What explains the fall in child stunting in Sub-Saharan Africa?

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ABSTRACT

There have been steep falls in rates of child stunting in much of Sub-Saharan Africa (SSA). Using Demographic and Health Survey data, we document significant reductions in stunting in seven SSA countries in the period 2005–2014. For each country, we distinguish potential determinants that move in a direction consistent with having contributed to the reduction in stunting from those that do not. We then decompose the change in stunting and in proximal determinants into a part that can be explained by changes in distal determinants and a residual part that captures the impact of unmeasured factors, such as vertical nutrition programs. We show that increases in coverage of child immunization, deworming medication and maternal iron supplementation often coincide with a fall in stunting. The magnitudes and directions of changes in two other proximal determinants – age-appropriate feeding and diarrhea prevalence – suggest that these have not been strong contributors to the fall in stunting. Utilization of maternity care emerges from the decomposition analysis as the most important distal determinant associated with reduced stunting, and also with increased coverage of iron supplementation, and, to a lesser extent, with child immunization and deworming medication. This circumstantial evidence is strong enough to warrant more detailed investigation of the extent to which maternity care is an effective channel through which to target further attacks on the blight of undernourished children.

1. Introduction

Globally, the average rate of stunting fell between 2005 and 2015 (UNICEF-WHO-World Bank, 2017). Economic growth, improved socioeconomic conditions, increased access to healthcare, nutrition and other vertical child health programs, and behavioral changes, such as increased breastfeeding and reduced fertility, may all have contributed to this welcome improvement in the wellbeing of children (Headey, Hoddinott, Ali, Teshaye, & Dereje, 2015; Smith & Haddad, 2015). Much of Sub-Saharan Africa has experienced the improvement (Bredenkamp, Buisman, & Van de Poel, 2014; UNICEF-WHO-World Bank, 2017). Unfortunately, not all African children have benefited, however. Rates of stunting have remained stubbornly high, or have even risen, in Malawi, Mozambique and Sierra Leone (Bredenkamp et al., 2014; World Development Indicators, 2019). To avoid children in these countries being left too far behind, it is important to learn from the success stories about what contributes to improvements in nutritional status. This paper documents changes in stunting in nine Sub-Saharan African (SSA) countries. For the seven in which stunting fell significantly, it decomposes the reductions into changes in potential determinants, with the goal of distinguishing factors that plausibly could have contributed to these reductions from those that could not.

Identification of the causes of nutritional status is difficult. Certainly, it cannot be done by regressing nutritional outcomes on proximal determinants (Hien & Hoa, 2009; Larrea & Kawachi, 2005; Marquis, Habicht, Lanata, Black, & Rasmussen, 1997). First, the timing of some measures rules out a causal effect between them: previous day feeding cannot impact on a child’s measured height. Second, there is reverse causality: undernutrition causes illness. Third, nutritional inputs, such as feeding, are behaviorally determined and likely correlated with unobserved determinants of nutritional status, such as hygiene and health knowledge. Recognizing these problems, attempts to explain trends in stunting have mostly paid attention to the contribution of more distal determinants (Wagstaff, van Doorslaer, & Watanabe, 2003; Van de Poel, Hosseinpoor, Jehu-Appiah, Vega, & Speybroeck, 2007; Headey, 2014; Headey & Hoddinott, 2014; Headey et al., 2015; Chirande et al., 2015; Salvucci, 2016). A limitation of this approach is that it loses sight of the immediate, biological mechanisms through which inputs and stresses impact on nutritional status. We avoid this limitation by examining trends in nutritional status and its proximate determinants without attempting to estimate the causal relationships between them, and by assessing the extent to which each can be explained by more distal determinants of nutrition. The objective is to obtain circumstantial evidence on what may have contributed to the
reductions in stunting rather than aiming for definitive evidence on the
causes.

We use the UNICEF framework (1990), and its adaptation in the
Lancet Maternal and Child Nutrition Series (2013), to distinguish proximal from distal determinants of nutritional status. We separate proximate determinants that move in a direction consistent with having contributed to the reduction in stunting from those that either display no trend or move in a direction that would impact negatively on nu-
tritional status. We then decompose the change in stunting, as well as
the mean height-for-age z-score (HAZ) and mean values of the proximal
determinants that plausibly could have contributed to the reduction in stuning, into a part that can be explained by changes in distal de-
terminants and a part that is left unexplained. This residual component
captures the impact of nutritional inputs, vertical programs and other
determinants of nutritional outcomes that are not measured.

We show that in at least 4 of the 7 countries in which stunting fell
significantly, the decline is coincident with increased coverage of child
immunization, deworming medication and maternal iron supple-
mentation. Two other proximal determinants – age-appropriate feeding
and diarrhea prevalence – do not appear to have been strong con-
tributors to the observed fall in stunting. They have improved in-
sufficiently, or not at all. From the decomposition analysis, maternity
care emerges as the most important distal determinant associated with
reduced stunting. Increased utilization of maternity care is also asso-
ciated with increased uptake of preventive services, particularly ma-
ternal iron supplementation and, to some extent, child immunization and
deworming medication.

Unlike our within country analysis (for a number of countries),
Headey (2013) conducts cross-country comparisons and also finds that
increased access to maternity care explains a substantial part of the
variation in the nutritional status of children. In addition, he finds
wealth (asset ownership), maternal education and lower fertility to be
strong predictors of improved nutritional status. Through longer birth
intervals, we also find an important role for lower fertility, and we find
a modest contribution from maternal (and paternal) education. Another
cross-country study by Smith and Haddad (2015) identifies economic
growth as an important distant driver of reductions in stunting. In
contrast to our analysis, this paper also finds improved drinking water
and sanitation to be important predictors. Country-specific analyses of
Bangladesh (Headey et al., 2015), Ethiopia (Headey, 2014) and Nepal
(Headey & Hoddinott, 2014) all find that wealth, maturity care, par-
ental education and sanitation are significantly associated with im-
proved nutritional status.

2. Material and methods

2.1. Data

We use Demographic Health Survey (DHS) data from nine Sub-
Saharan African (SSA) countries to document changes in child stunting
between 2005 and 2014. For each country, we use data from two survey
and Zambia (2007, 2013). The country inclusion criteria were entirely
based on availability of data. That is, data on child anthropometrics and
selected determinants (Table 1) needed to be available from two DHS
with the first survey occurring no earlier than 2005. All the DHS used
are nationally-representative household surveys.

We focus on children aged less than 24 months to cover the 1000-
day window from gestation when there is the potential for rapid phy-

sical and mental development and after which it is feared that any

1 For this reason, Malawi and Mozambique – two of the countries that have
not experienced improvements in child nutritional status – are not included.

2 There is an ongoing debate about the extent to which stunting by the age of
2 years is irreversible (see Behrman (2016) for a review). Studies by Addo et al.,
2015, Martorell et al., 2010, and Thurow, 2016 found t stunting to become
irreversible by the age of 2 years. This older belief in irreversibility has been
challenged by some more recent studies. For example, Lundeen et al. (2014)
show that there is more catch-up growth in height than many had previously
assumed.
Yit − Eit = − +

is equal to 1 in the later (Fortin, 2008). The former can be further de-

, where $X$, where $k$ be a nutritional outcome of child

δ is

mean of the outcome is:

that year, etc., and

specify this as a linear function of a vector of distal determinants

2.2. Methods

For each of the nine countries, we measure the change in each nu-

tritional outcome (mean HAZ and rate of (severe) stunting) between the
two DHS surveys conducted in the period from 2005 to 2014. Then, for
the seven countries in which there is a significant reduction in stunting,
we identify which of the proximal and distal determinants move in
directions consistent with having contributed to this decrease. Next, for
each of these seven countries, we pool data from the two survey years
and regress the outcomes on the distal determinants. The estimated
associations are used, along with the changes in the distal determinants,
to account for changes in the outcomes. Estimates of means and rates of
nutritional outcomes are obtained using all children aged 0–23 months
with a valid measure of height. We check that these estimates are robust
to using the restricted samples with full item response on all distal
determinants that are used for the regression analysis.

Let $Y_{it}$ be a nutritional outcome of child $i$ observed in year $t$, and
specify this as a linear function of a vector of distal determinants ($X_{it}$): $Y_{it} = \alpha + X_{it}\beta + \delta_{YEAR_t} + \varepsilon_{it}$, where $YEAR_t$ is equal to 1 in the later
year ($t = 1$) and is 0 in the earlier year ($t = 0$). Then, the change in the mean of the outcome is: $Y_{t} - Y_{0} = (X_{t} - X_{0})\beta + \delta$, where $Y_{t}$ is the mean outcome in the later year, $X_{t}$ is the vector of means of the covariates in
that year, etc., and $\beta$ and $\delta$ are least squares estimates. Thus, the change
in mean nutritional status is decomposed into a part explained by the changes in the means of distal determinants ($\bar{X}_{t} - \bar{X}_{0}\bar{\beta}$) and a part that
remains unexplained ($\delta$) (Fortin, 2008). The former can be further de-
composed into the contribution of each determinant. The contribution
of determinant $X_{k}$ is $(\bar{X}_{0k} - \bar{X}_{tk})\bar{\beta}_{k}$. The standard error of the con-
tribution of each determinant is obtained using the delta method. The
unexplained part can arise from changes in the associations between
nutritional status and its measured determinants, and from changes in
unmeasured determinants.

The same decomposition procedure is used to explain the change in
the mean of each proximal determinant. This provides some insight into
the pathways through which the distal determinants may possibly affect
nutritional status.

It is important to emphasize that this analysis does not identify the
causes of changes in nutritional status. The regressions capture asso-
ciations between the outcome and covariates, which do not necessarily
arise from a causal impact of the latter on the former. To avoid obvious
endogeneities, we do not regress nutritional outcomes on the proximal
determinants. But the distal determinants could also be associated with
the outcomes through correlated unobservables. Nonetheless, provided
the results are interpreted cautiously, they can be useful in distin-
guishing determinants that may have contributed to a reduction in
stunting from those that are unlikely to have been responsible.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcomes</strong></td>
<td>Height minus median height of child same age (months) and gender in reference population divided by standard deviation of height in reference population. Reference population is WHO, 2006 Child Growth Standards.</td>
</tr>
<tr>
<td>Stunted</td>
<td>1 if Height-for-Age z-score &lt; -2, 0 otherwise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Proximal determinants</strong></th>
<th>Poor age-appropriate feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 if poorly fed the previous day, 0 otherwise. Poorly fed: .... 0–5 months – option 1: not breastfed but complementary feeding and/or milk-based liquids; option 2) breastfed plus milk-based liquids and/or complementary feeding – but also allows water-based liquids to have been consumed. .... 6–23 months – complementary feeding from 0 to 1/7 food groups</td>
<td></td>
</tr>
</tbody>
</table>

| **Partial age-appropriate feeding** | 1 if partially appropriately fed the previous day, 0 otherwise. Partially appropriately fed: .... 0–5 months – breastfed plus water based liquids. .... 6–23 months – complementary feeding from 2 to 3/7 food groups |

| **Recommended age-appropriate feeding** | 1 if appropriately fed the previous day, 0 otherwise. Appropriately fed: .... 0–5 months – exclusively breastfed (breast milk only, but allows for oral rehydration salts). .... 6–23 months – complementary feeding from ≥ 4/7 food groups |

| **Mother received iron supplements** | 1 if mother received iron tablets or syrup during pregnancy and took it for at least 1 day, 0 otherwise |

| **No symptoms of diarrhea** | 1 if child reported not to have had any symptoms of diarrhea in the past two weeks, 0 otherwise |

| **Full immunization** | 1 if child aged 12–23 months received BCG, measles and three doses of polio and DPT, either verified by card or by recall of mother in the first 2 life years, 0 otherwise. Polio given at time of birth does not count towards 'full immunisation'. |

<table>
<thead>
<tr>
<th><strong>Distal determinants</strong></th>
<th>Deworming medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 if child aged 12–23 months received deworming medication in past 6 months, 0 otherwise</td>
<td></td>
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</tr>
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| **No symptoms of diarrhea** | 1 if child reported not to have had any symptoms of diarrhea in the past two weeks, 0 otherwise |

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</table>

Unless otherwise noted, all children are under the age of 2, all mothers are aged 15 to 49 and had a birth in the past 2 years. Data on feeding, antenatal care and iron supplements only collected for the youngest child.
evidence is circumstantial rather than conclusive, if you like.

3. Results

3.1. Changes in nutritional status

The rate of stunting (HAZ < −2) fell by an average of 5.7 percentage points over 6.5 years between 2005 and 2014 in the nine countries (Fig. 1, Table 2). In seven countries (Ethiopia, Ghana, Kenya, Liberia, Namibia, Niger and Rwanda), there was a significant reduction in stunting, which, on average, was equal to 7.3 percentage points over 6.8 years. In these seven countries, there was also a significant reduction in severe stunting (HAZ < −3) and, with the exception of Ghana, the mean HAZ also increased significantly (Table 2).

The two countries in which nutritional status did not improve are Zambia and Sierra Leone. The latter is the only country in which the rate of stunting increased significantly (p < 0.1). This is puzzling. The period examined begins six years after the end of the civil war in Sierra Leone, it is before the 2014 Ebola epidemic and it spans years of rapid economic growth. The increase in stunting is observed in both urban and rural areas. However, there is no substantial or significant change in the stunting rate among children aged 0–59 months (37.2%–37.4%). The increase is confined to younger kids, but it is not driven by infants (< 6 months) (Appendix Table A1). There is no significant change in the rate of wasting (height-for-weight z-score < −2) among children aged 0–23 months (12%–13%). Mortality selection is a possible

Table 2
Nutritional outcomes by country and year, children aged 0–23 months.

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean HAZ</th>
<th>Stunting rate (HAZ &lt; −2)</th>
<th>Severe stunting rate (HAZ &lt; −3)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year</td>
<td>Last year</td>
<td>First year</td>
<td>Last year</td>
<td>First year</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>−1.25 (0.05)</td>
<td>−1.04*** (0.03)</td>
<td>0.38 (0.01)</td>
<td>0.30*** (0.01)</td>
</tr>
<tr>
<td>Ghana</td>
<td>−0.51 (0.06)</td>
<td>−0.57 (0.04)</td>
<td>0.20 (0.01)</td>
<td>0.14*** (0.01)</td>
</tr>
<tr>
<td>Kenya</td>
<td>−1.11 (0.04)</td>
<td>−0.87*** (0.02)</td>
<td>0.32 (0.01)</td>
<td>0.22*** (0.00)</td>
</tr>
<tr>
<td>Liberia</td>
<td>−0.90 (0.04)</td>
<td>−0.69* (0.05)</td>
<td>0.27 (0.01)</td>
<td>0.22*** (0.01)</td>
</tr>
<tr>
<td>Namibia</td>
<td>−0.98 (0.04)</td>
<td>−0.47*** (0.06)</td>
<td>0.27 (0.01)</td>
<td>0.16*** (0.01)</td>
</tr>
<tr>
<td>Niger</td>
<td>−1.51 (0.05)</td>
<td>−1.16*** (0.04)</td>
<td>0.42 (0.01)</td>
<td>0.32*** (0.01)</td>
</tr>
<tr>
<td>Rwanda</td>
<td>−1.34 (0.04)</td>
<td>−1.23* (0.04)</td>
<td>0.35 (0.01)</td>
<td>0.32* (0.01)</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>−0.84 (0.07)</td>
<td>−0.94 (0.05)</td>
<td>0.29 (0.01)</td>
<td>0.32* (0.01)</td>
</tr>
<tr>
<td>Zambia</td>
<td>−1.32 (0.04)</td>
<td>−1.27 (0.03)</td>
<td>0.39 (0.01)</td>
<td>0.37 (0.01)</td>
</tr>
</tbody>
</table>

explanation for the rise in stunting in Sierra Leone. Over the period examined, the rate of infant mortality fell from 116.9 per 1000 live births in 2008 to 95.8 per 1000 live births in 2013 (World Development Indicators, 2019). This might have reflected greater survival of frail children that were stunted as economic and health conditions improved. As a consequence, the prevalence of stunting increased. If this interpretation is correct, then the rise in stunting would be temporary. It would decline as the health of children improved further and the rate of frail infants dropped.

Restricting the analysis to children aged 6–23 months, and so avoiding the greater measurement error in height among infants (< 6 months), has little impact on the trends observed in stunting (Appendix Table A1). As would be expected, stunting rates are higher when the samples are restricted to older children, but the only notable impact on the changes is that the marginally significant (p < 0.1) estimated 3.5 percentage point fall in stunting in Rwanda gains slightly in magnitude but loses significance.

3.2. Changes in determinants

For the seven countries in which there was a significant fall in stunting, the radar charts presented in Fig. 2 facilitate easy comparison of levels of determinants between years and across countries. All determinants are defined such that any impact on nutritional status, if it exists, is positive. Hence, the size of the surface provides an indication of the extent of coverage of nutrition-enhancing factors. Proximal determinants are positioned between 12 o’clock and 4 o’clock. See Appendix Table A3 for the means of all determinants by year and country.

In five of these seven countries (Liberia, Kenya, Namibia, Niger and Rwanda), the proportion of children (aged 12–23 months) who are fully immunized increased significantly (p < 0.1). In another group of five countries (Ethiopia, Ghana, Liberia, Namibia and Niger), the proportion of mothers taking iron supplements during pregnancy increased (p < 0.01). The proportion of children (aged 12–23 months) receiving deworming medication increased in four countries (p < 0.05: Ethiopia, Liberia, Namibia and Kenya). Note that the change cannot be assessed in Niger because deworming medication was not recorded in the 2006 DHS. A significant improvement in all three of these proximal determinants occurred only in Liberia and Namibia. However, these are the only two countries in which the prevalence of diarrhea increased (p < 0.01). The rate of this determinant decreased in four countries (p < 0.01: Ethiopia, Ghana, Kenya and Niger). Reductions in stunting did not generally coincide with increases in the rate of age-appropriate feeding. Only in Ethiopia (p < 0.05) and Namibia (p < 0.01) did recommended feeding improve, while deterioration was observed in Ghana, Kenya and Liberia (p < 0.01). The general lack of improvements in appropriate feeding is even more disappointing given that it is the determinant that is typically furthest from full population coverage.

Distal determinants, especially access to maternity care and father’s education, improved in most countries. The proportion of mothers who had at least four antenatal care (ANC) visits and delivered under the supervision of a skilled birth attendant increased in all countries (p < 0.01) except Namibia, where no change was observed in 4+ ANC visits.

Trends in the other distal determinants – water sources, sanitation facilities, birth interval and maternal height – are less clear. The proportion of households relying on sources other than surface water for drinking increased in three countries, while use of any sanitation other than open defecation increased in four countries.

Across countries, coverage of nutrition determinants is most sparse, by some distance, in Ethiopia and Niger.

3.3. Association of stunting with distal determinants

Table 3 displays coefficients from linear regressions of the binary indicator of stunting for the seven countries in which this outcome improved significantly. Obviously, these regressions can only be estimated using observations with full item response on all the covariates. Potentially, this introduces a selection bias to the estimated rate of stunting if item non-response is correlated with height. The estimates given in Appendix Table A2 show that this is not the case for six of the seven countries. With the exception of Niger, the levels and changes in stunting are very close to those given in Table 2 that are obtained from the full samples of children aged 0–23 months. In the case of Niger, the 10 percentage point (pp) significant fall in the rate of stunting in the full sample becomes an insignificant 1 pp fall in the restricted sample. For this country, the decomposition analysis cannot explain the observed fall in stunting. However, there is no such problem for the other six countries.

The regression coefficients on the year indicator imply that, conditional on the changes occurring in all covariates, the probability that a child is stunted fell by an amount that varied from a 0.8 percentage points in Rwanda (p < 0.1) to a very significant 19.6 percentage points in Niger over the period spanned by the respective surveys. Given that the rate of stunting fell by 3.5 percentage points in Rwanda (Table A2), the insignificant year coefficient implies that only 23% ((1-0.008/-0.035) × 100) of the reduction in stunting cannot be explained by changes in any of the child, maternal and household characteristics controlled for in the regression. So, 77% of the fall can be explained (but is not necessarily caused) by changes in these distal determinants.

In the other countries, a much lower fraction of the reduction in stunting can be statistically explained by the changes in covariates – 3% in Ghana, 13% in Namibia, 23% in Kenya, 29% in Ethiopia and Niger, and 55% in Liberia. For these countries, unmeasured factors explain by far the greatest portion of the fall in stunting.3

In all 7 countries, the rate of stunting varies with demographics as anticipated: boys and older children are more likely to be stunted. Except in Namibia and Niger, there is a substantial wealth gap in stunting even after controlling for wealth-related differences in other distal determinants, such as education. Conditional on all else, an Ethiopian child in the top 60% of the wealth distribution is 3.9 percentage points less likely to be stunted than the equivalent child that is among the poorest 40%. The gap is even larger at 7.0, 6.1, 4.3 and 6.7 percentage points in Ghana, Kenya, Liberia and Rwanda, respectively.

Use of maternity care, which changed in a direction consistent with contributing to the reduction in stunting, is sometimes, but not consistently, negatively associated with stunting. The strongest negative association is in Rwanda, where a child delivered by a skilled birth attendant is 5.2 percentage points less likely to be stunted. Conditional on this, the probability of being stunted is 19 percentage points lower for Rwandan children whose mothers attended four or more ANC sessions compared with those whose mothers had no ANC. These are very large differences relative to the 3.5 percentage point reduction in the rate of stunting in Rwanda. They are consistent with the observed increase in utilization of maternity care having made an important contribution to the reduced rate of stunting. However, in Kenya, use of maternity care is positively associated with stunting. Since it is not plausible that such utilization causes nutritional deficiency, this result is a reminder that the regression coefficients should not be interpreted as estimates of causal effects. Maternity care and stunting are likely to be correlated through unmeasured common factors.

While parental education also generally moved in a direction consistent with having contributed to the reduction in stunting, evidence that it is significantly negatively associated with stunting is rather

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3 This is because stunting is substantially higher among children with missing information on the covariates in the earlier year.

4 The regressions presented in Table A4 obtained from the samples of children aged 6–23 months reveal that the unexplained part of the changes in stunting (shown by the year coefficients) is somewhat larger compared with the estimates obtained from children aged 0–23 months (Table 3).
weak. Except for Ghana and Liberia, maternal education does have a negative regression coefficient, but it is never significant. Paternal education is significantly negatively correlated with stunting only in Liberia, Niger and Rwanda. Counterintuitively, parental education is positively associated with stunting in Namibia. Furthermore, maternal and paternal education are never jointly significant.

Some point estimates are consistent with avoidance of open defecation and drinking surface water both being associated with a lower probability of a child being stunted but none of these relationships reaches statistical significance. Counterintuitively, avoidance of surface water is positively associated with stunting in Ghana.

Taller and older mothers are less likely to have stunted children in

Fig. 2. Coverage of determinants of nutritional status by country and year. Deworming medication is not available in the 2006 Niger DHS.
most countries. But the fraction of mothers who are taller than 150 cm increased only in Kenya, Namibia and Rwanda and could have contributed to the reduction in stunting only in these four countries. Mother's age increased only in Niger so this is also not a strong candidate to explain the fall in stunting.

In Appendix Tables A5-A11 we show regressions of each proximal determinant. But the fraction of mothers who are taller than 150 cm increased only in Kenya, Namibia and Rwanda and could have contributed to the reduction in stunting only in these four countries. Mother's age increased only in Niger so this is also not a strong candidate to explain the fall in stunting.

### Table 3: Least squares regressions of indicator of stunting of children aged 0–23 months.

<table>
<thead>
<tr>
<th></th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Kenya</th>
<th>Liberia</th>
<th>Namibia</th>
<th>Niger</th>
<th>Rwanda</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
<td>Beta (SE)</td>
</tr>
<tr>
<td>Mother had 1-3 skilled ANC visits</td>
<td>0.007</td>
<td>(0.015)</td>
<td>0.070</td>
<td>(0.034)</td>
<td>-0.223</td>
<td>(0.034)</td>
<td>-0.171</td>
</tr>
<tr>
<td>Mother had 4+ skilled ANC visits</td>
<td>-0.056</td>
<td>(0.019)**</td>
<td>-0.003</td>
<td>(0.029)**</td>
<td>-0.262</td>
<td>(0.054)**</td>
<td>-0.029</td>
</tr>
<tr>
<td>Delivered by skilled birth attendant</td>
<td>-0.079</td>
<td>(0.029)**</td>
<td>-0.014</td>
<td>(0.021)</td>
<td>0.021</td>
<td>(0.039)</td>
<td>0.035</td>
</tr>
<tr>
<td>Mother has any education</td>
<td>0.004</td>
<td>(0.016)</td>
<td>0.026</td>
<td>(0.020)**</td>
<td>0.040</td>
<td>(0.045)*</td>
<td>0.026</td>
</tr>
<tr>
<td>Father has any education</td>
<td>-0.020</td>
<td>(0.014)</td>
<td>0.020</td>
<td>(0.028)</td>
<td>0.040</td>
<td>(0.022)**</td>
<td>0.041</td>
</tr>
<tr>
<td>Wealth index in top 60%</td>
<td>-0.039</td>
<td>(0.013)**</td>
<td>-0.038</td>
<td>(0.016)**</td>
<td>-0.043</td>
<td>(0.024)*</td>
<td>-0.055</td>
</tr>
<tr>
<td>Surface water not used for drinking</td>
<td>-0.004</td>
<td>(0.005)***</td>
<td>0.003</td>
<td>(0.006)***</td>
<td>-0.156</td>
<td>(0.010)</td>
<td>-0.111</td>
</tr>
<tr>
<td>Any sanitation other than open defecation</td>
<td>-0.021</td>
<td>(0.015)</td>
<td>0.016</td>
<td>(0.027)</td>
<td>-0.034</td>
<td>(0.053)**</td>
<td>0.046</td>
</tr>
<tr>
<td>Birth order</td>
<td>-0.003</td>
<td>(0.004)</td>
<td>0.012</td>
<td>(0.005)**</td>
<td>-0.000</td>
<td>(0.010)</td>
<td>0.009</td>
</tr>
<tr>
<td>Birth interval &gt; 24 months</td>
<td>-0.022</td>
<td>(0.004)</td>
<td>0.001</td>
<td>(0.005)**</td>
<td>-0.178</td>
<td>(0.010)</td>
<td>-0.021</td>
</tr>
<tr>
<td>Mother taller than 150 cm</td>
<td>-0.102</td>
<td>(0.018)**</td>
<td>-0.118</td>
<td>(0.018)</td>
<td>-0.176</td>
<td>(0.047)**</td>
<td>0.047</td>
</tr>
<tr>
<td>Mother's age at birth (in years)</td>
<td>-0.002</td>
<td>(0.002)</td>
<td>0.005</td>
<td>(0.002)**</td>
<td>-0.004</td>
<td>(0.003)</td>
<td>0.006</td>
</tr>
<tr>
<td>Have livestock</td>
<td>0.001</td>
<td>(0.002)</td>
<td>0.017</td>
<td>(0.002)***</td>
<td>0.057</td>
<td>(0.003)</td>
<td>-0.006</td>
</tr>
<tr>
<td>Age - 6-11 months</td>
<td>0.115</td>
<td>(0.017)**</td>
<td>0.053</td>
<td>(0.017)**</td>
<td>0.045</td>
<td>(0.017)**</td>
<td>0.059</td>
</tr>
<tr>
<td>Age - 12-17 months</td>
<td>0.258</td>
<td>(0.017)**</td>
<td>0.189</td>
<td>(0.017)**</td>
<td>0.212</td>
<td>(0.017)**</td>
<td>0.110</td>
</tr>
<tr>
<td>Age - 18-23 months</td>
<td>0.407</td>
<td>(0.018)**</td>
<td>0.227</td>
<td>(0.018)**</td>
<td>0.245</td>
<td>(0.018)**</td>
<td>0.307</td>
</tr>
<tr>
<td>Male</td>
<td>0.073</td>
<td>(0.026)**</td>
<td>0.040</td>
<td>(0.026)**</td>
<td>0.079</td>
<td>(0.026)**</td>
<td>0.051</td>
</tr>
<tr>
<td>Wet season</td>
<td>NA</td>
<td>(0.012)**</td>
<td>NA</td>
<td>(0.012)**</td>
<td>NA</td>
<td>(0.012)**</td>
<td>NA</td>
</tr>
<tr>
<td>Year = most recent</td>
<td>-0.059</td>
<td>(0.014)**</td>
<td>-0.064</td>
<td>(0.017)**</td>
<td>-0.074</td>
<td>(0.013)**</td>
<td>-0.024</td>
</tr>
<tr>
<td>Constant</td>
<td>0.452</td>
<td>(0.052)**</td>
<td>0.371</td>
<td>(0.056)**</td>
<td>0.351</td>
<td>(0.067)</td>
<td>0.667</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.16</td>
<td>(0.052)</td>
<td>0.10</td>
<td>(0.056)</td>
<td>0.13</td>
<td>(0.067)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

$N$ = 4993

SE = Robust standard errors; *p < 0.1; **p < 0.05; ***p < 0.01; NA = variable not available. Children aged 0–5 months is reference age category; Mother had 0 skilled ANC visits is reference category. Regressions include region indicators.

### 3.4. Explaining the decrease in stunting over time

Having identified characteristics that are associated with stunting, and determined which of these characteristics changed in a direction...
consistent with a significant fall in stunting, we now put these two pieces of information together to decompose the fall into contributions made by sets of distal determinants and other covariates. The year coefficients in the regressions imply the proportion of the fall in the rate of stunting that cannot be explained by changes in covariates. For each country, we will now account for the explained part, which is 3% in Ghana, 13% in Namibia, 23% in Kenya, 29% in Ethiopia and Niger, 55% in Liberia, and 77% in Rwanda.

The distal determinants and covariates are grouped into six categories: maternity care, socioeconomic status, water and sanitation, maternal risk characteristics, geographic characteristics, and demographics (see notes to Fig. 3). Fig. 3 shows the contributions of each category to the fall in stunting and whether this fall is statistically significant at the 10% level. Improvements in maternity care account for the largest portion of the explained reduction in the rate of stunting in Ethiopia (24.8%), Kenya (52.3%), and Rwanda (29.2%). This reflects both the positive trends in the use of maternity care and the strong correlation between this care and the likelihood of stunting. Socioeconomic status (SES) and maternal risk characteristics are the next most important contributors to the decrease in stunting. SES is an important contributor in Ethiopia (16.9%), Ghana (523.2%), Kenya (21.4%), and Liberia (37.1%). This is due to substantial reductions of uneducated mothers and fathers combined with the (non-) significant negative correlation between education and stunting. Maternal risk characteristics are important contributors to the reductions in stunting in Kenya (27.8%), Namibia (29.4%), and Rwanda (24.1%). This derives from substantial reductions in the proportion of births with a short birth interval and short maternal height combined with the (non-)significant negative correlation between each of these variables and stunting. The picture in Niger differs from the six other countries: mainly demographics and geographic characteristics have contributed to the fall in stunting between 2006 and 2012. The large contribution of demographics is due to the younger sample of children in 2012 and the significant positive correlation between age and stunting. The substantial relative contribution of geographic factors is the result of a change in the distribution of births across households living in urban or rural areas and across regions.

Fig. 4 shows the contributions of distal determinants and other covariates to the change in each of the proximal determinants by country. It should be kept in mind that based on improvements in the mean rates, full immunization, deworming medication, and mother’s iron supplementation were identified as the proximal determinants with the highest potential contribution to the fall in stunting, while the contribution of age-appropriate breastfeeding and children free of diarrhea was less clear. Also note that these changes are the same across decompositions of the change in each proximal determinant. What differs are the direction and strength of the association of each proximal determinant with the distal determinants and covariates.

Most striking is the large positive contribution of increased use of maternity care to the rise in the propensity of mothers to take iron supplements in all countries. The contribution of maternity care is due to the strong positive correlations of ANC and skilled birth attendance with the likelihood of iron supplementation in all countries (Appendix Tables A5-A11). For two other proximal determinants – full immunization and deworming medication – that displayed strong favorable changes consistent with playing a part in the reduction in stunting, patterns in contributions of sets of distal determinants and covariates are less clear. Maternal risk characteristics are the most important contributors to improvements in full immunization in Kenya and Rwanda, while maternity care is an important contributor to improvements in full immunization in Liberia and Niger.

In Ethiopia and Kenya, the countries in which deworming
medication may have been an important contributor to the fall in stunting, at least according to the decomposition analysis, maternity care is an important contributor to the explained change in deworming medication. In addition, in Ethiopia, the largest contribution to the explained change in deworming medication is from water and sanitation (99%). Most of this contribution stems from the strong positive and significant correlation of deworming medication with absence of open defecation, combined with the large reduction in the rate of the latter.

In conclusion, the decomposition analysis reveals that, in a statistical accounting sense, improvements in maternity care make the largest contribution to the reduction in stunting, and to improvements in proximal determinants. This is a result of more mothers having 4+ ANC visits and delivery by a skilled attendant, and the strong negative associations between these indicators and stunting.5

Fig. 4. Contributions of changes in distal determinants and covariates to changes in proximal determinants of stunting by country, children aged 0–23 months.

5 Appendix Fig. A1 presents estimates of the decomposition of changes in mean height-for-age z-scores. The decomposition results for rates of stunting are generally robust to dropping children aged 0–5 months (Appendix Fig. A2). One notable difference is that the contributions of demographics in Ethiopia and Ghana are larger than are obtained from the sample of children aged 0–23
4. Discussion

The proportion of young children (< 2 years old) in Sub-Saharan Africa who are stunted fell by 1.3 percentage points annually between 2005 and 2014 on average, in seven out of nine countries with sufficient data available. While this is a welcome improvement in nutritional status that heralds future gains in population health and labour productivity, it is unacceptable that about a third of infants in Ethiopia, Niger and Rwanda, and a fifth of infants in Ghana, Kenya, Liberia and Namibia remain undernourished to an extent that severely impairs their growth. Nonetheless, understanding what has contributed to the achieved reduction in undernutrition in these countries can help us predict whether the trend is likely to continue, speculate on how it may be accelerated and suggest how to possibly replicate it elsewhere.

The fall in stunting in these countries coincides with substantial increases in three proximal determinants: full immunization (5 countries), iron supplements (5 countries) and deworming medication (4 countries). Changes in age-appropriate feeding and prevalence of diarrhea are not consistent with these immediate causes of nutritional status having contributed importantly to the substantial reductions observed in child stunting. Among the distal determinants, use of maternity care and, to a lesser extent, parental education have improved substantially in recent years in most SSA countries examined.

Maternity care emerges from our decomposition analysis as the most important distal determinant associated with reduced stunting, and its effect, if that is indeed what it is, may operate through increased coverage of preventive services like iron supplementation. While it cannot be presumed that this is causal, the result is consistent with what one might expect: increased contact with ANC increases the likelihood that women get and take iron supplements on at least one day during pregnancy. The contribution also derives from the strong positive correlation of iron supplementation with delivery by a skilled professional. The latter cannot possibly increase the likelihood of taking iron supplements during pregnancy. Hence, this correlation, and most likely part of the correlation with the use of ANC, must be due to mothers who have greater opportunities and motivation to use maternity care also being more likely to take iron supplements. It is also possible that access to maternity care increased because more facilities have become available, which highlights the importance of unmeasured factors in explaining the fall in stunting.

Nutritional status can only improve as a result of better dietary intake and reduced experience of disease. Understanding of trends in stunting is constrained by limitations in our ability to measure these biological determinants within the context of large surveys. The DHS uses a recall period of only 24 h to record food intake and gathers information only on the types of food consumed and not their quantities. These limitations make it impossible to relate nutrition outcomes to energy inputs at the child level. Reliance on reported illness may also induce bias if the respondent omits to mention episodes of sickness that did not result in the utilization of medical care or medicines.

The DHS does not record the duration of breastfeeding. We approximated this by calculating the median age of the children (0–23 months) currently breastfed. In every survey year, this was 9–11 months, suggesting that there has been no substantial change in the length of time that infants are breastfed and, consequently, that this is unlikely to have contributed to the reduction in the rate of stunting.

The DHS does not seek to measure household living standards by collecting detailed data on consumption. It relies on asset ownership and housing conditions to construct a proxy index of wealth. This is useful in distinguishing between socioeconomic groups and measuring inequality in nutritional status between them. However, it is not very sensitive to changes in living standards over time. As a result of relying on this measure, we have underestimated the contribution of improved economic conditions to gains in the nutritional status of children. Its effect will be part of the unexplained reduction in stunting in our decompositions.

5. Conclusions

Our analysis suggests that the fall in stunting in Sub-Saharan Africa has not been driven by better feeding practices, nor by reduced prevalence of diarrhea. Improved access to maternity care does correlate with improved nutritional status. Given the potential for correlated unobservable determinants of both nutritional status and maternity care, our decomposition analysis does not identify the contribution of the latter to improvements in the former. But the circumstantial evidence it offers is at least strong enough to warrant more detailed investigation of the question of whether maternity care is potentially a channel through which to target further attacks on the blight of undernourished children.

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Ethical statement

Ethics approval is not required because the data is not collected from human subjects and we use secondary data.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2019.100384.

References


