that rely on maternal recall and do not gauge the severity of symptoms and related illness or the magnitude of nutrient inadequacies.

Regressions (1) and (2) use diarrhea and fever in the preceding two weeks as dependent variables. The GNI growth elasticities for diarrhea and fever are both negative and highly statistically significant and similar in magnitude (about 0.07). The growth elasticity for low maternal BMI is also significant and negative and of a similar magnitude: a 10% reduction in GNI per capita would increase low BMI prevalence by around 8.7%.

In the smaller sample of children with dietary data we find a positive and relatively large elasticity between minimum dietary diversity prevalence and GNI growth of 0.19, suggesting child dietary diversity is highly sensitive to fluctuations in economic growth. Appendix Figure A4 looks at GNI growth elasticities for individual food groups. As might be expected, the growth elasticity for starchy staples is not significantly different from zero, but all other elasticities are positive and significantly larger than zero at the 5% level. Legumes/nuts, dairy, eggs and vitamin A-rich fruits and vegetables have modest elasticities (less than 0.1), whereas flesh foods and other fruit/vegetables have especially large elasticities, suggesting that children's consumption of these foods is highly sensitive to income fluctuations.

Are these mechanism indicators correlated with wasting? In regression (5) we test associations between moderate/severe wasting and child morbidity symptoms and low maternal BMI in a model that exclude GNI growth, while regression (6) also includes MDD in the more limited sample of children with dietary data. Both diarrhea and fever prevalence predict increased risks of wasting, as does low maternal BMI, while achieving minimum dietary diversity reduces the risk of wasting by 1 percentage point. The results in Table 3 are therefore consistent with both disease and dietary mechanisms explaining the adverse impacts of growth shocks on child wasting, as well as a possible mechanism via maternal nutrition.

Table 4. Exploring disease and diet mechanisms linking GNI growth shocks and child wasting

	(1)	(2)	(3)	(4)	(5)	(6)
	N=1,230,393	N=1,230,393	N=884,436	N=323,014	N=1,174,216	N=302,542
Dependent variable	Diarrhea in past 2 weeks	Fever-only in past 2 weeks	Low maternal BMI	Minimum diet diversity	Moderate or severe wasting	Moderate or severe wasting
Age range	0-59m	0-59m	15-49 years	6-35m	0-59m	6-35m
Growth elasticity ($w.g^n$)	-0.073***	-0.071***	-0.087***	0.194***		
	(-0.101, -0.046)	(-0.104, -0.039)	(-0.126, -0.047)	(0.157, 0.230)		
Diarrhea in past 2 weeks					0.018***	0.018***
					(0.012, 0.024)	(0.005, 0.030)
Fever-only in past 2 weeks					0.016***	0.025***
					(0.011, 0.021)	(0.013, 0.037)
Mother underweight					0.068***	0.075***
					(0.061, 0.075)	(0.063, 0.087)
Minimum diet diversity						-0.015***
						(-0.024, -0.006)
R-squared	0.063	0.065	0.164	0.156	0.072	0.073

Notes: 95% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses, with significance levels as follows: *** p<0.01, ** p<0.05, * p<0.10. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics and trend effects. Note that these regressions refer to contemporaneous GNI growth rates rather than lagged growth rates. Regressions are weighted to be representative of the < 5 year population of children of all countries included in this DHS dataset.

5. Discussion

This study examined the impact of recent economic shocks on the risk of child wasting in LMICs using data on large numbers of under-5 children linked to lagged changes in national income. We find robust evidence that the elasticity of wasting with respect to recent income changes is negative and relatively large in magnitude, implying that a 10% decline in national income would predict a 14% increase in moderate/severe wasting and a 22% increase in severe wasting. The results are generally robust to variations in specification, although point estimates using World Bank GNI data are larger in absolute magnitude. We find no evidence of significantly different impacts on boys and girls and only modest evidence of more significant impacts among urban children. However, we do find evidence that both morbidity and poor diets are likely part of the pathways from economic shocks to increased wasting. We also find evidence consistent with a possible causal link between maternal nutrition and child wasting, although maternal nutrition could also be a proxy for household food or nutrition insecurity, implying this evidence should be treated with caution.

This study makes a novel contribution to the existing literature on economic growth and nutrition, which has been largely confined to studying the impacts of longer term economic growth on child stunting.[7-13] Moreover, since wasting is a major risk factor in early childhood mortality,[42] our results help explain previous findings demonstrating that adverse economic shocks in LMICs significantly increase child mortality rates.[9]

Our findings are also highly relevant in the context of the complex COVID-19 crisis because they predict that the aggregate income shocks alone will have severe impacts on wasting, which in turn is associated with large increases in mortality, especially for severe wasting.[6] The size of these shocks is uncertain, however. Estimates of annual GDP growth from the IMF[1] released in April 2020 appeared overly optimistic at the time,[2] but in light of new economic data they appear well off the mark. For example, the IMF predicted that the Indian economy would grow by a modest 0.5% in 2020, but various financial intelligence agencies now predict a decline of between 4.7 and 7.0%,[43] and a global analysis of the potential impacts of COVID-19 predicted that Indian GDP would be 10% lower than it would have been without COVID-19's economic disruptions.[4] Using that estimate we predict that approximately 4 million Indian children that would not have been wasted in the absence of the COVID19 crisis will now be wasted, including over 3 million severely wasted children who are almost 12 times more likely to die before their fifth birthday. Other major countries with large populations of nutritionally vulnerable children – such as Nigeria, a major oil exporter – could experience even sharper economic contractions.

This study has limitations, particularly for the extrapolation to the COVID-19 crisis. Although we have a large sample of children, the number of economic shocks we study is small and offers limited opportunities for exploring heterogeneity across shocks. Some macroeconomic shocks are accompanied by rising food prices, for example, but the real GNI indicator used herein only partially incorporates the real income effects of rising food prices. It is also well known that national income measures are imperfect predictors of household welfare,[44] and some early country case studies suggest that losses in household income will be much larger than losses in national income averaged over the population.[45] As a result, the impacts of any specific economic shock in 2020 could differ substantially from the predictions of our model both in aggregate terms and in relation to the distribution of impacts across rural and urban populations or other demographic groups. Our expectation is that these estimates may therefore be conservative when applied to the COVID-19 crisis, unless greater efforts are made to protect vulnerable groups through both income support and continued provision of essential health and nutrition services.

A final limitation is that this study only assessed the impacts on wasting due to economic shocks. While these income channels are important, the COVID-19 crisis will also affect child wasting and mortality through health system disruptions, including suspension of a range of essential nutrition and health actions such as antenatal care, vitamin A supplementation, and immunization, and the prevention and treatment of severe acute malnutrition and infections.[46] Reassignment of health staff to COVID-19 tasks, restrictions on mobility, lack of transport, and fear of using health services will also affect access to and utilization of health and nutrition services. A recent COVID-19 study estimated that different scenarios of reduced coverage of health and nutrition services combined with assumptions about increases in wasting could result in between 253,500 and 1,157,000 additional deaths in under-five children in LMICs, depending on the degree and duration of health services disruptions and the level of increase in wasting.[41] With these scenarios, wasting would account for close to 25% of the additional deaths. Our study complements these findings by identifying an important channel of impact: negative economic shocks increasing the risk of all types of wasting. This implies that efforts to protect health systems also need to be bolstered by nutrition-sensitive social protection programs to protect incomes of poor and vulnerable populations. Malnutrition, as is well recognized, is a multidimensional problem requiring concerted multisectoral solutions, especially in the devastating wake of COVID-19.

Appendix

Table A1. Wasting prevalence and GNI growth by country and DHS round

Country	Survey year(s)	Any wasting (WHZ<-1)	Moderate/severe wasting (WHZ<-2)	Severe wasting (WHZ<-3)	GNI growth (lag 1 year)
Albania	2017-2018	2.15%	7.62%	0.79%	3.64%
Armenia	2000-2000	2.30%	7.18%	0.75%	3.77%
Armenia	2005-2005	5.31%	12.58%	2.70%	15.71%
Armenia	2010-2010	4.28%	11.56%	2.03%	-15.33%
Armenia	2015-2016	5.24%	11.06%	2.07%	2.17%
Bangladesh	1996-1997	21.30%	48.43%	7.80%	2.49%
Bangladesh	1999-2000	12.67%	44.09%	2.78%	3.01%
Bangladesh	2004-2004	14.66%	46.53%	3.71%	4.37%
Bangladesh	2007-2007	17.27%	52.01%	3.49%	5.74%
Bangladesh	2011-2011	15.94%	48.45%	4.35%	4.56%
Bangladesh	2014-2014	15.75%	44.80%	4.33%	4.39%
Benin	2001-2001	10.15%	26.83%	3.89%	2.73%
Benin	2006-2006	9.10%	22.96%	3.68%	-0.80%
Benin	2011-2012	17.61%	29.87%	10.09%	0.44%
Benin	2017-2018	5.25%	23.34%	1.21%	2.59%
Bolivia	1998-1998	1.98%	6.46%	0.85%	3.48%
Bolivia	2003-2003	2.16%	6.79%	1.01%	0.45%
Bolivia	2008-2008	1.70%	6.23%	0.72%	5.65%
Burkina Faso	1993-1993	14.86%	36.26%	5.90%	-1.00%
Burkina Faso	1998-1999	15.79%	37.39%	5.99%	3.93%
Burkina Faso	2003-2003	24.18%	43.41%	12.70%	1.60%
Burkina Faso	2010-2010	15.96%	37.57%	6.53%	-0.97%
Burundi	2010-2010	6.27%	23.00%	1.77%	-0.05%
Burundi	2016-2017	5.12%	23.44%	0.88%	-4.13%
Cambodia	2000-2000	17.79%	41.75%	8.45%	7.97%
Cambodia	2005-2005	8.65%	35.14%	1.66%	9.88%
Cambodia	2010-2010	12.07%	36.81%	3.93%	-1.49%
Cambodia	2014-2014	10.20%	35.96%	3.31%	6.68%
Cameroon	2004-2004	6.18%	16.84%	2.44%	4.61%
Cameroon	2011-2011	5.84%	17.67%	1.97%	3.68%
Chad	2004-2004	18.60%	40.51%	8.39%	-5.57%
Chad	2014-2015	15.29%	38.21%	5.29%	-3.33%
Colombia	1995-1995	1.77%	10.16%	0.63%	5.86%
Colombia	2000-2000	1.35%	7.50%	0.52%	-5.83%
Colombia	2005-2005	2.22%	11.76%	0.66%	2.84%
Colombia	2010-2010	1.16%	8.62%	0.26%	0.59%
Congo Rep.	2005-2005	8.53%	21.49%	3.97%	-7.30%
Congo Rep.	2011-2012	5.75%	22.06%	1.85%	12.41%
Congo DRC	2007-2007	11.14%	26.97%	5.68%	-0.78%
Congo DRC	2013-2014	8.76%	24.96%	3.57%	3.09%
Cote d'Ivoire	1998-1999	6.74%	22.41%	2.31%	4.07%
Cote d'Ivoire	2011-2012	7.43%	23.07%	2.14%	-6.14%
Dominican Rep.	1996-1996	2.27%	11.53%	0.68%	5.02%
Dominican Rep.	2002-2002	2.27%	10.54%	0.90%	0.32%
Dominican Rep.	2007-2007	2.23%	10.19%	0.84%	9.69%
Dominican Rep.	2013-2013	2.56%	12.57%	0.80%	1.39%
Egypt	1992-1992	4.20%	9.87%	1.98%	4.65%

Egypt	1995-1995	6.37%	14.17%	2.98%	2.91%
Egypt	2000-2000	3.23%	8.17%	1.56%	3.99%
Egypt	2003-2003	5.09%	16.40%	1.89%	0.49%
Egypt	2005-2005	5.68%	13.20%	2.73%	2.12%
Egypt	2008-2008	8.34%	16.04%	4.36%	7.68%
Egypt	2014-2014	12.95%	23.12%	7.55%	-0.77%
Ethiopia	2000-2000	14.34%	38.57%	4.88%	-10.41%
Ethiopia	2005-2005	13.71%	34.61%	5.66%	10.43%
Ethiopia	2011-2011	12.15%	36.00%	3.63%	-1.26%
Ethiopia	2016-2016	12.37%	35.56%	3.66%	7.24%
Gabon	2000-2000	4.48%	15.07%	1.65%	-28.47%
Gabon	2012-2012	4.61%	15.83%	1.83%	10.59%
Ghana	1998-1998	10.27%	30.99%	2.95%	1.81%
Ghana	2003-2003	9.60%	26.21%	3.44%	2.19%
Ghana	2008-2008	10.15%	28.92%	3.57%	1.76%
Ghana	2014-2014	5.05%	24.14%	1.11%	8.10%
Guatemala	1995-1995	4.35%	13.18%	1.81%	1.83%
Guatemala	1998-1999	3.04%	10.08%	1.41%	2.87%
Guatemala	2014-2015	0.74%	7.12%	0.12%	1.78%
Guinea	1999-1999	10.50%	28.04%	4.77%	1.52%
Guinea	2005-2005	11.51%	27.70%	4.68%	-0.09%
Guinea	2012-2012	11.43%	29.10%	5.26%	4.98%
Guinea	2018-2018	9.39%	25.69%	4.13%	10.19%
Haiti	2000-2000	6.16%	20.41%	2.05%	0.66%
Haiti	2005-2006	9.57%	23.44%	3.75%	-1.41%
Haiti	2012-2012	5.37%	21.02%	1.71%	4.12%
Haiti	2016-2017	3.80%	16.45%	0.95%	0.17%
Honduras	2005-2006	1.46%	8.48%	0.40%	3.81%
Honduras	2011-2012	1.47%	9.25%	0.33%	0.12%
India	2005-2006	19.26%	46.41%	7.40%	6.22%
India	2015-2016	21.18%	47.92%	8.84%	6.53%
Jordan	1990-1990	4.49%	12.92%	1.77%	-18.18%
Jordan	1997-1997	2.37%	11.71%	0.62%	-0.82%
Jordan	2002-2002	2.47%	12.02%	0.78%	3.98%
Jordan	2012-2012	2.42%	10.66%	0.86%	-2.70%
Kazakhstan	1995-1995	6.50%	16.38%	1.98%	-11.94%
Kazakhstan	1999-1999	2.97%	12.28%	1.19%	-0.44%
Kenya	1993-1993	7.54%	22.10%	2.86%	-3.12%
Kenya	1998-1998	8.79%	23.63%	4.10%	-2.48%
Kenya	2003-2003	7.42%	21.33%	3.31%	-2.27%
Kenya	2008-2009	8.92%	23.99%	3.42%	0.46%
Kenya	2014-2014	5.85%	21.59%	1.55%	2.66%
Lesotho	2004-2004	6.10%	16.00%	3.42%	3.78%
Lesotho	2009-2010	4.93%	16.25%	2.24%	3.77%
Lesotho	2014-2014	3.93%	12.55%	1.39%	-0.22%
Liberia	2007-2007	8.40%	21.65%	3.76%	14.41%
Liberia	2013-2013	6.77%	21.61%	2.62%	-0.13%
Madagascar	1992-1992	6.26%	25.24%	1.33%	-11.19%
Madagascar	1997-1997	10.12%	30.99%	3.19%	0.11%
Madagascar	2003-2004	15.45%	37.11%	6.34%	-0.71%
Malawi	1992-1992	5.93%	17.08%	2.14%	7.39%
Malawi	2000-2000	6.93%	17.76%	2.96%	-0.86%
Malawi	2004-2004	6.97%	16.27%	3.61%	2.33%
Malawi	2010-2010	4.46%	13.82%	1.77%	6.14%
Malawi	2015-2016	3.40%	14.28%	0.93%	2.37%
Maldives	2009-2009	12.14%	37.16%	3.52%	6.94%

Maldives	2016-2017	10.10%	36.20%	2.59%	1.13%
Mali	2006-2006	17.37%	37.34%	7.79%	6.89%
Mali	2012-2013	13.81%	32.67%	6.18%	5.85%
Mali	2018-2018	9.88%	32.83%	3.15%	4.22%
Morocco	1992-1992	2.79%	8.69%	1.27%	4.64%
Morocco	2003-2004	11.86%	22.09%	6.14%	3.23%
Mozambique	2003-2003	5.39%	15.83%	2.38%	1.08%
Mozambique	2011-2011	5.72%	16.36%	2.14%	10.88%
Namibia	1992-1992	9.50%	28.00%	3.19%	6.05%
Namibia	2000-2000	10.69%	31.81%	3.63%	-1.76%
Namibia	2006-2007	8.40%	26.95%	2.68%	4.13%
Namibia	2013-2013	8.86%	27.36%	3.40%	1.85%
Nepal	2001-2001	10.81%	38.57%	2.70%	4.48%
Nepal	2006-2006	12.69%	42.11%	2.98%	2.78%
Nepal	2011-2011	10.93%	37.48%	2.92%	3.88%
Nepal	2016-2016	9.85%	36.82%	2.01%	2.64%
Nicaragua	1998-1998	3.35%	10.79%	1.63%	4.76%
Nicaragua	2001-2001	2.54%	9.35%	1.09%	2.64%
Niger	2006-2006	13.34%	35.02%	5.06%	3.66%
Niger	2012-2012	19.50%	44.30%	8.40%	-1.64%
Nigeria	1990-1990	10.92%	27.87%	4.25%	0.19%
Nigeria	2003-2003	12.45%	29.06%	5.82%	14.46%
Nigeria	2008-2008	16.86%	30.19%	10.07%	-1.88%
Nigeria	2013-2013	17.91%	36.33%	9.16%	1.61%
Pakistan	1990-1991	11.09%	28.18%	4.08%	1.89%
Pakistan	2012-2013	11.04%	29.13%	4.50%	1.42%
Pakistan	2017-2018	9.47%	25.80%	4.22%	3.03%
Peru	1991-1992	2.33%	7.95%	0.90%	-5.35%
Peru	1996-1996	2.34%	6.89%	1.12%	5.10%
Peru	2000-2000	1.84%	6.44%	0.69%	-0.19%
Peru	2003-2008	1.08%	4.82%	0.28%	6.23%
Peru	2009-2009	0.77%	5.03%	0.29%	9.23%
Peru	2010-2010	0.83%	5.70%	0.18%	1.01%
Peru	2011-2011	0.59%	5.18%	0.12%	6.17%
Peru	2012-2012	0.67%	5.69%	0.16%	5.43%
Rwanda	1992-1992	5.05%	17.68%	1.95%	-0.97%
Rwanda	2000-2000	9.09%	21.62%	4.10%	-0.86%
Rwanda	2005-2005	4.96%	14.58%	1.74%	6.07%
Rwanda	2010-2010	3.00%	10.86%	1.00%	3.96%
Rwanda	2014-2015	2.41%	9.23%	0.89%	3.49%
Senegal	1992-1993	9.81%	28.37%	3.44%	-1.21%
Senegal	2005-2005	9.45%	30.85%	2.62%	3.51%
Senegal	2010-2011	10.24%	34.02%	3.02%	0.76%
Senegal	2012-2013	10.37%	36.49%	2.78%	-1.34%
Senegal	2014-2014	6.99%	30.49%	1.05%	5.04%
Senegal	2017-2017	9.71%	36.83%	1.71%	3.45%
Sierra Leone	2008-2008	11.74%	25.91%	5.90%	2.00%
Sierra Leone	2013-2013	10.45%	21.88%	5.41%	17.89%
Tajikistan	2012-2012	10.56%	25.24%	4.75%	-4.17%
Tajikistan	2017-2017	6.74%	19.32%	2.42%	-3.31%
Tanzania	1991-1992	8.70%	23.08%	3.35%	3.70%
Tanzania	1996-1996	9.24%	25.35%	3.58%	1.23%
Tanzania	1999-1999	5.87%	21.75%	2.35%	2.15%
Tanzania	2004-2005	4.51%	18.22%	1.50%	3.76%
Tanzania	2010-2010	6.82%	20.82%	2.35%	2.56%
Tanzania	2015-2016	5.11%	19.50%	1.54%	3.67%

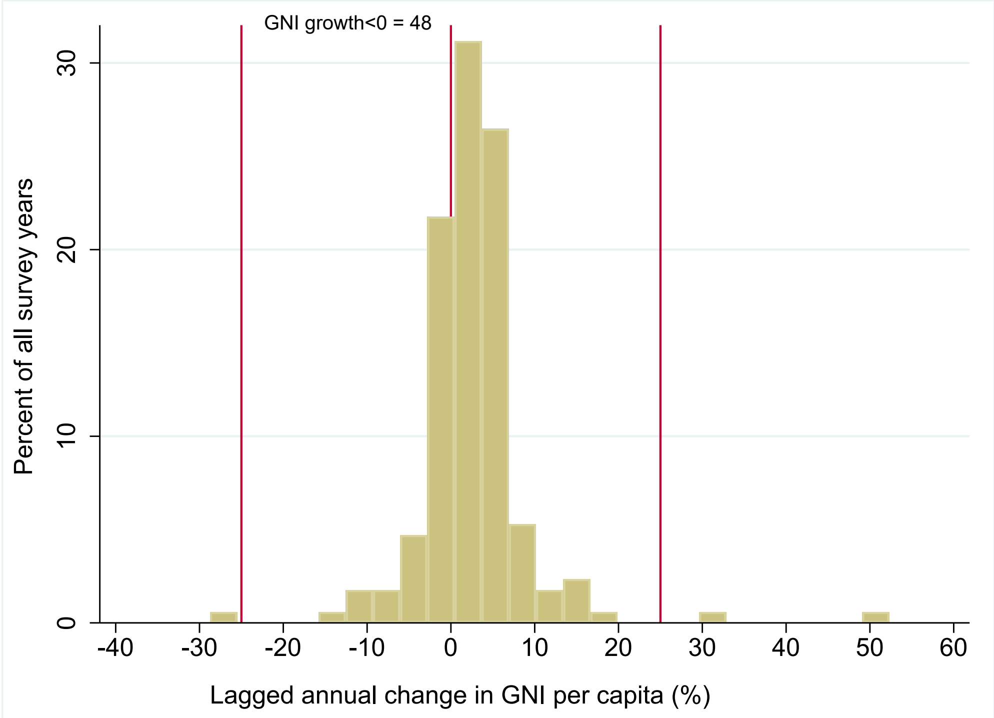
Turkey	1993-1993	3.56%	11.47%	0.98%	4.52%
Turkey	1998-1998	3.66%	12.21%	1.35%	6.40%
Turkey	2003-2003	1.11%	4.92%	0.30%	4.05%
Uganda	2000-2001	5.12%	16.95%	1.73%	1.65%
Uganda	2006-2006	7.11%	20.06%	2.51%	6.31%
Uganda	2011-2011	5.89%	20.36%	2.00%	4.53%
Uganda	2016-2016	4.07%	15.81%	1.62%	2.68%
Yemen	1991-1992	15.38%	35.52%	6.55%	12.77%
Yemen	2013-2013	17.04%	43.81%	6.25%	3.06%
Zambia	1992-1992	6.72%	19.07%	2.55%	-7.42%
Zambia	1996-1996	5.66%	17.33%	1.95%	0.47%
Zambia	2001-2002	6.51%	19.87%	2.52%	2.66%
Zambia	2007-2007	6.56%	17.75%	3.08%	3.30%
Zambia	2013-2014	6.88%	19.19%	3.03%	10.31%
Zimbabwe	1999-1999	9.34%	21.53%	5.19%	-1.96%
Zimbabwe	2005-2006	7.61%	19.42%	3.30%	-4.49%
Zimbabwe	2010-2011	3.75%	15.06%	1.26%	36.92%
Zimbabwe	2015-2015	3.84%	13.62%	1.53%	0.97%

Table A2. Pooled DHS sample sizes by country

Country	First year	Last Year	Total Observations	Share of total < 5 years observations in this DHS dataset	Share of total < 5 y years population in DHS countries
Albania	2008	2018	3780	0.30%	0.05%
Armenia	2000	2016	5578	0.44%	0.06%
Bangladesh	1996	2014	33293	2.65%	5.03%
Benin	2001	2018	38118	3.03%	0.43%
Bolivia	1998	2008	22499	1.79%	0.36%
Burkina Faso	1993	2010	23946	1.91%	0.74%
Burundi	2010	2017	8929	0.71%	0.49%
Cambodia	2000	2014	15104	1.20%	0.51%
Cameroon	2004	2011	8141	0.65%	1.00%
Chad	2004	2015	14268	1.14%	0.75%
Colombia	1995	2010	30359	2.42%	1.26%
Congo Rep.	2005	2012	7943	0.63%	0.21%
Congo DRC	2007	2014	11223	0.89%	3.98%
Cote d'Ivoire	1998	2012	4691	0.37%	0.90%
Dominican Rep.	1996	2013	24875	1.98%	0.32%
Egypt	1992	2014	70457	5.61%	2.98%
Ethiopia	2000	2016	30686	2.44%	4.24%
Gabon	2000	2012	6668	0.53%	0.06%
Ghana	1998	2014	10785	0.86%	1.03%
Guatemala	1995	2015	24092	1.92%	0.59%
Guinea	1999	2018	13282	1.06%	0.51%
Haiti	2000	2017	17239	1.37%	0.38%
Honduras	2005	2012	18283	1.46%	0.31%
India	2005	2016	268786	21.40%	38.14%
Jordan	1990	2012	23443	1.87%	0.24%
Kazakhstan	1995	1999	1213	0.10%	0.39%
Kenya	1993	2014	35322	2.81%	1.96%
Lesotho	2004	2014	4206	0.33%	0.08%
Liberia	2007	2013	6762	0.54%	0.19%
Madagascar	1992	2004	11554	0.92%	0.87%
Malawi	1992	2016	29972	2.39%	0.73%
Maldives	2009	2017	4006	0.32%	0.01%
Mali	2006	2018	23552	1.88%	0.78%
Morocco	1992	2004	10053	0.80%	1.00%
Mozambique	2003	2011	16879	1.34%	1.20%
Namibia	1992	2013	9835	0.78%	0.08%
Nepal	2001	2016	15800	1.26%	1.04%
Nicaragua	1998	2001	12613	1.00%	0.21%
Niger	2006	2012	8603	0.68%	0.90%

Nigeria	1990	2013	54032	4.30%	8.44%
Pakistan	1990	2018	10997	0.88%	6.48%
Peru	1991	2012	70667	5.63%	0.92%
Rwanda	1992	2015	21280	1.69%	0.46%
Senegal	1992	2017	33166	2.64%	0.67%
Sierra Leone	2008	2013	5595	0.45%	0.35%
Tajikistan	2012	2017	10392	0.83%	0.31%
Tanzania	1991	2016	36573	2.91%	2.18%
Turkey	1993	2003	9846	0.78%	2.02%
Uganda	2000	2016	13529	1.08%	1.72%
Yemen	1991	2013	15971	1.27%	1.11%
Zambia	1992	2014	31990	2.55%	0.67%
Zimbabwe	1999	2015	15200	1.21%	0.66%
Total	1990	2018	1256076	100.00%	100.00%

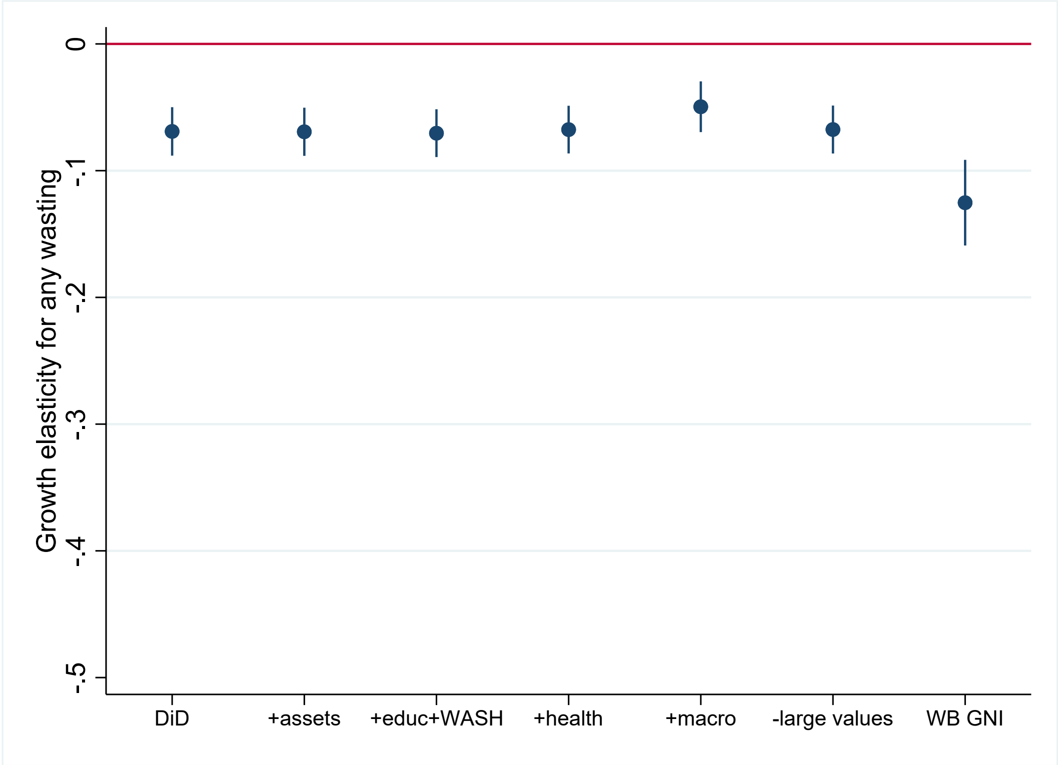
Figure A1. A histogram of lagged annual changes in GNI per capita across 210 surveys covering 1990-2018



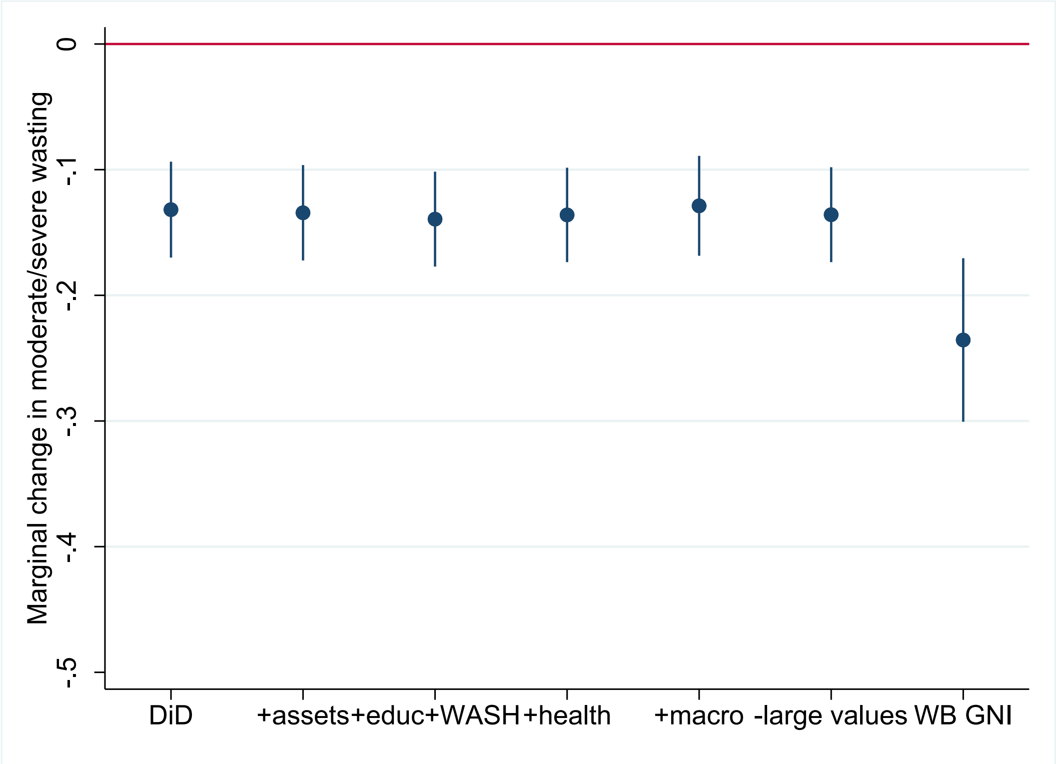
Source: Authors' from UN data on annual changes in GNI.

Figure A2. Variation of the elasticity of wasting with respect to GNIpc growth for different specifications and sample restrictions

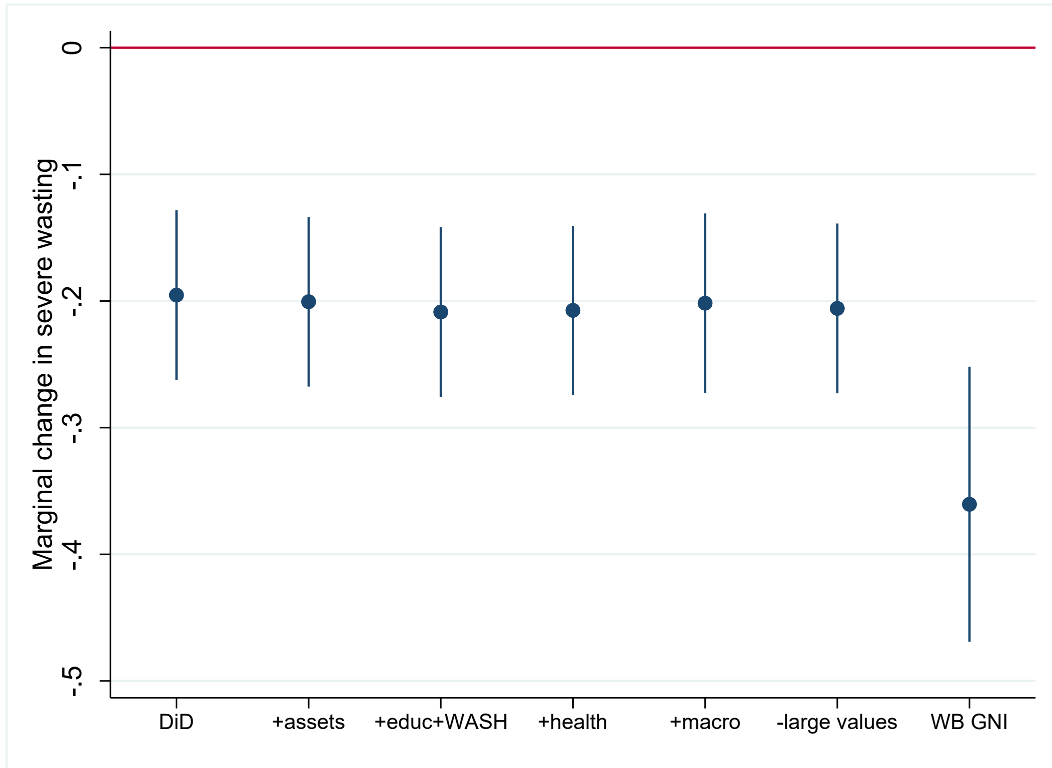
Panel A: Any wasting



Panel B: Moderate/severe wasting


Marginal change in moderate/severe wasting
0
-.1
-.2
-.3
-.4
-.5
DiD
+assets
+educ
+WASH
+health
+macro
-large values
WB GNI

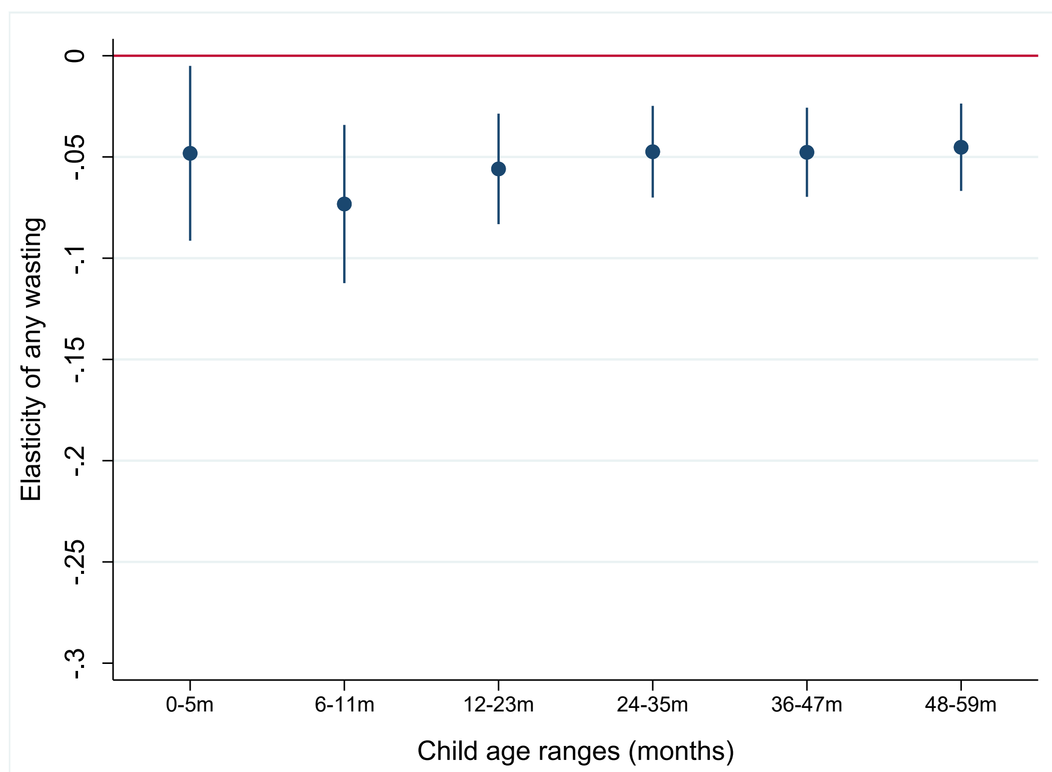
Panel C: Severe wasting



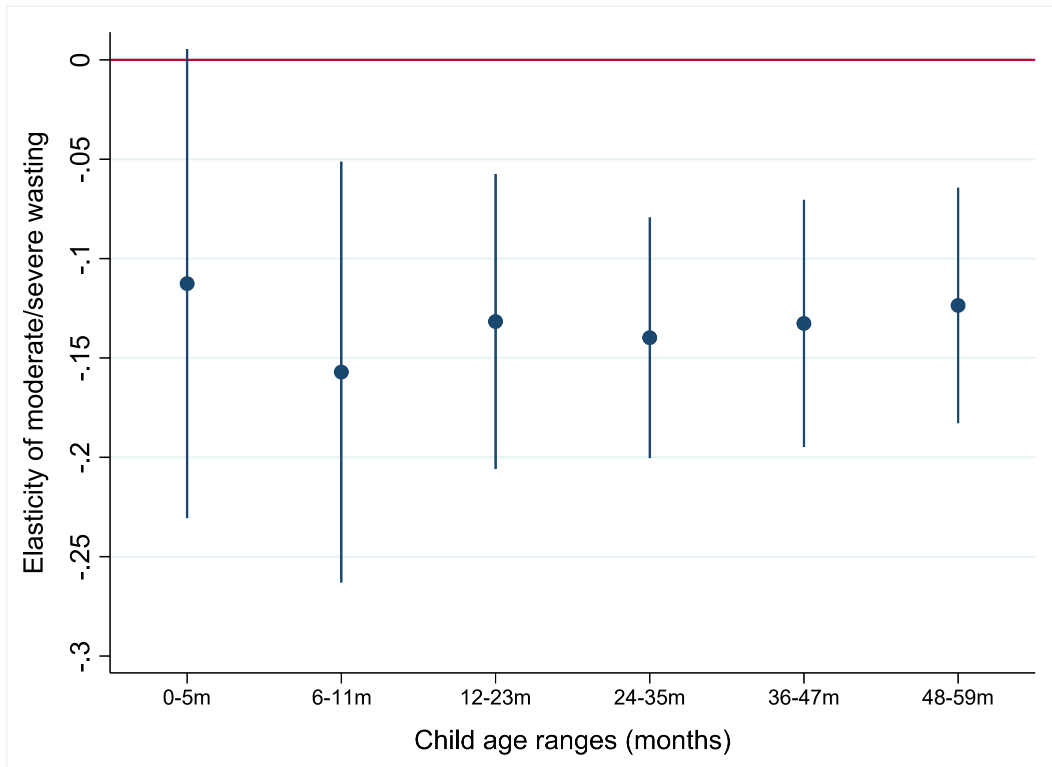
Notes: The different model specifications are specified sequentially as follows: basic DiD = fixed effects and time effects only: "+ assets" adds household asset indicators to the basic DiD model; "+educ+WASH" adds maternal education, improved water and improved sanitation to the +assets model; "+health" adds antenatal care, medical facility birth and all vaccinations to the +educ+WASH model; "+macro" adds controls for rainfall, temperature and battle deaths; "-large values" remove GNI growth values greater than 25% in absolute magnitude; "WB GNI" replaces the UN GNI measure with the World Bank GNI measure.

Figure A3. Variation of the elasticity of wasting with respect to GNIpc growth for different age ranges (with 90% confidence intervals)

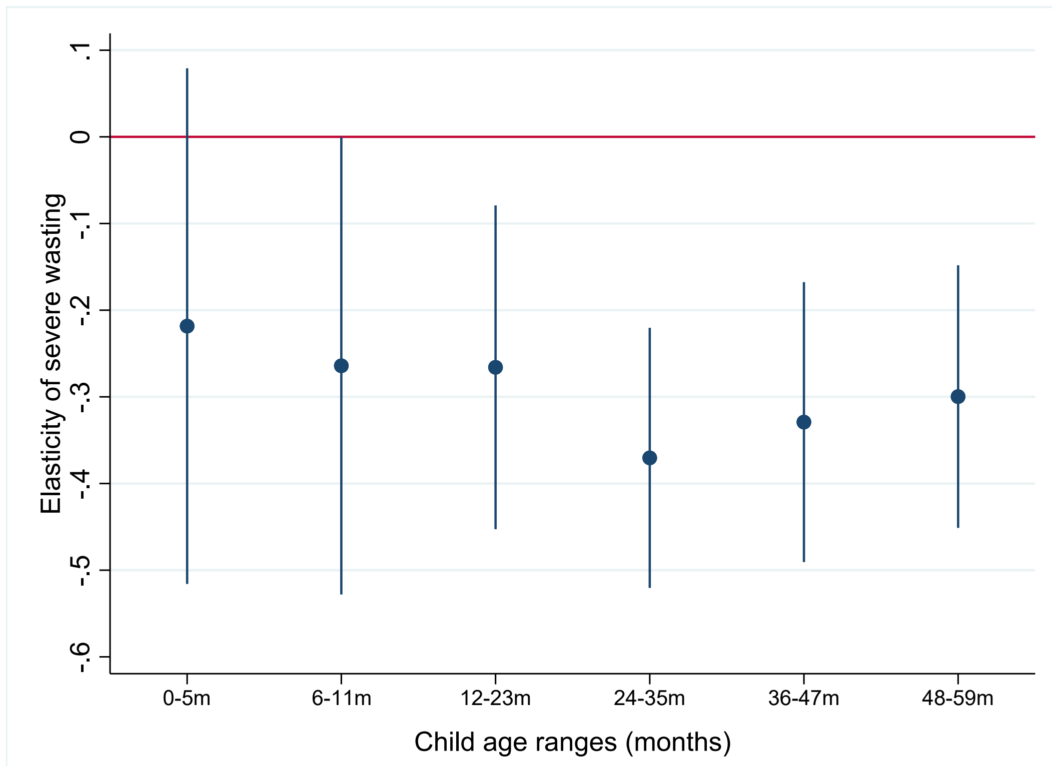
Panel A: Any wasting (WHZ<-1)



Panel B: Moderate/severe wasting (WHZ<-2)



Panel C: Severe wasting (WHZ<-3)



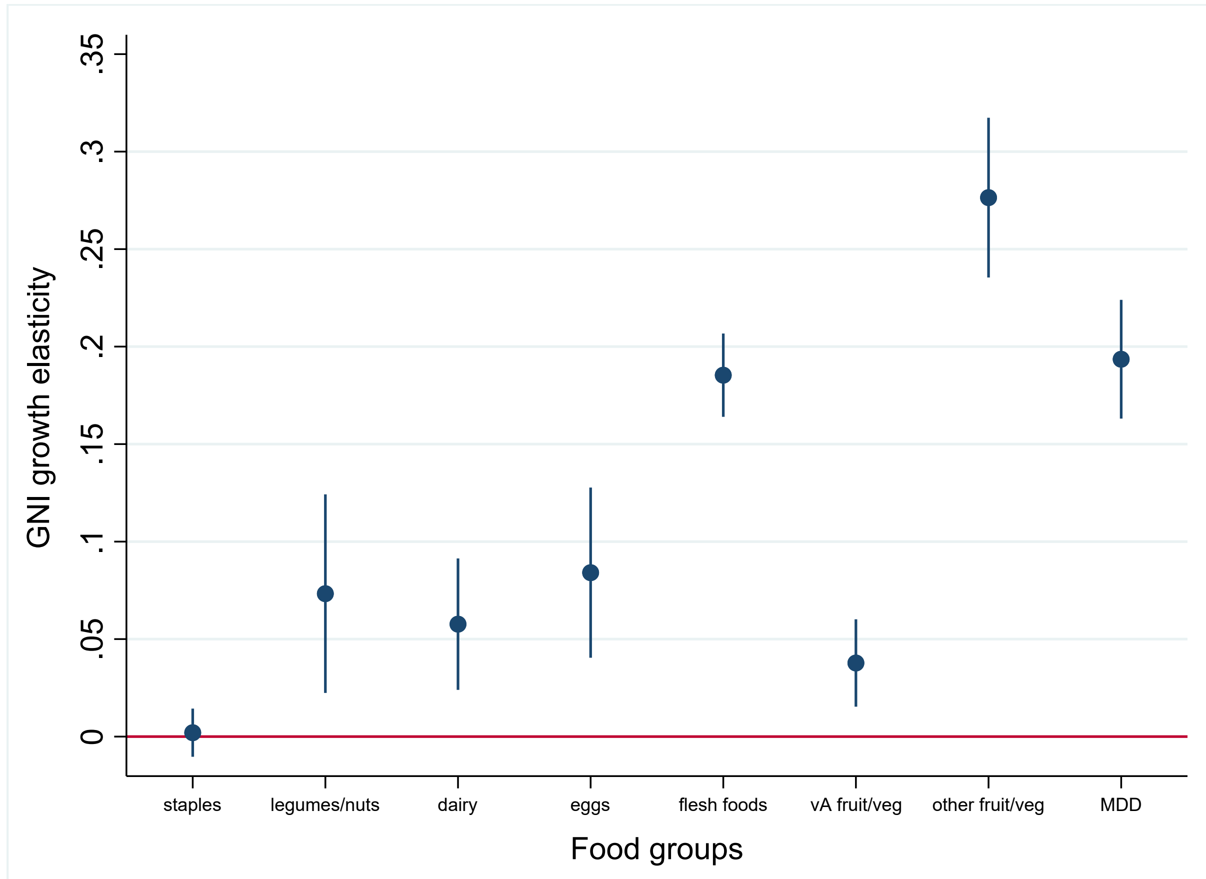
Notes: 90% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics, trend effects and the control variables listed in Table 2. Regressions are weighted as described in the main text.

Table A3. Difference-in-difference linear probability models of wasting risks with interactions for urban location and female status (children 0-59 months)

	Any wasting (WHZ < -1)	Moderate/severe wasting (WHZ < -2)	Severe wasting (WHZ < -3)
	(1)	(2)	(3)
	N=1,256,076	N=1,256,076	N=1,256,076
Growth elasticity ($w.g^n$)	-0.060***	-0.148***	-0.223***
	(-0.083, -0.037)	(-0.189, -0.106)	(-0.300, -0.147)
Growth elasticity ($w.g^n$)*urban dummy	-0.047**	-0.076	0.004
	(-0.087, -0.006)	(-0.187, 0.035)	(-0.103, 0.111)
R-squared	0.432	0.200	0.085
	(4)	(5)	(6)
	N=1,256,076	N=1,256,076	N=1,256,076
Growth elasticity ($w.g^n$)	-0.079***	-0.132***	-0.197***
	(-0.104, -0.054)	(-0.180, -0.084)	(-0.277, -0.118)
Growth elasticity ($w.g^n$)*girl dummy	0.016	-0.026	-0.050
	(-0.012, 0.044)	(-0.077, 0.026)	(-0.135, 0.035)
R-squared	0.432	0.200	0.085

Notes: 95% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses, with significance levels as follows: *** p<0.01, ** p<0.05, * p<0.10. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics and trend effects. Regressions are weighted to be representative of the < 5 year population of children of all countries included in this DHS dataset.

Figure A4. The elasticity of children's consumption of various foods with respect to GNI growth (90% CIs)



Notes: 90% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics, trend effects and the control variables listed in Table 2. Regressions are weighted as described in the main text. "staples" includes grains, roots, tubers. "flesh foods" refers to meat, organs and fish. "vA fruit/veg" refers to vitamin A-rich fruits and vegetables, while "other fruit/veg" refers to all other fruits and vegetables. MDD refers to minimum dietary diversity.

Table A4. Difference-in-difference linear probability models of diarrhea, fever, low maternal BMI and minimum dietary diversity as a function of recent economic growth and other control variables

	(1) Diarrhea N=1,230,393	(2) Fever N=1,230,393	(3) Low BMI N=884,436	(4) MDD N=323,014
Growth elasticity ($w.g^n$)	-0.073*** (-0.101, -0.046)	-0.071*** (-0.104, -0.039)	-0.087*** (-0.126, -0.047)	0.194*** (0.157, 0.230)
Household has some assets vs none	-0.004 (-0.010, 0.001)	-0.010*** (-0.017, -0.004)	-0.047*** (-0.055, -0.039)	0.016*** (0.005, 0.027)
Household has all 5 assets vs none	0.005 (-0.006, 0.016)	-0.011 (-0.023, 0.002)	-0.091*** (-0.104, -0.078)	0.043*** (0.021, 0.064)
Mother 9+ years of schooling	-0.018 (-0.022, -0.012)	-0.009 (-0.015, -0.002)	-0.045 (-0.05, -0.037)	0.070 (0.057, 0.082)
Household has piped water	-0.001 (-0.006, 0.003)	-0.024*** (-0.030, -0.017)	0.003 (-0.004, 0.009)	-0.012* (-0.024, 0.000)
Household has flush toilet	-0.003 (-0.009, 0.003)	0.008** (0.000, 0.016)	-0.062*** (-0.071, -0.054)	0.050*** (0.036, 0.064)
Child born in medical facility	-0.005** (-0.009, -0.000)	-0.008*** (-0.014, -0.003)	-0.045*** (-0.052, -0.038)	0.031*** (0.020, 0.041)
4 or more ANC visits	-0.002 (-0.007, 0.002)	0.006** (0.000, 0.012)	-0.015*** (-0.021, -0.009)	0.046*** (0.036, 0.056)
Received all vaccinations	-0.009*** (-0.013, -0.004)	-0.004 (-0.010, 0.001)	0.010*** (0.004, 0.016)	0.051*** (0.041, 0.061)
Teenage pregnancy	0.013*** (0.009, 0.018)	0.002 (-0.004, 0.008)	-0.007 (-0.023, 0.009)	-0.026*** (-0.037, -0.015)
Mother has 4 or more children	0.002 (-0.002, 0.006)	0.001 (-0.004, 0.006)	0.017*** (0.009, 0.025)	-0.028*** (-0.037, -0.019)
Rural community	-0.002 (-0.008, 0.004)	0.003 (-0.004, 0.011)	0.011*** (0.004, 0.019)	-0.019*** (-0.032, -0.005)
Female child	-0.013*** (-0.016, -0.010)	-0.012*** (-0.016, -0.008)		-0.000 (-0.007, 0.007)
Country fixed effects?	Yes	Yes	Yes	Yes
Region-specific trends, seasonality and age dynamics?	Yes	Yes	Yes	Yes
R-squared	0.063	0.065	0.162	0.156

Notes: 95% confidence intervals are based on standard errors clustered at the DHS cluster level are reported in parentheses, with significance levels as follows: *** p<0.01, ** p<0.05, * p<0.10. All regressions control for country fixed effects, region-specific seasonality effects, wasting-age dynamics and trend effects. Regressions are weighted to be representative of the < 5 year population of children of all countries included in this DHS dataset.

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Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org