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Analysis of the Drivers of Change in Women's Anemia in Tanzania 2005-2015

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ABSTRACT

Although the prevalence of anemia among women of reproductive age in Tanzania remains high, there have been documented improvements. It declined from 47.2% in 2004-05 to 40.1% 2010, but by 2016 it has risen again to 44.8%, according to the nationally representative Demographic and Health Surveys from those years. Women's anemia can lead to many detrimental consequences, including decreased work productivity, mortality, postpartum hemorrhage, and adverse birth outcomes. Thus, it is important to document the factors that may have contributed to improvements in anemia status. Using a regression decomposition approach, which previously has been applied to identifying potential drivers of changes in stunting, we examine which improvements in the underlying determinants of anemia contributed to improvements in the overall prevalence of anemia among women of reproductive age in Tanzania. This study is the first known application of this methodology to understanding changes in the prevelance of anemia. Among all adult women, the largest contributers of change from factors we could include in our models were increases in wealth and education, use of hormonal contraceptives, and the decrease in the proportion of women who are currently pregnant or postpartum (i.e., from the decrease in fertility rates). Notably, use of hormonal contraceptives was least common among the poorest quintile. Additionally, change was attributable to reductions in infection, specifically fever and improvements in open defecation. Among older adolescent girls (15-19 years), the largest share in the improvements in anemia were attributable to education and wealth increases. Among postpartum women, we were limited by the sample size, but found that attending all four antenatal care visits and being administered medications to prevent malaria during pregnancy were important determinants of improved hemoglobin levels.

Keywords: anemia, nutrition, nutrition policy, regression decomposition, Tanzania

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ACRONYMS

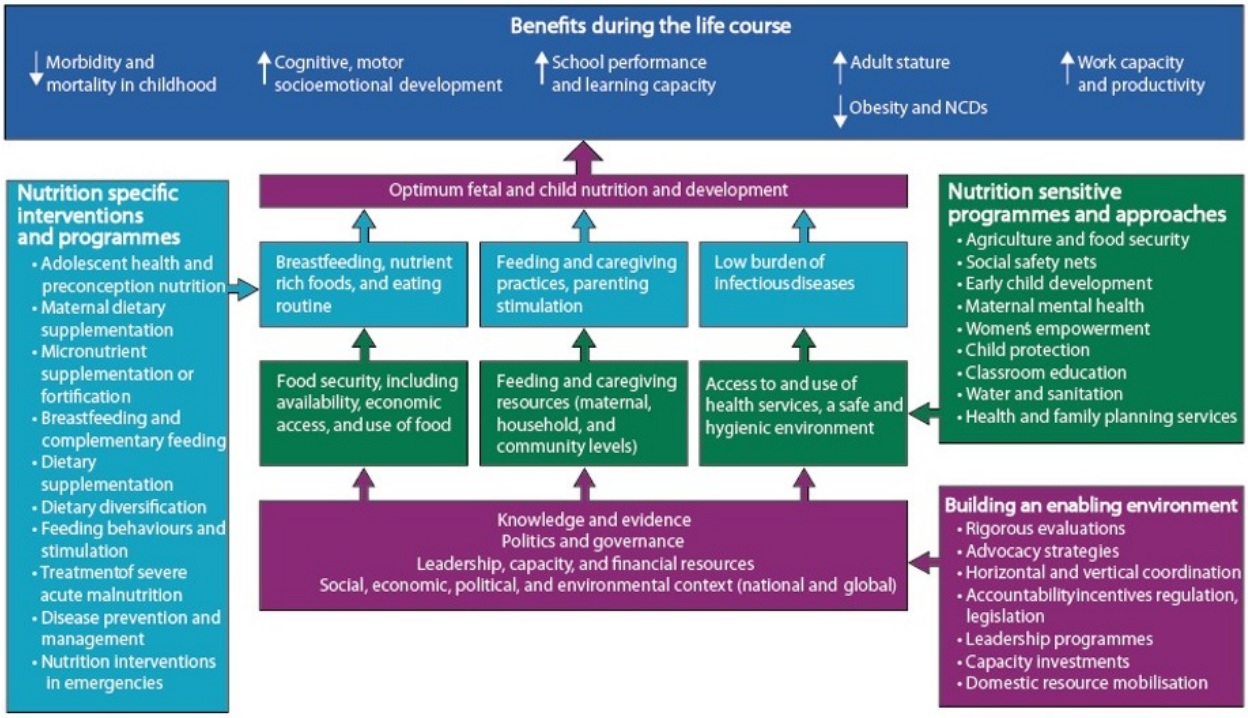
ANC	antenatal care
DHS	Demographic and Health Surveys
FANC	focused antenatal care
dL	deciliter
g	gram
IPTp	intermittent preventive treatment in pregnancy
JMP	Joint Monitoring Programme for Water Supply, Sanitation and Hygiene
NNS	National Nutrition Strategy
pp	percentage point
RBM	Roll Back Malaria
UNICEF	The United Nations International Children's Emergency Fund
WASH	water, sanitation, and hygiene
WHO	World Health Organization
WSDP	Water Sector Development Programme

1. INTRODUCTION

The prevalence of anemia among women of reproductive age in Tanzania is high and is the source of many deleterious consequences. It can lead to reduced work productivity (Haas and Brownlie 2001), maternal mortality (Black et al. 2008), postpartum hemorrhage (Kavle et al. 2008) and delivering infants that are premature, of low birth weight, and more likely to die (Kozuki et al. 2012; Zhang et al. 2009). Though child stunting, one of the most commonly used indicators of nutritional status, declined steadily from 2005 to 2015, the prevalence of women's anemia did not. It declined between the 2004-05 and 2010 DHS from 47.2% to 40.1% in 2010, but by 2016 it had increased to 44.8%. Notably, this same pattern, whereby the prevalence of anemia declined among women between approximately 2005 and 2010, and later increased between 2010 and 2015, occurred throughout East Africa (Burundi, Ethiopia, Malawi, Rwanda, Uganda) at varying magnitudes (ICF-International, & USAID 2017). Thus, the trend observed in Tanzania is an interesting puzzle with findings that are of potentially broader interest.

It is important to understand the improvements in the underlying factors that may have contributed to the overall improvement in women's anemia status to maintain progress in these areas, identify factors where improvements could further contribute to reducing anemia, and document share these lessons with the nutrition community. Conceptual thinking on the determinants of nutritional status is largely guided by the 2013 Lancet Nutrition Series framework (Figure 1.1) (Black et al. 2013). This approach points to the importance of a multisectoral perspective, as the underlying determinants of malnutrition are complex and caused by diets, disease, and the interplay between the two. Diets and disease, in turn, have further determinants, including socioeconomic status, food security, access to markets, parental education, nutritional knowledge, hygiene knowledge and practices, access to public health services, the Water, Sanitation and Hygiene (WASH) environment, the general disease environment (e.g., exposure to diarrheal disease, malaria, respiratory infections), demographic factors (birth spacing, fertility), and cultural factors (e.g., norms about child feeding practices). Thus, understanding change in undernutrition in general and women's anemia in particular, requires taking a multisectoral perspective that considers both nutrition-specific and nutrition-sensitive factors.

Figure 1.1 The Lancet 2013 Nutrition Series Child Nutrition Conceptual Framework



Source: Black et al. (2013).

Determinants of anemia

The determinants of hemoglobin concentration and anemia status are complex and interrelated. Some causes are genetic with clinical manifestations (e.g., sickle cell disease), and these are not well-addressed through nutrition interventions. Most anemia in developing countries, however, is driven by poor quality diets and high levels of infection. In East Africa, the primary drivers of anemia among women and girls are, in order of magnitude: iron-deficient anemia, schistosomiasis (both intestinal and urogenital), malaria, hookworm, sickle cell disease, and other neglected and infectious disease (Kassebaum et al 2014). In 2010, the Tanzania Demographic and Health Survey included a unique biomarker module that tested blood samples for soluble transferrin receptors (National Bureau of Statistics and ICF Macro 2011). The presence of these receptors can indicate whether anemia is attributable to iron-deficiency or infection (caused by malaria or helminths). Data were not collected to differentiate among the possible types of infection. The key takeaways from an analysis of these data are that approximately one-thirds of anemia among adult women is iron-deficient anemia, and the remaining two-thirds is attributable to infection. There was geographic variability in the share of anemia attributable to iron-deficiency versus anemia. The Northern Zone has an especially high share of anemia attributable to iron-deficient anemia (approximately half), whereas anemia in the Southern Zone is more often attributable to infection (less than 20% attributable to iron deficiency. Overall, this information on the most common causes of anemia in Tanzania suggests that in addition to socioeconomic drivers, improvement in diets, WASH (specifically community-level sanitation and drinking water sources), and infectious disease control (and treatment) are potentially the largest underlying drivers of change in anemia among women of reproductive age.

Several additional factors are commonly correlated with anemia in women of reproductive age, and previous work has corroborated these findings specifically in Tanzania. Fist, the use of biomass fuels (e.g., charcoal, wood, plant debris) is associate with anemia, operating via the development of peptic ulcers, which lead to increased blood loss. However, to date in Tanzania, the use of non-biomass fuels has been low, though there is certainly a potential for increased use as a result of economic growth. The use of hormonal contraceptives is also commonly associated with decreased menstrual bleeding and improvements to hemoglobin concentration (Haile et al. 2015).

The prevalence of anemia is typically higher among children and adolescent girls, compared to adults. During adulthood, however, it does not typically follow any distinct age patterns among of adult women. Anemia, however, does vary considerably with pregnancy related life cycle factors with postpartum women being of highest risk for anemia. For this reason, and the recent (though small) fertility declines in Tanzania, the proportion of women who are currently pregnant or recently given birth may be one determinant underlying change in the prevalence of anemia. Additionally, the risk of anemia during pregnancy and the postpartum period is primarily addressed with ante-, peri-, and postnatal care services that aim to both directly increase the intake of iron (via supplements), reduce infection during this period of high risk for anemia (via IPTp and antiparasitic medications), and decrease maternal hemorrhage (via delivery in a medical setting).

National context and factors potentially driving changes anemia in Tanzania

Over the period in which Tanzania has experienced improvements in the nutritional status of its population, there have been dramatic improvements in a range of nutrition-sensitive sectors that could have helped drive changes in women's anemia. We briefly summarize those herein. The Roll Back Malaria (RBM) campaign, launched in 1998 across many African countries, prioritized adoption of insecticide-treated bed nets, indoor residual spraying, and drug-based treatment of infections (e.g., artemisinin-based combination therapy). Several Tanzania-specific studies find that RBM has been effective (Bhattarai et al. 2007).

Progress on the uptake of family planning and the decline in the total fertility rate has generally been slow. Tanzania's total fertility rate has remained near 5.2 children per woman, but modern contraceptive use did increase from 27% to 32% between 2010 and 2016 (Family Planning 2020, 2018a). Adolescent pregnancy also remains an issue, as 25% of girls aged 15 – 19 have had a child (Family Planning 2020, 2018a). Similarly, the implementation of maternal health policies has been uneven. Less than half of pregnant women in Tanzania attend four (minimum recommendation) or more antenatal care visits (Afnan-Holmes et al. 2015). More recently, the government of Tanzania implemented the "National Road Map Strategic Plan to Improve Reproductive, Maternal, Newborn, Child, and Adolescent Health in Tanzania (2016-2020): One Plan II" and increased funding for family planning policies (Family Planning 2020, 2018b). It has also prioritized five underserved regions to enhance health care coverage emergency obstetric care (Dutta et al. 2016) and implemented an antenatal care program based on the WHO's focused antenatal care (FANC) model (Kearns et al. 2014). Yet, obstacles in the healthcare system as well as customary practices impede the improvement of maternal care delivery (Kearns et al. 2014).

A number of national initiatives have also targeted the WASH sector. The Government of Tanzania implemented the Water Sector Development Programme (WSDP) for the years 2005 to 2025

(Ministry of Water, 2006). The program is composed of four separate aims: Water Resources Management; Rural Water Supply and Sanitation; Urban Water Supply and Sewerage; and Institutional Development and Capacity Building (Ministry of Water, 2006). The Government of Tanzania also developed the National Sanitation Campaign (Ministry of Water, 2006), aimed at enhancing the capacity of local sanitation workers and promote better management of fecal material (Ministry of Water, 2006). Despite this broad push to improve WASH, local experts feel that hygiene conditions in Tanzania are still very poor, and that, beyond access to improved water and sanitation facilities, basic sanitation practices, such regular handwashing are not yet widely adopted.

Tanzania remains a predominantly agrarian economy. Despite abundant land and water resources, rural poverty remains high and poverty and food insecurity are the result of low agricultural productivity from poor infrastructure, gaps in agricultural extension programming, and limited access to local seed systems, appropriate technologies, and financial services (SAGCOT Centre Ltd, 2011). Outside of the agricultural sector, the Tanzanian economy is diversifying and has ambitious goals of developing industry, as well as tourism and other services sectors, which have not yet been fully realized.
Education levels are very low in Tanzania, particularly in terms of secondary education and beyond. In the past two decades, education expenditures have increased with a significant push on expanding primary education. However, because of the significant lag in time between education investments and improvements in the educational attainment of the adult population, over the 2004-5 and 2015-16 DHS rounds education attainment among adult women only advanced only slowly (see following sections).

Nutrition-specific programming in Tanzania has also been limited, and only recently seen a greater budgetary allocation. Cognizance of the uneven performance of nutrition-sensitive and nutrition-specific sectors has led Tanzania to strengthen its longstanding multisectoral approach to combat nutrition. This is a departure from the more common single-sector approaches taken by many countries in which a ministry of health takes almost sole responsibility for nutritional programming. The government has a strong political commitment to fighting undernutrition from a multi-sectoral perspective, has put in place and institutionalized a range of policy measures that facilitate horizontal coordination across sectors and vertical coordination across administrative layers within the government, and has strengthened financing for local level action on nutrition. However, there are still many operational and financial challenges to the effective implementation of this multisectoral approach, as discussed below. The government's commitment has also been demonstrated by a five-year National Nutrition Strategy (NNS) launched in 2011, which included the establishment of multisectoral committees at council level, the placement of nutrition focal points in each ministry, and the recruitment of district and region-level nutrition officers.

Research objectives

Herein, to answer questions about which improvements in the underlying determinants of anemia contributed to improvements in the overall prevalence of anemia among women of reproductive age in Tanzania. We draw on regression-decomposition methods and the drivers of change approach to identify the potential drivers. This approach has previously been applied to understanding trends in the decline in stunting first by Headey et al. (2015) to Bangladesh, and subsequently to other South Asian and sub-African countries (D. Headey 2014; D. Headey et al. 2016; D. D. Headey & Hoddinott 2015). This, however, its the first known application of this methodology to changes in the prevelance of anemia. We emphasize from the start that these analyses pertain to associations, rather than causal relationships, as the latter can only be identified through experimental work. This approach, however, does what experimental studies generally cannot do and aims to understand historical changes in outcomes, and in some sectors. Regression-decomposition techniques, instead, provide a systematic means of exploring potential drivers of change over time.

2. METHODS

To examine changes in maternal anemia status, we draw on a regression-decomposition approach, which has been applied to understanding trends in the decline in stunting (D. Headey 2014; D. Headey et al. 2016; D. D. Headey & Hoddinott 2015). It is based on four simple steps:

1. Preparing multiple rounds of DHS data so that all variables are strictly standardized across surveys.
2. Analyzing trends in nutrition outcomes and its determinants, including age-disaggregated nutrition outcomes, and trends in the survey-weighted means of the explanatory variables.
3. Conducting multivariate regression analysis to see which factors have statistically significant associations with the nutrition outcome(s).
4. Using the observed changes in the means of the explanatory variables and the regression coefficients to estimate the predicted historical change in nutrition, so as to assess which factors account for historical changes in nutrition, and whether the model as a whole accurately predicts nutritional change over time.

In these analyses we examine both the linear outcome (hemoglobin concentration) and the binary outcome (anemia). We focus our analyses on two special populations of women. The burden of anemia is higher among adolescent girls. Thus, we repeat these analyses for those aged 15-19 years. (Hemoglobin data are not collected for younger adolescents.) Additionally, pregnant and postpartum women are especially vulnerable to anemia, and some existing anemia interventions target women during this part of the lifecycle. Thus, we also examine the trends and determinants of anemia among women who have given birth in the past 6 months using multivariate regression. However, we do not conduct a regression decomposition for post-partum women because of the small sample size. Additionally, we do not include further analysis of pregnant women. Gestational age cannot be accurately determined from DHS data, and both anemia cutoffs and the healthcare related determinants of anemia that should be included as predictor variables in the regression equations vary by gestational age.

Data preparation

To examine changes in anemia among women of reproductive age, we merge the nationally representative DHS datasets from the 2004-2005 (n = 9,609), 2010 (n = 9,470), and 2015-2016 (n = 12,372) surveys. We construct consistent identifiers for 26 regions (based on classifications from 2005) and nine ecological zones (Figure 2.1). We also construct dummy variables for the month of the interview in order to include month-level fixed effects and account for seasonal differences in survey administration, which may be correlated with hemoglobin concentration via seasonal changes in diets and prevalence of infections. Additionally, we merge the DHS data with data from the Malaria Atlas Project, which contain the regional prevalence of malaria among children 2-9 years of age to provide an indicator of the role of malaria in explain in driving anemia changes (Bhatt et al., 2015).

Figure 2.1 A map of Tanzania's major ecological zones

The selection of putative drivers of change in anemia among adult women was informed by the characteristics associated with anemia and blood hemoglobin concentration as described in the UNICEF (1990) and Lancet nutrition frameworks (Black et al., 2013) and by various cross-sectional studies examining anemia among women of reproductive age and among pregnant and postpartum women. The specific variables are described in Table 2.1 below. The two dependent variables, blood hemoglobin concentration (g/dL) and anemic, are measured for each woman in the dataset. Blood hemoglobin levels are altitude adjusted. Non-pregnant women are considered anemic if their altitude adjusted hemoglobin concentration is <12 g/dL. Pregnant women are considered anemic if these values are <11 g/dL; this accounts for the increased volume of blood plasma (and therefore dilution of hemoglobin) experienced during pregnancy.

We considered a number of hypothesized explanatory variables that were measured at the individual (woman), household, village, and regional level. We create a variable to represent the number of years of maternal education. To account for pregnancy-related trends in the general population we construct variables for whether the woman is currently pregnant, whether she has given birth in the last year, and the number of children to which she has given birth. Related to women's own health practices, we construct variables for whether she currently uses hormonal (i.e., pills, injectables, implants, or IUD) or non-hormonal contraceptives (i.e., condoms, diaphragms, sterilization, or standard days method) and whether she currently sleeps under an insecticide treated bed net. For women who gave birth in the past year, we also constructed variables for whether she attended an ANC visit during the first trimester, whether she completed four ANC visits, whether she took prenatal iron supplements, whether she took at least one dose of IPTp, and whether she gave birth in a medical facility.

At the household level, we follow previous studies in constructing a household asset index using principal components analysis, with the weights on each asset consistent across DHS rounds. We follow the JMP/WHO definition of improved drinking water and sanitation, as described in Gunther and Fink (2010). We also construct a variable for whether the household uses biomass fuels (e.g., wood, coal) for cooking, as opposed to clean burning substances (e.g., propane, electric). At the village level we calculate the proportion of households that engage in open defecation (as a proxy for the village-level sanitation environment), the proportion of children who experienced a fever in the past two weeks (such data are not available for adults, but serves as a proxy for levels of infectious disease), whether the survey cluster was considered rural or urban according to national statistics office definitions, and whether the center of the village is above 1,600 meters to further account for the effects of altitude on blood hemoglobin concentration.

Table 2.1 Definitions of key variables used in the study

Short name	Definition
Woman: Hemoglobin	Blood concentration of hemoglobin (g/dL), altitude adjusted
Woman: Anemic	Altitude adjusted hemoglobin <12 g/dL if not pregnant or <11 g/dL if pregnant
Woman: Age	Age in years
Woman: Education	Number of years of formal education
Woman: Short birth interval (0/1)	Birth interval less than 24 months (0 if no previous births)
Woman: Birth last year	Gave birth in the 12 months preceding the survey
Woman: Pregnant	Woman reports that she is currently pregnant
Woman: Number of children	Number of children ever born to woman
Woman: Hormonal contraceptives	Currently uses pills, injectables, implants, or IUD
Woman: Non-hormonal contraceptives	Currently uses condoms, diaphragms, sterilization, or standard days method
Woman: Bednet	Currently sleeps under and insecticide treated bed net
Woman: ANC1st	Attended an ANC visit during the first trimester (if gave birth in last year)
Woman: ANC4	Attended at least 4 ANC visits (if gave birth in last year)
Woman: IPTp	Received at least one IPTp dose (if gave birth in last year)
Woman: Prenatal iron	Received prenatal iron supplements (if gave birth in last year)
Woman: Facility birth	Gave birth in a medical facility (if gave birth in last year)
Household: Asset score (0-10)	Asset index based on first principal component of 7 variables (ownership of a radio, TV, bicycle, motorbike, car; household electricity, improved flooring) ;re-scaled to vary between 0-10; analysis on 2006-06, 2010 and 2015-16 DHS.
Household: Improved water (0/1)	Improved drinking water according to JMP/WHO definition
Household: Improved toilet (0/1)	Flush toilets or improved pit latrines
Household: Biomass fuel (0/1)	Cooks with biomass fuel (e.g., wood, coal, plant debris), as opposed to gas
Village: Open defecation (0-1)	Proportion of households that engage in open defecation.
Village: Fever prev (0-1)	Proportion of children 0-5 years experiencing fever within the previous two weeks.
Village: Medical births (0-1)	Cluster share of children born in a medical facility
Village: Rural (0/1)	Cluster defined as rural in DHS
Village: High altitude (0/1)	Above 1,600 meters
Region: Malaria prevalence	Estimated malaria prevalence for children 2-9 years of age at the year of the survey, averaged at the region level

Descriptive analysis

After defining these variables, we then analyze trends in hemoglobin concentration and anemia status and the proposed determinants of these markers of nutritional status. We then compute trends in survey-weighted means for all variables at the national, rural/urban, and subnational level. We also look at national trends among women who have given birth in the past six months adolescents (15-19 years). We then use non-parametric plots to look at changes in the distribution of hemoglobin concentration, and how hemoglobin trends vary across the lifecycle and in accordance with other expected determinants.

Regression analysis

We then used linear probability models to estimate associations, or "marginal effects", between anemia/hemoglobin (*N*) for individual i at time t and a vector of time-varying intermediate determinants (***X***), and a vector of control variables (women's age, subnational fixed effects; $\boldsymbol{\mu_i}$), trend effects represented by a vector of DHS survey year dummy variables (***T***). The vector of coefficients ($\boldsymbol{\beta}$) represent estimated effects of these underlying determinants on nutrition outcomes constitutes the set of parameters of principal interest. With the addition of a standard white noise term (ε), we represent this relationship by equation (1):

$$(1)\ \ N_{i,t} = \boldsymbol{\beta X}_{i,k} + \boldsymbol{\mu_i} + \boldsymbol{T} + \varepsilon_{i,t}$$

The main utility of equation (1) is to compare the size and precision of different coefficients. For example, how important is household wealth compared to maternal education? Also important is the overall goodness of fit, as reflected in R-squared terms.

Finally, it is important to note that we implement equation (1) for different sub-populations: rural/urban and adolescents (15-19 years). We also conduct regression analysis for women who are up to six months postpartum to account for maternal care factors, as these interventions have a limited time frame of impact on anemia status.

Decomposition analysis

While equation (1) describes the importance of underlying determinants in explaining cross-sectional variation in nutrition outcomes, the regression approach by itself does not inform the question of which factors have been driving changes in anemia and hemoglobin status over time in Tanzania. For this a decomposition of the regression model is required. The simplest decomposition of change over time assumes that the effects of $\boldsymbol{X}$ on the outcomes is unchanged over time (e.g., maternal education is just as effective in 2005 as it is in 2015-16), which can be tested. If these tests reveal no strong evidence of coefficient changes over time, then the contribution of each explanatory variable to nutritional change over time is the product of its coefficient times the change in its mean value over time:

$$(2)\ \Delta N_{i,t} = \boldsymbol{\beta} \Delta \boldsymbol{X}_{i,k} + \varepsilon_{i,t}$$

3. RESULTS

Trends in anemia

When examining differences in anemia trends by agroecological zones and rural/urban locations in Tanzania, we find considerable subnational variability (Table 3.1). In 2005 over half of women (15-49 years old) were anemic in the Lake, Eastern, and Zanzibar zones. The Southern Highlands, South-Western Highlands, and Northern zones all had a prevalence of anemia below 40%. While the overall trend from 2005 to 2015-16 in Tanzania showed a small improvement (2.4 pp), three zones showed increases in anemia: Western (6.6 pp), Southern (5.5 pp), and Southern Highlands (1.9 pp). Though the Southern Highlands had the lowest prevalence of anemia to begin with (and remains well below the national average), both the Western and Southern zones had a similar prevalence to the national average. Two zones also showed considerably large reductions in anemia: Central (9.8 pp) and South-Western Highlands (8.6 pp). The rebound in the prevalence of anemia between 2010 and 2015-16 was observed in most of the country, with the exception of the South-Western Highlands and Eastern Zones, which both experienced small improvements during this period (<1 pp).

In comparing rural and urban areas, the prevalence of anemia is relatively similar between the two. They differed only by 2 pp in 2005 and by less than 1 pp in 2015-16. The primary difference between urban and rural areas is that the improvements observed between 2005 and 2010 were of a much larger magnitude in rural areas, compared to urban ones. Turning specifically to women who gave birth in the past 6 months, overall, the prevalence of anemia follows the same pattern of a small improvement in 2010. However, the size of this improvement was smaller (only 2.7 pp) than the improvement among the general population of women, and there was little net change from 2005 to 2015-16.

Table 3.1 Trends in prevalence of anemia for nine ecological zones, rural and urban areas, and all Tanzania (women 15-49 years of age), and among women who gave birth in the past 6 months

	2005	**2010**	**2015-16**	**Change 2005 to 2015-16**
n=	9,609	9,470	12,372	
	(%)	**(%)**	**(%)**	**(%)**
Lake	56.5	45.1	51.9	-4.6
Western	47.0	44.8	53.6	**6.6**
Northern	37.3	28.8	36.1	-1.2
Central	41.0	28.6	31.2	-9.8
South-Western Highlands	37.4	28.9	28.8	-8.6
Eastern	54.9	51.8	51.3	-3.6
Southern Highlands	28.9	30.4	34.4	**5.5**
Southern	45.9	44.4	47.8	**1.9**
Zanzibar	62.8	58.7	60.1	-2.7
Rural Tanzania	47.7	38.8	45.0	-2.7
Urban Tanzania	45.8	43.4	44.4	-1.4
All Tanzania	47.2	40.1	44.8	-2.4
Women who gave birth in the past 6 months[1]	52.7	50.0	53.6	**0.9**

Source: Authors' calculations from Tanzania DHS.

[1] The samples sizes for postpartum women are 1,832 for 2005 round, 1,709 for 2010 and 2,199 for 2015-16

Among older adolescents (15-19 years old; n = 7320), as shown in Table 3.2, the overall prevalence of anemia is somewhat higher: 47.8% in 2005, compared to 47.2% among adult women in general. The time trends and geographical patterns are similar to those among adult women in general, with a few notable exceptions, as follows. Overall, improvements in the prevalence of anemia were more modest, only 0.6 percentage points. In the Northern Zone there was an increase in anemia among older adolescents, whereas the population of adult women experienced slight improvements. Additionally, in rural areas, there was an improvement of 2.7 percentage points in the general population of adult women, anemia increased slightly among rural adolescents.

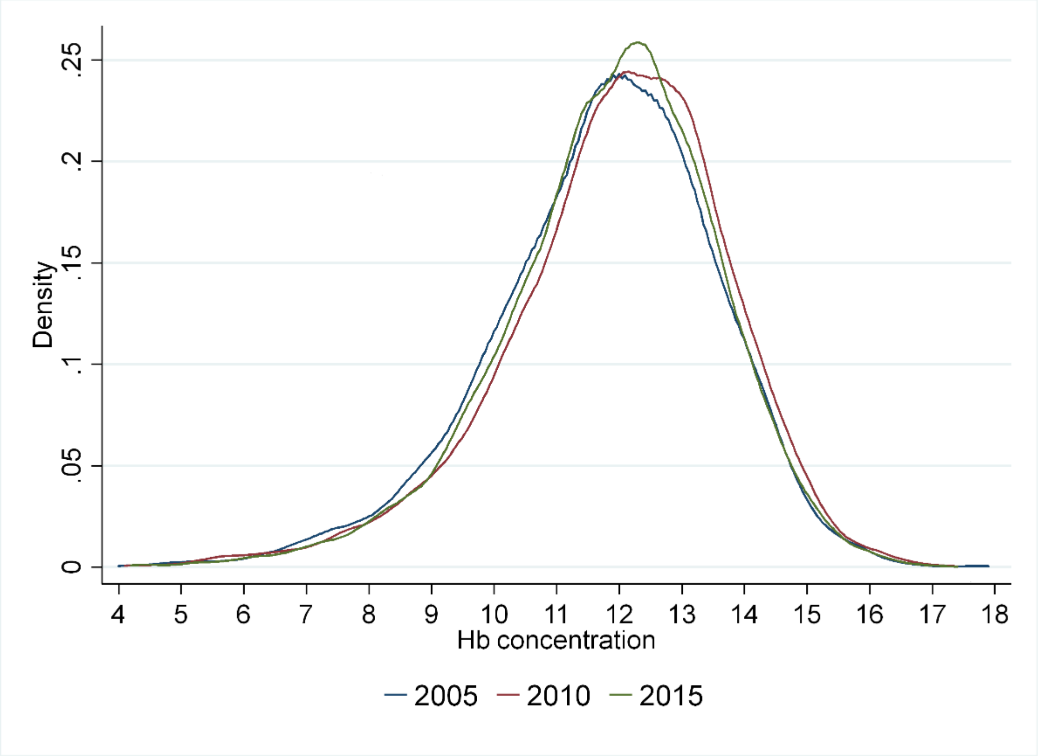
Table 3.2 Trends in prevalence of anemia among older adolescents (15-19 years) for nine ecological zones, rural and urban areas, and all Tanzania

	2005	**2010**	**2015-16**	**Change**
n =	2,246	2,178	2,896	
	(%)	**(%)**	**(%)**	**(%)**
Lake	57.7	47.4	55.0	-2.7
Western	48.0	46.3	55.9	**7.9**
Northern	30.5	27.1	36.3	**5.8**
Central	41.6	32.5	33.8	-7.8
South-Western Highlands	38.5	29.8	26.0	-12.5
Eastern	58.3	57.02	53.6	-4.7
Southern Highlands	30.7	28.3	38.3	**7.6**
Southern	46.8	41.5	48.8	**2.0**
Zanzibar	61.4	59.4	61.2	-0.2
Rural Tanzania	48.3	39.9	48.9	**0.6**
Urban Tanzania	46.5	47.7	44.5	-2.0
All Tanzania	47.8	42.2	47.2	-0.6

Source: Authors' calculations from Tanzania DHS.

We also examine changes in the distribution of blood hemoglobin concentration over time. Figure 3.1 depicts the distribution of blood hemoglobin in all three survey waves. In general blood hemoglobin concentration is normally distributed. There was a slight shift to the right between 2004-05 and 2010 (mirroring the changes to the reduction in the prevalence of anemia during this period). In 2015-16, there was a slight shift to the left, again mirroring the increase in the prevalence of anemia. In 2015-16, there was also an increased concentration of individuals directly above the 12 g/dL cutoff, and fewer in the tails at both ends of the distribution. These trends were similar among older adolescents (figure not shown).

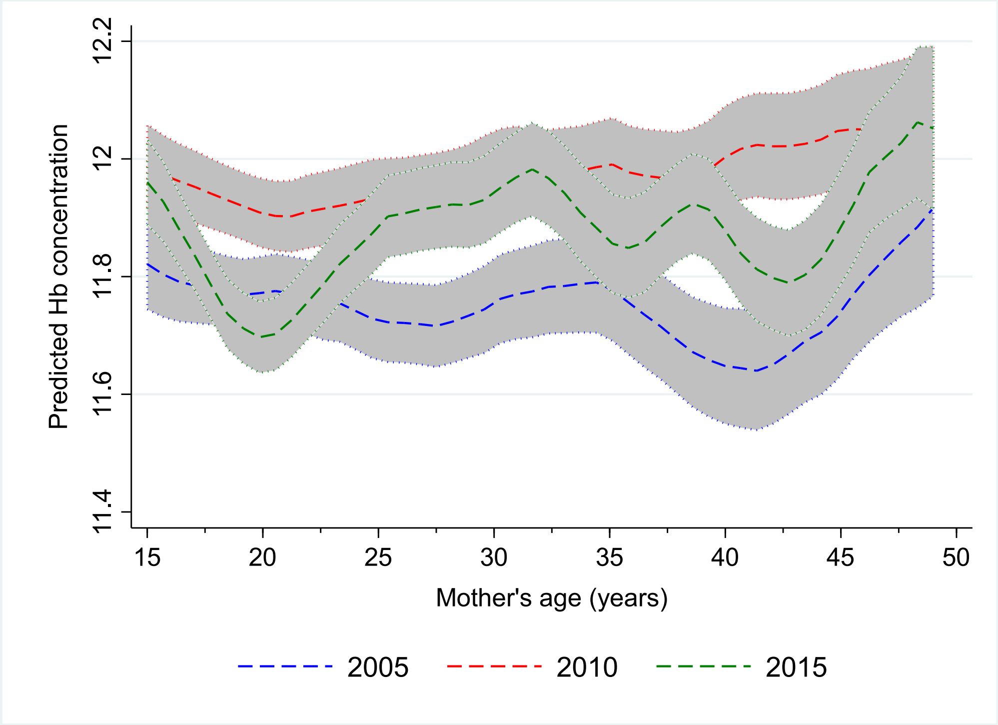
Figure 3.1 Changes in the distribution of hemoglobin concentration for women 15-49 years of age, 2005 to 2015-16



Source: Authors' calculations from Tanzania DHS.

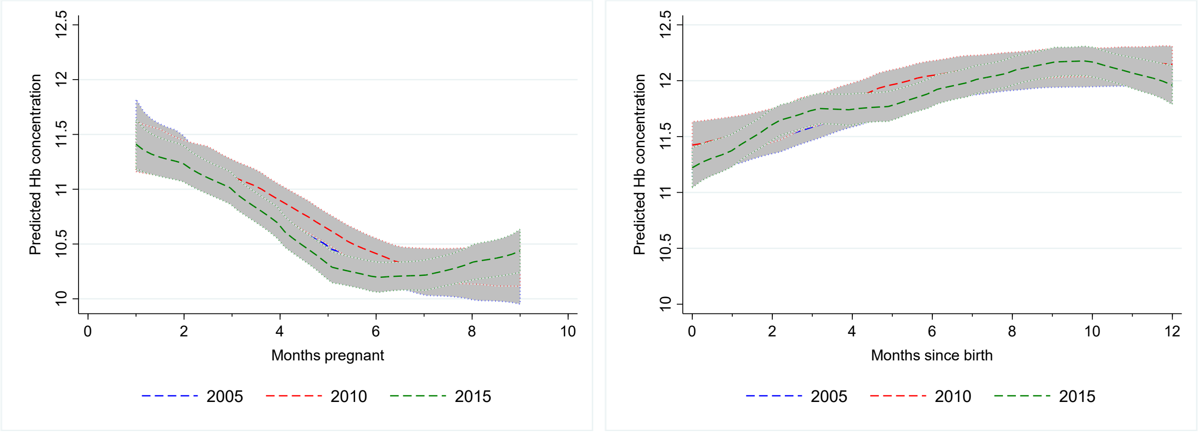
In examining the lifecycle related trends in hemoglobin concentration, although there is variability, there are not strong age-related patterns found (Figure 3.2). There are, however, strong pregnancy-related patterns (Figure 3.3). Even after accounting for the increased volume of blood plasma during pregnancy, the average hemoglobin concentration falls well-below pregnancy-level cutoffs for anemia (<11g/dL). There is a steady decline in the concentration of hemoglobin during the first and second trimesters of pregnancy, and the low levels are maintained through the end of pregnancy. Notably, in 2010, the decline during the second trimester is less steep. During the postpartum period, hemoglobin concentrations slowly increase during the first six months in all three survey waves, though starting from a higher level in 2010.

Figure 3.2 Hemoglobin concentration according to women’s age, 2005 to 2015-16



Source: Authors’ calculations from Tanzania DHS using the local polynomial smoother regression in STATA *(lpolyci* command*)*.

Figure 3.3 Changes in hemoglobin concentration by month of pregnancy and months postpartum from 2005 to 2015-16



Source: Authors’ calculations from Tanzania DHS using the local polynomial smoother regression in STATA *(lpolyci* command*)*. Samples sizes for pregnant women are 1,077 for 2004-05 round, 945 for 2010 and 1,137 for 2015-16. Samples sizes for postpartum women are 1,832 for 2004-05 round, 1,709 for 2010 and 2,199 for 2015-16.

Trends in potential determinants of anemia

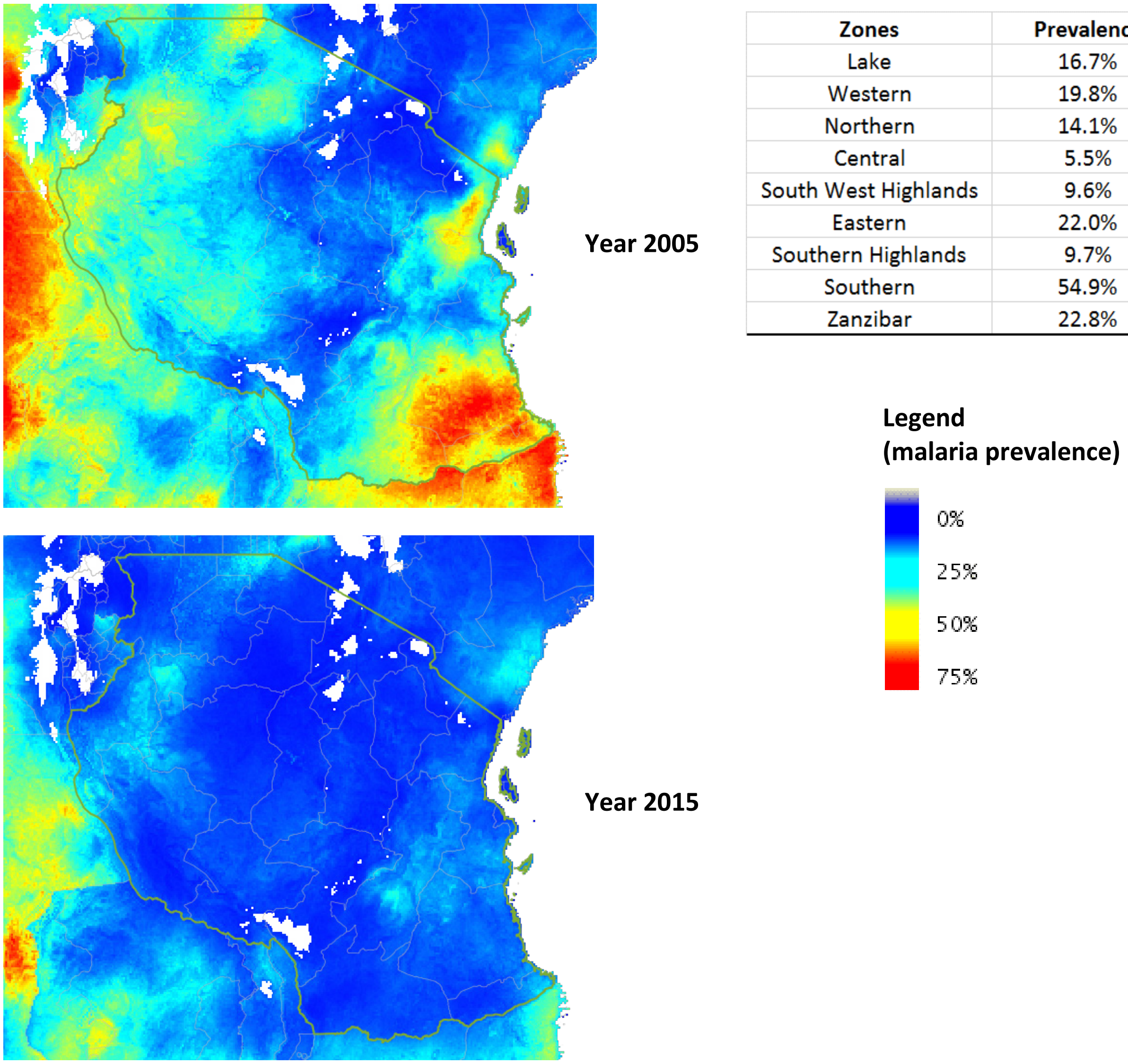
In Table 3.3 we report trends on the hypothesized determinants of women's anemia and hemoglobin status. There are steady improvements in general socioeconomic trends, including women's years of education (from 5.18 to 6.40) and the asset score (from 1.31 to 2.30). These improvements were also reflected in the WASH environment. More women lived in households with improved water sources and toilets, and the prevalence of open defecation at the village level also decreased.

In terms of the infection-related hypothesized drivers, in addition the WASH environment, other factors also improved. The overall prevalence of malaria declined dramatically during this period (from 0.15 to 0.03. This trend is also depicted in Figure 3.4, which shows the spatial changes in the prevalence of malaria among children 2-9 years old. Additionally, more women slept under bed nets (from 18% to 52%). The prevalence of fever among children during the past two weeks, which may reflect any combination of infectious diseases, also declined (from .25 to .18). There were very small decreases in the number of women who lived in households that used biomass fuel.

There were small, but consistent decreases in fertility-related measures. At each subsequent wave, fewer women had given birth in the past year and fewer were currently pregnant. The total number of births per women also deceased. Alongside this, increasingly more women were currently using hormonal contraceptives (from 12% to 20%), and there was relatively no change in the use of non-hormonal contraceptive methods.

If we look at trends in maternal care among women who gave birth in the past six months, we find somewhat erratic trends. Attending an ANC visit during the first trimester is extremely uncommon but did increase a small amount from 11% to 20% between 2005 and 2015-16. The percentage of women who attended all four recommended ANC visits declined over this period from 49% in 2005 to 30% in 2010, before improving to 44% in 2015-16. This trend makes it unlikely that ANC visits alone were driving changes in anemia. In terms of actual services received at ANC visits, the percentage of women taking ITPp increased steadily from 59% to 71% across the 10-year period. Prenatal iron supplementation increased, overall from 63% to 86% with a low point of 55% in 2010. Additionally, there was a consistent positive trend in women who gave birth in medical facilities (from 47% in 2005 to 64% in 2015). This increase in facility-based births is also reflected in the cluster-level aggregate of women who had given birth during the three years prior.

Figure 3.4 Changes in malaria prevalence among children 2-9 years of age



Zones	Prevalence
Lake	16.7%
Western	19.8%
Northern	14.1%
Central	5.5%
South West Highlands	9.6%
Eastern	22.0%
Southern Highlands	9.7%
Southern	54.9%
Zanzibar	22.8%

Source: Bhatt et al. (2015).

Table 3.3 Changes in hypothesized underlying determinants of anemia, 2005-2016

	2005	**2010**	**2015-2016**
Age	28.17	28.57	28.69
Education	5.18	5.74	6.40
Short birth interval (0/1)	0.06	0.06	0.07
Birth last year	0.19	0.18	0.17
Pregnant	0.11	0.10	0.09
Number of children	2.91	2.88	2.74
Hormonal contraceptives use	0.12	0.16	0.20
Non-hormonal contraceptive use	0.05	0.07	0.06
Bed net	0.18	0.51	0.52
Asset score (0-10)	1.31	1.53	2.03
Improved water (0/1)	0.39	0.43	0.65
Improved toilet (0/1)	0.08	0.02	0.39
Biomass fuel (0/1)	0.98	0.97	0.95
Open defecation, cluster (0-1)	0.13	0.13	0.09
Fever prev (0-1)	0.25	0.24	0.18
Medical births, cluster (0-1)	0.54	0.57	0.70
Rural (0/1)	0.72	0.71	0.64
High altitude (0/1)	0.09	0.11	0.10
Malaria prevalence	0.15	0.06	0.03
Among women who gave birth in the last 6 months			
ANC1st	0.11	0.11	0.20
ANC4	0.49	0.30	0.44
IPTp	0.59	0.63	0.71
Prenatal iron	0.63	0.55	0.86
Facility birth	0.47	0.51	0.64

Source: Authors' calculations from Tanzania DHS.

Note: The values reported in this table represent the population of adult women (15-49 years) and differ slightly from population-level estimates reported in other documents that are representative of children <5 years.

In Table 3.4 we show how changes in the underlying determinants of anemia have changed by zone. There were substantial improvements in several indicators across all nine zones, even those where the prevalence of anemia increased. Both the Central and South-Western Highlands zones (where the largest improvements in the prevalence of anemia occurred) experienced improvements in the percentage of women who used IPTp, though so did the Northern and Southern Highlands zones, which did not experience these improvements. The Lake zone, where improvements were larger than the national average, had a stellar increase in bed net use (from 19% to 72%), but the same trend (9% to 71%) occurred in the Western zone, which experienced the largest increase in anemia over this period.

In terms of iron supplementation during pregnancy, both the Central and South-Western Highlands zones stand out as experiencing large improvements in maternal iron supplementation and also achieving very high levels of supplementation (above 90% in both cases).

Table 3.4 Zonal changes in the various underlying determinants of anemia

	Zones (ranked by anemia change)	**Change in anemia**	**<u>Major changes in determinants over 2005-2016</u>**
1	Central	-9.8 pp	Fever prev (.23 to .08); Hormonal contraceptives (13% to 25%); Slept under a bed net (8% to 24%); Mother took iron (64% to 97%); IPTp (61% to 81%); Facility birth (29% to 61%)
2	South-Western Highlands	-8.6 pp	Open defecation (.12 to .06); Hormonal contraceptives (11% to 24%); Number of children born (3.4 to 2.9); Slept under a bed net (8% to 34%); Mother took iron (69% to 92%); IPTp (34% to 75%); Facility birth (46% to 67%)
3	Lake	-4.6 pp	Open defecation (.20 to .13); Hormonal contraceptives (6% to 14%); Slept under a bed net (19% to 72%); Malaria prev (.19 to .04); Clean water (25% to 54%); Mother took iron (59% to 81%)
4	Eastern	-3.6 pp	Fever prev (.28 to .17); Biomass fuel (95% to 86%); Malaria prev (.13 to .03); Clean water (45% to 85%); ANC 1st Tri (14% to 35%); Mother took iron (57% to 93%); Facility birth (61% to 86%)
5	Zanzibar	-2.7 pp	Fever prev (.32 to .18); Open defecation (.26 to .13); Biomass fuel (99% to 95%); Number of children born (2.8 to 2.4); Slept under a bed net (18% to 46%); Clean water (74% to 98%); Mother took iron (60% to 80%)
6	Northern	-1.2 pp	Biomass fuel (93% to 89%); Number of children born (2.6 to 2.3); Slept under a bed net (15% to 40%); Clean water (43% to 82%); IPTp (53% to 75%)

7	Southern	1.9 pp	Fever prev (.35 to .23); Hormonal contraceptives (20% to 42%); Slept under a bed net (13% to 49%); Malaria prev (.45 to .04); Clean water (32% to 55%); Facility birth (48% to 91%)
8	Southern Highlands	5.5 pp	Fever prev (.29 to .14); Hormonal contraceptives (16% to 28%); Slept under a bed net (13% to 40%); Malaria prev (.10 to .02); Clean water (44% to 64%); ANC 1st Tri (11% to 27%); Mother took iron (54% to 81%); IPTp (54% to 75%)
9	Western	6.6	Fever prev (.38 to .18), Open defecation (.22 to .16); Hormonal contraceptives (6% to 13%); Slept under a bed net (9% to 71%); Malaria prev (.18 to .03); Clean water (23% to 47%)

Source: Authors' estimates from DHS data.

Regression results

Table 3.5, 3.6, 3.7, and 3.8 report results from linear probability models in which hemoglobin concentration and anemia status are a function of the variables described above. All regression control for regional fixed effects as well as dummy variables for the month of the survey to account for seasonal patterns. Table 3.5 presents the pooled regression results (2005, 2010, and 2015-16) for both outcomes. Table 3.6 divides these analyses by rural and urban areas for both outcomes. Table 3.7 limits the analysis to women who gave birth in the past 6 months, which allows us to include variables related to maternal care. Table 3.8 limits the analysis to older adolescents (15-19 year olds).

In examining the determinants of hemoglobin concentration and anemia for the complete pooled samples of data from 2005, 2010, and 2015-16 (Table 3.5), the determining factors are for the most part similar for the two outcomes. The usual socioeconomic indicators—women's education and the asset index—are both strongly correlated with improvements to these outcomes. Specific characteristics, such as improved water sources and improved toilets at the household level, however, are not strongly predictive of hemoglobin or anemia status. Notably though, sanitation characteristics at the village level, measured by the prevalence of open defecation is strongly related to better hemoglobin and anemia status.

In terms of infection, the prevalence of malaria is surprisingly not correlated with either of these outcomes. This is particularly surprising given the considerable decline in the prevalence of malaria over this period, but it may be the result of underlying disease dynamics related to reduced immunity and treatment strategies that we elaborate on in the discussion. Additionally, bednet use is associated with lower hemoglobin concentration, which is again unexpected. (Several hypothesized interactions between malaria prevalence and preventative practices were also considered, but similar unexpected patterns still emerged.) We elaborate further on these points in the discussion. The village-level prevalence of fever in children<5, which is indicative of general levels of infectious disease locally, suggest that reductions in the prevalence of infectious disease transmission locally is associated with higher hemoglobin concentration and less anemia, though we do not necessarily have an indication of the illnesses causing the fevers.

Characteristics related to pregnancy and the declining fertility rate also emerged as important predictors. Being currently pregnant or giving birth in the past year are both associated with lower hemoglobin concentration and higher anemia. Women who had given birth following a short birth interval were also considerably more likely to be anemia. Additionally, the use of hormonal contraceptives is also strongly correlated with better hemoglobin and anemia status, though the use of non-hormonal contraceptives is not.

There are minimal differences in the determinants of anemia between rural and urban areas (Table 3.6), and some of these differences may be attributable to the smaller sample sizes for each of these sub-populations. Notably, short birth intervals and the prevalence of open defecation appear to be important determinants of these outcomes only in rural areas. Bednet use and not using biomass fuel, on the other hand, are particularly important in urban areas.

Table 3.5 Least squares and linear probability models explaining variation in hemoglobin concentration and anemia status, pooled 2005, 2010 and 2015-16 DHS

Nutritional outcome	(1) Hemoglobin concentration	(2) Anemia status
Education	0.010**	-0.002*
	(0.003)	(0.001)
Age	-0.003+	-0.001
	(0.002)	(0.000)
Short birth interval	0.059	-0.022*
	(0.037)	(0.011)
Birth last year	-0.128**	0.028**
	(0.026)	(0.008)
Pregnant	-1.283**	0.089**
	(0.033)	(0.010)
Number of children	0.001	0.003
	(0.006)	(0.002)
Hormonal contraceptive	0.558**	-0.131**
	(0.027)	(0.008)
Non-hormonal contraceptive	0.004	-0.007
	(0.004)	(0.013)
Bed net	-0.039+	0.010
	(0.022)	(0.006)
Asset index (0-10)	0.033**	-0.013**
	(0.011)	(0.003)
Improved water	-0.026	0.012
	(0.027)	(0.008)
Improved toilet	0.059	-0.014
	(0.040)	(0.012)
Biomass fuel	-0.103	-0.002
	(0.065)	(0.019)
Open defecation, cluster	-0.412**	0.099**
	(0.081)	(0.021)
Fever prev	-0.214*	0.074**
	(0.090)	(0.025)
Medical births, cluster	0.076	-0.016
	(0.065)	(0.018)
Rural	0.103**	-0.021+
	(0.039)	(0.011)
High altitude	0.382**	-0.089**
	(0.058)	(0.015)
Malaria prevalence	0.282	-0.109
	(0.293)	(0.079)
Regional fixed effects?	Yes	Yes
Survey month effects?	Yes	Yes
Observations	31,451	31,451
R-squared	.143	.079

Notes: ** p<0.01, * p<0.05, + p<0.1. See the main text for definitions of variables.

Table 3.6 Least squares and linear probability models explaining variation in hemoglobin concentration and anemia status, by rural and urban area, pooled 2005, 2010 and 2015-16 DHS

	(1)	(2)	(3)	(4)
Nutritional outcome	**Hemoglobin concentration**		**Anemia status**	
Population	**Rural**	**Urban**	**Rural**	**Urban**
Education	0.014**	-0.002	-0.003*	0.000
	(0.004)	(0.006)	(0.001)	(0.002)
Age	-0.003	-0.003	-0.000	-0.001
	(0.002)	(0.003)	(0.001)	(0.001)
Short birth interval	0.082*	-0.041	-0.027*	0.001
	(0.040)	(0.095)	(0.012)	(0.025)
Birth last year	-0.103**	-0.213**	0.018*	0.065**
	(0.029)	(0.059)	(0.009)	(0.017)
Pregnant	-1.298**	-1.224**	0.092**	0.074**
	(0.037)	(0.076)	(0.011)	(0.022)
Number of children	0.003	-0.012	0.003	0.004
	(0.007)	(0.014)	(0.002)	(0.004)
Hormonal contraceptive	0.541**	0.616**	-0.126**	-0.147**
	(0.033)	(0.050)	(0.010)	(0.014)
Non-hormonal contraceptive	0.064	-0.064	-0.022	0.010
	(0.054)	(0.073)	(0.017)	(0.020)
Bed net	-0.017	-0.078*	0.008	0.013
	(0.028)	(0.039)	(0.008)	(0.011)
Asset index (0-10)	0.023	0.062**	-0.010*	-0.020**
	(0.016)	(0.016)	(0.005)	(0.005)
Improved water	-0.038	0.021	0.019*	-0.016
	(0.031)	(0.056)	(0.009)	(0.015)
Improved toilet	0.032	-0.022	-0.016	0.010
	(0.053)	(0.063)	(0.016)	(0.019)
Biomass fuel	0.048	-0.126+	-0.056	0.013
	(0.212)	(0.066)	(0.055)	(0.021)
Open defecation, cluster	-0.419**	0.069	0.100**	0.057
	(0.086)	(0.538)	(0.023)	(0.125)
Fever prev	-0.115	-0.303*	0.050+	0.093*
	(0.108)	(0.151)	(0.030)	(0.042)
Medical births, cluster	0.084	-0.098	-0.018	0.028
	(0.073)	(0.156)	(0.020)	(0.045)
High altitude	0.402**	0.301*	-0.096**	-0.063*
	(0.064)	(0.125)	(0.017)	(0.031)
Malaria prevalence	0.098	1.321*	-0.106	-0.237
	(0.340)	(0.567)	(0.092)	(0.148)
Regional fixed effects?	Yes	Yes	Yes	Yes
Survey month effects?	Yes	Yes	Yes	Yes
Observations	22,996	8,455	22,996	8,455
R-squared	.157	.124	.088	.071

Notes: ** p<0.01, * p<0.05, + p<0.1. See the main text for definitions of variables.

In terms of women who have given birth within the past 6 months (Table 3.7), who had the potential to have benefited from specific maternal health interventions that aim to improve mothers' hemoglobin status, a few ANC characteristics emerge as important. Both attending a minimum of four ANC visits and being administered IPTp are significant determinants of improved hemoglobin concentration. Though IPTp is only marginally significant in reducing anemia and attending four ANC visits, the smaller sample size for this population, the size of the standard errors, and the fact that they are significant for hemoglobin concentration suggest that these are important for interventions for improving maternal hemoglobin and anemia status, although seeking prenatal care may also associated with other positive health practices that lead to higher hemoglobin concentration (e.g., iron-rich diets, early treatment for infections).

For older adolescents (15-19 years), the patterns are largely similar with a few notable differences (Table 3.8). The coefficients for years of education is larger. This is found in the context of recent national policies of educational expansion that have increased educational access among these this younger cohort. The coefficient for age is marginally significant, which suggests that within the 15-19 years old age span, younger individuals are more susceptible to anemia. Additionally, both open defecation and fever prevalence at the cluster level are significant with effects of a reasonably large magnitude in the general population of adult women, but not among adolescents. This difference may be the consequence of smaller sample size in the sub-population of adolescents.

Table 3.7 Least squares and linear probability models explaining variation in hemoglobin concentration and anemia status, among women who gave birth in the past 6 months

Nutritional outcome	(1) Hemoglobin concentration	(2) Anemia status
Education	0.003	0.001
	(0.011)	(0.003)
Age	0.007	-0.002
	(0.010)	(0.003)
Short birth interval	0.084	-0.013
	(0.098)	(0.027)
Number of children	-0.013	-0.001
	(0.027)	(0.007)
Hormonal contraceptive	0.245+	-0.061+
	(0.128)	(0.037)
Non-hormonal contraceptive	-0.206	0.073
	(0.201)	(0.057)
Bed net	0.001	-0.008
	(0.073)	(0.021)
ANC1st	0.011	-0.023
	(0.096)	(0.028)
ANC4	0.171*	-0.037+
	(0.071)	(0.020)
Prenatal iron	0.011	0.020
	(0.077)	(0.022)
IPTp	0.119+	-0.030
	(0.071)	(0.020)
Facility birth	-0.018	0.009
	(0.082)	(0.024)
Asset index (0-10)	0.026	-0.021
	(0.044)	(0.013)
Improved water	0.009	0.019
	(0.079)	(0.022)
Improved toilet	0.142	0.009
	(0.135)	(0.040)
Biomass fuel	-0.167	-0.042
	(0.286)	(0.088)
Open defecation, cluster	-0.339+	0.079
	(0.188)	(0.055)
Fever prev	0.112	0.005
	(0.261)	(0.076)
Medical births, cluster	0.027	-0.002
	(0.182)	(0.051)
Rural	0.127	-0.021
	(0.106)	(0.032)
High altitude	0.433**	-0.100*
	(0.154)	(0.042)
Malaria prevalence	-0.071	-0.106
	(0.813)	(0.251)
Observations	2,831	2,831
R-squared	.101	.090

Notes: ** p<0.01, * p<0.05, + p<0.1. Regressions include region and month of survey fixed effects.

Table 3.8 Least squares and linear probability models explaining hemoglobin concentration and anemia status in older adolescents (15-19 years), pooled 2005, 2010 and 2015-16 DHS

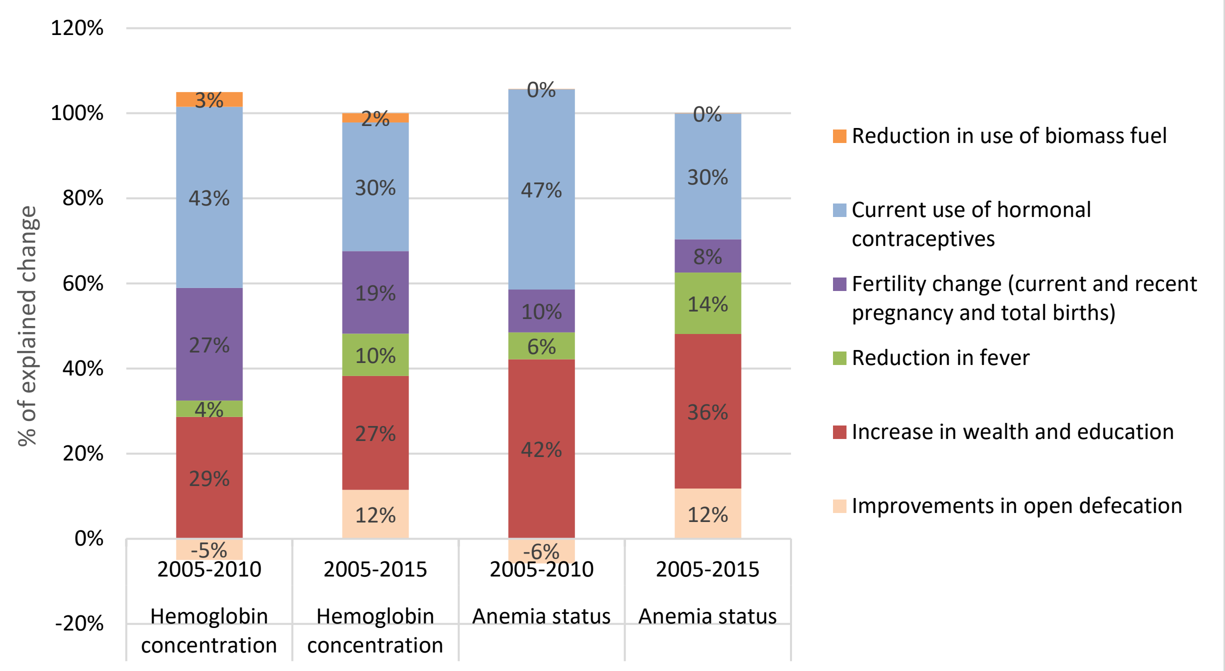
Nutritional outcome	(1) Hemoglobin	(2) Anemia status
Education	0.031**	-0.008**
	(0.009)	(0.002)
Age	-0.045**	0.006
	(0.015)	(0.005)
Short birth interval	0.135	-0.059
	(0.199)	(0.063)
Birth last year	-0.232*	0.053+
	(0.095)	(0.028)
Pregnant	-1.545**	0.164**
	(0.083)	(0.023)
Number of children	0.068	0.001
	(0.077)	(0.021)
Hormonal contraceptive	0.339**	-0.081*
	(0.110)	(0.035)
Non-hormonal contraceptive	0.196+	-0.054
	(0.103)	(0.034)
Bed net	-0.072	0.022
	(0.044)	(0.014)
Asset index (0-10)	0.043*	-0.023**
	(0.021)	(0.007)
Improved water	0.004	0.007
	(0.048)	(0.015)
Improved toilet	0.003	-0.006
	(0.072)	(0.022)
Biomass fuel	-0.092	-0.033
	(0.144)	(0.053)
Open defecation, cluster	-0.188	0.064+
	(0.122)	(0.037)
Fever prev	-0.233	0.074+
	(0.146)	(0.043)
Medical births, cluster	0.047	0.003
	(0.106)	(0.031)
Rural	0.083	-0.034+
	(0.065)	(0.021)
High altitude	0.381**	-0.076**
	(0.104)	(0.027)
Malaria prevalence	-0.575	0.040
	(0.449)	(0.137)
Regional fixed effects?	Yes	Yes
Survey month effects?	Yes	Yes
Observations	6,819	6,819
R-squared	0.156	0.089

Notes: ** p<0.01, * p<0.05, + p<0.1. See the main text for definitions of variables.

Decomposition results: predicted drivers of anemia reduction

We now combine the results from Table 3.3 (changes in weighted sample means) with the results from Table 3.5 (pooled regression coefficients) to calculate a decomposition at the means. This allows us to identify plausible drivers of the decline in anemia between 2004-05 and 2010 and between 2004-05 and 2015-16 (Figure 3.5). We then repeat this for the sub-population of those aged 15-19 years (Figure 3.6). Note that we do not decompose the trends from 2010 and 2015-16, because during this period there was an increase in anemia (and decline in hemoglobin). Additionally, we do not decompose the changes specific to anemia among mothers who had given birth in the previous six months, because there were relatively few additional factors identified and the sample size was small.

Figure 3.5 Predicted drivers of hemoglobin concentration and anemia improvements, 2004-05 to 2010 and 2004-05 to 2015-16



Notes: Authors' estimation of predicted changes in hemoglobin concentration and anemia status using the regression results from Table 3.5 and sample-specific changes in weighted means from Table 3.3.

In this figure, each bar represents change in the particular outcome over the given time period. Each of these bars is then broken down into the percentage of the overall predicted change that can be explained by improvements in those characteristics. Across both outcomes for both time periods, improvements to household wealth and women's education contribute to a large share of the predicted change (between 37% and 43%), with larger shares being responsible for the change of anemia status compared to hemoglobin concentration.

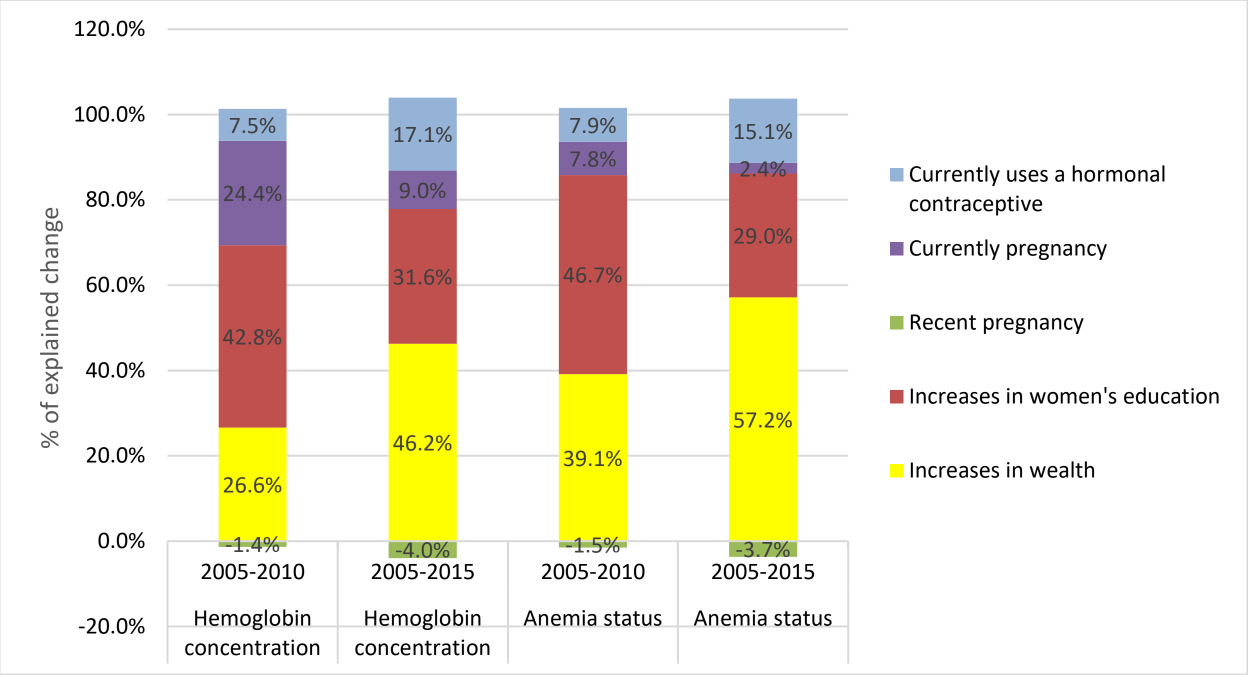
Improvements in open defecation, which likely reduced infection, also played a small role in the observed change between 2004-05 to 2015-16. However, it also had a small negative contribution, which should be interpreted as zero, between 2004-05 and 2015-16. Similarly related to infection, the reduction in fevers among young children contributed between 4% and 14% across the outcomes and time periods and was responsible for a larger share of the change between 2004-05 and 2015-16, compared to between 2010 and 2015-16. Reductions in the use of biomass fuel contributed a small amount (2% to 3%) to the change in hemoglobin concentration (but not anemia status) for both time periods.

The use of hormonal contraceptives is also a substantial factor, accounting from between 30% to 47% of the change. Though it is certainly biologically plausible, and there was an increase in the use of hormonal contraceptives over this period, the size of this contribution may be overestimated. It is possible that use of hormonal contraceptives is also tied to other interactions with healthcare workers and facilities. These interactions may prompt other healthcare practices, such as iron supplementation and treatment for parasites or other infections. However, these are factors that could not be measured with the data available.

The aspects underlying fertility change also contributed to the predicted change in hemoglobin concentration (between 8% and 27%). These factors contributed a larger proportion of the overall change in hemoglobin concentration compared to anemia status. With even small declines in total fertility rates, as experienced in Tanzania, fewer women are pregnant or have recently given birth at any given time period. This dynamic is, at least in small part, driving improvements in anemia status.

Similar to the previous figure, the drivers of improvements in hemoglobin concentration and anemia prevalence for the subpopulation of those aged 15-19 are shown in Figure 3.6. Compared to the general population, no new factors emerged as important, but the importance of some factors decreased while others emerged as more important. Improvements in wealth and education emerge as the most important potential drivers for this younger cohort. Hormonal contraceptive use and pregnancy dynamics remain important factors. However, the share of their contribution is considerably smaller than in the general population of adult women.

Figure 3.6 Predicted drivers of hemoglobin concentration and anemia improvements among older adolescents (15-19 years old), 2004-05 to 2010 and 2004-05 to 2015-16



4. CONCLUSIONS

There were notable improvements in the prevalence of anemia among women of reproductive age (15-49) between 2004-05 and 2010 (47.2% to 40.1%). The prevalence of anemia then rose again to a prevalence of 44.8% in 2015-16. Underpinning these trends was considerable subnational heterogeneity. Improvements were larger in rural areas. Additionally, while the Central and South-Western Highlands Zones experienced dramatic improvements, three zones experienced overall declines (increases in anemia): Western, Southern Highlands, and Southern.

In comparing these trends in women's anemia by zone to the trends in stunting by zone over the same time period (Headey et al., 2019), we observe quite different patterns. The zones with the most dramatic improvements in stunting were not the same ones that experienced large improvements in women's anemia. In fact, the patterns are nearly polar opposite; the Western, Southern Highlands, and Southern zones where anemia among women increased were the top three performers in terms of reductions in stunting. The factors that limit optimal nutritional status differ among nutritional outcomes, and the different pattern for child stunting and women's anemia is likely the results of regional differences in the underlying disease dynamics and food/nutrient availability.

Among the putative drivers of improvements in hemoglobin concentration and anemia status, increases in household wealth and women's education, increased use of hormonal contraceptives, and the pregnancy dynamics underlying fertility change are among the largest potential drivers of these changes. Notably, the improvements attributable to hormonal contraceptives may also be tied to increased interactions with the healthcare system and masking unmeasured characteristics, such as iron supplementation, counseling in the consumption of iron-rich foods, and quicker treatment and more-frequent prevention of infectious diseases.

Improvements in infection-related characteristics, specifically reductions in the prevalence of fever and open defecation, are likely also driving factors. Reductions in the use of biomass fuel for cooking possibly had a small role in improving hemoglobin levels, and considering the high prevalence of the use of biomass fuels, there is a high likelihood that they could contribute more to these improvements if the use on non-biomass fuels expands.

Among pregnant women in particular, completing all four ANC visits and receiving IPTp to reduce malaria during pregnancy were correlated with better hemoglobin concentration and anemia status. Though IPTp could not be included in the decompositions since it is only applicable to a small population of women, its correlation with improved outcomes and the steady increase in its use over the time period being examined suggests that it should be considered a potential driver, particularly among women who are pregnant or have recently given birth.

For older adolescents (15-19 years old), the improvements in national-level trends were much more modest than in the general population of adult women. Though some factors differed in their relative contribution to the change in adolescent anemia, no new factors emerged as potential drivers of anemia or changes in anemia in this subpopulation. It will be important to consider interventions (e.g., iron-supplementation programs) that specifically target adolescents with either school and community-based approaches.

A striking finding from these analyses is that the dramatic reductions in the prevalence of malaria are not associated with the improvements in hemoglobin concentration and anemia status. We offer two plausible explanations for this finding. First, the reduction in exposure to malaria may lead to a reduction labile immunity. This means that adults who contact malaria will have a more severe response and a larger drop in hemoglobin concentration (Ghani et al. 2005; Nkumama et al. 2017). Another explanation is that mefloquine, a common medication for treating malarial infection, is also effective at treating schistosomiasis, which is responsible for a large share of the anemia burden in the region (Fahmy et al. 2013). Thus, with the decline in the prevalence of anemia women are no longer being inadvertently treated for schistosomiasis infection. Unfortunately, the lack of more appropriate biomarker data, both in terms of the breadth of data being collected and the frequency of measurement limit further exploration of these hypothesized explanations. Collecting more comprehensive biomarker data in the future will be important for developing a complete understanding of the determinants of anemia and understanding the factors driving the reduction in anemia.

Policy recommendations

These findings suggest several potential policy recommendations. To reduce anemia among women, interventions that address infection control/treatment and increase the intake of iron and folic acid should be prioritized. Management of vectors of infection, both medically and via improved sanitation, will need to be prioritized to see substantial improvements in the anemia status of women. These should include improving access to high-quality sanitation and water supply and improving screening and treatment for infectious diseases that may contribute to anemia, especially during pregnancy. The lack of direct information on diets prevents a thorough analysis, though there is reason to believe that increasing dietary diversity to include iron-rich foods, has the potential to contribute to improvements in the anemia status of women. Additionally, initiated iron and folic acid supplementation programs for adolescents at the community and school level should be considered.

Furthermore, it is recommended that there be increased focus on improving access to maternal care and reproductive health services, along with focusing on the higher anemia-related needs of pregnant and postpartum women via iron supplementation and the prevention and treatment of infection. Reducing anemia among women during vulnerable parts of their lifecycle is essential. There is also scope to prevent anemia – and child malnutrition – through appropriate family planning interventions, especially as these may have the added benefit of reducing adolescent pregnancies and short birth intervals.

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