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Abstract

Malnutrition is currently one of the largest threats to public health, with three million children dying worldwide per year as a result. This paper examines the determinants of children's nutritional status in Egypt over time using an anthropometric index, height for age z score (HAZ), to assess children's nutritional status. Over the last two decades, the HAZ distribution and the stunting rates in Egypt have changed markedly. However, what factors led to changes in the HAZ distribution in Egypt over time remains unknown. Using data from Egypt's Demographic and Health Survey (EDHS) for the years 1995, 2003 and 2014, I identify factors that are correlated with the change in the height of children aged 2-4. I use a semi-parametric approach proposed by Dinardo, Fortin and Lemieux (DFL,1996) that decomposes the changes in the HAZ distribution and stunting rates between 1995 and 2003, 2003 and 2014, and 1995 and 2014 into differences that could potentially be explained by differences in covariates and/or return to covariates. The covariates include child characteristics, maternal characteristics, household socioeconomic status and access to health care. The results indicate that the variation in HAZ distribution and stunting rates in Egypt over time are driven mainly by a change in the return to covariates. There is suggestive evidence that the change in the return to mother's height and weight over time had a positive impact on the change of the child's height. Additionally, health inequality exists across households with different income. Better policies targeted at increasing household income, mother's employment and education can help reduce stunting rates by reducing illness and malnutrition.

Keywords: Stunting, height-for-age, DFL, development, health

JEL Classifications: D0, I1, J1, O1

1 Introduction

Stunting is a serious health problem in Egypt. In 2014, 2.1 million Egyptian children under the age of five were stunted, indicating that one in five Egyptian children are short for their age. This is the largest number of stunted children in the Middle East and North Africa (MENA) region. Additionally, the stunting rate in Egypt is higher than other low-middle income countries and is similar to that of low income countries. For instance, Egypt and Jordan have similar Gross National Incomes (GNI), but the average stunting rate in Egypt in the period 2005-2016 was almost threefolds that of Jordan (22.3% in Egypt and 7.8% in Jordan) (United Nations Children's Fund, 2016).

There is a clear correlation between stunting an malnutrition. Stunting is a long term outcome of chronic malnutrition. According to the World Health Organization, malnutrition is one the largest threats to public health (WHO, 2018). Globally, malnutrition accounts for almost 45% of child mortality, with almost three million children under the age of five dying per year as a result of malnutrition (WHO, 2018; Global Panel, 2016). Stunted children who survive suffer from cognitive/psychological problems. These problems include physical and neurocognitive damage, impaired cognitive development, learning delays, and increased risk of diseases. In addition, stunting is more than being short; a stunted child's brain does not fully grow and that impedes his/her ability to learn (Onis, 2016). Therefore, stunting is one of the main impediments to human development. In addition to the cognitive/physiological costs, stunting is associated with economic and health costs. These economic and health costs include lower levels of educational attainment, employment, and higher levels of morbidity and mortality. An observed reduction of 2-3% of GDP demonstrates the combined cost associated with childhood stunting in Egypt (Onis, 2016; USAID,2017).

In recent decades, there has been marked changes in stunting in Egypt. The stunting rate was 35.6% in 1995 and declined to 16.7% in 2003. Surprisingly, that decline didn't persist and the stunting rate increased from 16.7% in 2003 to 20.5% in 2014. What factors explain these changes in stunting are unknown. In this paper, I examine what factors led to the change in the height-for-age distribution and stunting of Egyptian children aged 2-4 from 1995 to 2014. The analysis uses data from Egypt's demographic and health survey (EDHS), which is currently the only and best source of information on the health of Egyptian children.

To examine what factors led to the change in the HAZ distribution, I use the DFL approach (DFL,1996) and re-centered influence function (RIF). The DFL and RIF decompositions as are two important methods for modelling quantiles as a function of covariates, and are used in this paper as complementary approaches. The difference between the DFL decomposition and the RIF is that the dfl considers that the distributional statistic of HAZ can be the result of a large change in the cumulative distribution function (cdf) of the outcome variable (HAZ), such as in the case of an income transfer and the RIF examines small changes. Since the results don't support such a large change, I proceed by examining whether there is a small change in the cdf of HAZ. To examine that, I estimate the RIF.

I assess the potential that changes in the HAZ distribution over the years 1995, 2003 and 2014 could be explained by differences in the level of covariates and/or differences in associations between covariates and height-for-age. The covariates include child characteristics, mother characteristics, household socioeconomic status (SES) and access to health care.

Results from my analysis indicate that the HAZ distribution and the stunting rates are changing over time primarily not because of changes in demographic and socioeconomic factors as is commonly known in the literature. By using the DFL decomposition, I find suggestive evidence that the return to mother's height and weight is changing over time, despite that there is little change in the mother's height and weight. To better understand what causes the return to mother's height and weight to change over time, I follow the DFL with an RIF decomposition to test the changes in which covariates could lead to the change in the return to mother's height and weight.

This is the first paper to provide evidence that the change in the HAZ distribution and the stunting rates are due to changes in the associations between covariates and HAZ. More specifically, there is suggestive evidence that the stunting rates are changing due to the change in the returns to mother's height and weight. The results show that holding constant mean of covariates, the stunting rate in 1995 would be lower by 52.8% if covariates had the same association with HAZ as they did in 2003. Holding associations between covariates and HAZ, if the values of covariates in 1995 were the same values as the 2003, the stunting rate in 1995 would be lower by 5.6%. Holding constant mean of covariates, the stunting rate in 1995 and 2003 would be lower by 41.7% and 41.2% respectively if covariates had the same association with HAZ as they did in 2014. Holding associations between covariates and HAZ, if the values of covariates in 1995 and 2003 were the same values as 2014, the stunting rate would decrease by 11.1% and wouldn't change respectively.

2 Literature Review

Stunting is a serious health problem in Egypt. In 2014, 2.1 million Egyptian children under the age of five were stunted, indicating that one in five Egyptian children are short for their age. This represents the largest number of stunted children in the Middle East and North Africa (MENA) region. Additionally, the stunting rate in Egypt is higher than other low-middle income countries and is similar to that of low income countries. For instance, Egypt and Jordan have similar Gross National Incomes (GNI), but the average stunting rate in Egypt in the period 2005-2016 was almost threefolds that of Jordan (22.3% in Egypt and 7.8% in Jordan) (United Nations Children's Fund, 2016).

While there's an extensive literature on the determinants of children's nutritional status, evidence on Egypt remains limited. Demographic, social and economic factors explain about three quarters of the variability in stunting prevalence among countries (Frongillo et al., 1997). Despite that, it is still unclear why the rate of stunting prevalence has been declining in some countries, but not in others (Gillespie et al., 1996). Even within the same country,reasons for the variation in stunting rates across regions over time remains unclear.

There are three proximate factors that determine a child's height: maternal height (genetics), illness and nutrition. A short mother is more likely to have a stunted child. Additionally, if the child experiences repeated rounds of infection such as diarrhea, fever or respiratory illness, or improper breastfeeding or non-nutritious food then it is more likely that the child will be stunted. Besides these three proximate factors, there are other distal factors that contribute to stunting as they are correlated with the main factors. These distal factors include access to health care, place of residence, socio-economic status and education among others (WHO, 2018).

In developing countries, income and the child's nutritional status have been positively associated. Unsurprisingly, wealthier families could afford more nutritious food, better sanitation and medical care and consequently had healthier children (Pritchett, 1996; Easterly, 1999; Ruel et al., 2013; Sharaf, 2018). According to UNICEF, the child's dietary intake and health status determine the child's nutritional status. These immediate determinants are affected by the underlying environment such as household food security, income, mother's health, safe water supply, adequate sanitation, and healthcare availability (UNICEF, 1990). Generally, the likelihood of a stunted child increases with low economic growth and agricultural production (Fenske, 2013; Headey, 2012), poor sanitation, open defecation (Fenske et al., 2013; Spears, 2013), high birth order, discrimination against women (Jayachandran, 2015), poor maternal undernutrition (Coffey, 2015), poor child feeding practices (Menon, 2015), and dietary deficiencies (Deaton, 2008) as they are all determinants of a child nutritional status.

Understanding the determinants of stunting in Egypt, which has unusually high stunting rates relative to its economic development and is changing drastically over time, merits investigation. The few studies that have focused on stunting in Egypt, examined the factors that affect the likelihood of being stunted at one time period only. For instance, using data from Egypt's Demographic and Health Survey (EDHS) for the year 2000, Zottarelli (2007) reported that short birth spacing, high birth order, and living in a rural area were all factors associated with an increased likelihood of having a stunted child. In addition, children whose mothers were not educated faced greater risk of being stunted compared to children whose mothers were educated. Short mothers (height $<$ 150 centimeters) had a higher probability of having stunted children compared to taller mothers (height $>$ 150 centimeters) (Zottarelli, 2007).

More recent studies found similar conclusions regarding the factors that affect stunting. For instance, Sharaf (2018) employed a quantile regression approach to examine the variation in the stunting rate in Egypt in 2014 across different groups. Demographic and social characteristics affected the stunting rate. Children who lived in a household with higher income or whose mother was educated had a higher height for age z-score (HAZ) compared to households with lower income or education (Sharaf, 2018). In another study, Sharaf (2016) employed a Blinder-Oaxaca decomposition to examine regional inequalities in Egypt, Jordan and Yemen for the years 2012-2014. The results indicated that the HAZ gap between rural and urban areas in Egypt is insignificant in 2014 (Sharaf, 2016). It's still unknown whether this HAZ gap is insignificant across time periods, rather than within a time period, and whether it is insignificant across different governorate subdivisions.

This paper is the first to consider the correlates of changes in child HAZ and stunting rate in Egypt over time. Considering rates over time helps to provide policy directives. In addition to showing why the child HAZ and stunting rate is changing over time, this paper also uses a new methodology to examine how stunting is changing. This methodology, the DFL decomposition (DFL,1996) , examines the marked variability in the HAZ distribution and stunting prevalence in Egypt over time.

The advantage of using the DFL approach is that it examines the entire height-for-age distribution and entire distribution of covariates, instead of the mean height-for-age. By considering changes at the mean only, this will not capture those who are at the left tail of the height for age distribution (those who are stunted).[1] So this paper aims at providing

[1]Children at the right tail of the distribution earn higher earnings relative to those at the left tail and children that are very tall are at larger risk of developing heart attacks and strokes (American Heart Association, 2017). Given that the height-for-age z-score distribution in Egypt is skewed to the right, as shown in Figure 1, this paper focuses on the left tail of the distribution (stunted children) as they represent

the reader with an insight of the correlates of changes in childrens' HAZ and consequently provide policy implications that improve childrens' health status.

In addition, a recentered influence function (RIF) postulated by Firpo, Fortin and Lemieux (FFL) (Firpo et al. , 2009) will be estimated to examine what factors affect the stunting rate in Egypt across different parts of the height distribution. I also the RIF to examine the socioeconomic inequalities in health using one of the dominant measures of socioeconomic health which is the concentration index using Heckley, Gerdtham and Kjellsson's methods (JHE, 2016). These methodologies will offer the reader with an insight of the correlates of changes in childrens' HAZ, the relationship between malnutrition and absolute poverty, and consequently provide policy implications that improve children's health status.

3 The Pathogenesis of Stunting

Despite the high global prevalence of stunting, the pathogenesis underlying stunting is surprisingly poorly understood (Prendergast, 2014). Stunting is the result of growth retardation, which is attributed to medical (proximate) and socioeconomic (distal) factors. According to the World Health Organization (WHO), stunting is a long term/cumulative outcome that occurs due to chronic or recurrent undernutrition, chronic illness, psycho-social deprivation, and poor maternal health (WHO, 2018). Malnutrition starts during the prenatal period is mainly due to either the mother's nutritional status or any associated genetic diseases (Mbuya, 2010). Growth retardation could begin in utero and may continue into infancy and early childhood.

Besides the proximate factors that affect stunting, which are mentioned above, there are several distal socioeconomic factors that can indirectly contribute to stunting. Such indirect factors include household wealth, living in a poor socioeconomic environment, access to health care, place of residence, sanitation and political stability among others (Rachmi,

a larger proportion of Egyptian children and have more serious future outcomes compared to those at the right tail.

2016). These factors contribute to stunting by influencing the direct causes of stunting, for example, malnutrition and disease.

The maternal contributors to stunting are short stature, short birth spacing, illiteracy, poor neonatal care, and malnutrition (Rachmi, 2016). If the mother is short (around 150 centimeters or less), the child is more likely to be stunted. Maternal height is partially an outcome of mother's nutrition from childhood to adolescence. Hence, shorter mothers are more likely to be malnourished. Another factor that impacts child height is mother's health. In the child's first 1000 days the risk of stunting increases if the mother has any chronic disease such as diarrhea, hypertension, macro and micro-nutrient deficiencies including vitamins or iron leading to anemia, and lack of proper sanitation among others (WHO, 2018).

Regarding the child contributors, improper breastfeeding increases the likelihood of childhood stunting. Improper breastfeeding can occur if the child isn't breastfed either immediately after birth, for a long duration (2 years) or not exclusively breastfed. The rationale is that natural growth simulators are found in the mother's milk and provide the child with good immunity, which reduces the risk of illness and poor growth. After 6 months, if breastfeeding is not complemented with nutritious food, stunting is likely (WHO, 2018).

Other child related causes include repeated infections such as diarrhea, fever or respiratory illnesses. Poor hygiene and an unsanitary living environment can lead to subclinical infections which cause nutrient malabsorption leading to stunting. Repeated infections lead to a cycle of worse health conditions; where the child is faced with a higher frequency of infections and diseases increasing susceptibility of death. Stunted children who survive suffer from physical and neurological deficit, poor educational outcome, reduced economic productivity and increased risk of diseases (WHO,2018).

Stunting is reversible. A stunted child can catch up, which means that for a given time period, the child is growing at a faster-than-expected rate for their age, which enables him/her to overcome their previous accumulated height deficit. Previous research suggests that among children older than two years, there is catch up. Catch up occurs if the environment a child lives improves through health-related interventions or better nutrition. However, if a stunted child remains in the same living conditions when s/he was stunted, then there will be little to no chance of catching up (IFPRI, 2015).

Based on the above conceptualization of stunting and the factors that impact HAZ, the analysis in this paper will rely on covariates that have both a medical (proximate) and socioeconomic (distal) impact on stunting. These covariates will be classified mainly into child characteristics, maternal characteristics, household SES and access to health care.

4 Data

To conduct the DFL decomposition, I use data from Egypt's Demographic and Health Survey (EDHS) from the 1995 and 2014 EDHS. I also use Egypt's Interim Demographic and Health Survey (EIDHS) for the year 2003. [2] The DHS is an international survey conducted in more than 90 countries. The main aim of the survey is to provide estimates of population, health and nutrition indicators for each of Egypt's governorates. An advantage of using the EDHS is that it is a nationally representative health survey, implemented under the supervision of the Ministry of Health and Population (Ministry of Health and Population, 2015). [3]

The survey design is based on a stratified two-stage cluster design, where the main cluster/sampling unit for urban areas is the district and the main cluster for rural areas is the village. The target sample of the survey is ever-married women between the age of 15 and 49 and their children aged 0-4. Anthropometric data used in the analyses is provided for only one child per household in the survey, even for households with more than one

[2] The EIDHS is different from the EDHS in that Menya govenorate and slum regions in Greater Cairo were oversampled in the EIDHS. A total of 540 clusters/primary sampling units (PSUs) were sampled in 2003, of which 466 PSUs were from the 2000 EDHS sample and 74 additional PSUs were selected from Menya and slum regions. Additionally, frontier governorates were excluded from the EIDHS sample. For consistency, I limit the analysis for all the years to the non-frontier governorates (El-Zanaty, 2004).

[3] The survey was implemented by El-Zanaty and Associates, which is an organization that provides quality research and studies in the areas of health, environment, water resources and agriculture. The survey is funded by the United States Agency for International Development (USAID).

child. The survey includes data on 12,135 children in 1995, 6,661 in 2003 and 15,848 in 2014 (El-Zanaty, 1996; El-Zanaty, 2004; Ministry of Health and Population, 2015).

I restrict the analysis to children aged 2-4, as height is imprecisely measured during the age 0-2. The age 0-2 is known as the growth faltering period, where recumbent length assessment is used to measure the height for this age group, as opposed to measuring the height while standing which is a more accurate procedure which happens only for children above the age of 2 (Rifas-Shiman, 2018;DHCS, 2016). After restricting the sample to children aged 2-4, the sample consists of 5,826 children for the year 1995, 3,684 in 2003 and 8,070 in 2014.

In this study, the main variable of interest is the nutritional status of children measured by HAZ. Anthropometric data on the height for age of children is used to quantify chronic malnutrition (stunting). A child is stunted if their HAZ is less than 2 standard deviations below the WHO median where the HAZ of child i is measured as

$$HAZ_{ij} = \frac{h_{ij} - h_j^-}{\sigma_j} \tag{1}$$

where h_{ij} is the height of child i in group j; where the group is based on the child's sex and age. h_j^- is the median height of group j in the new WHO reference population and σ_j is the standard deviation value of group j in the new WHO reference population.[4] The new WHO reference population includes children from 6 countries which are representative of children worldwide. These countries are Brazil, Ghana, India, Norway, Oman and USA. The statistics reported in the 1995 and 2003 surveys are based on the old WHO reference population defined by the U.S National Center for Health Statistics (NCHS) (WHO, 2018). To compare the 1995 and 2003 stunting rates with the 2014 stunting rates, I re-estimate the stunting rates in 1995 and 2003 using the new WHO reference population. [5] Tables 1 and 2

[4]The z-scores are computed using the WHO IGROWUP ADO file, and implausible values that are flagged by the WHO were removed.

[5]As a result of using the new WHO reference population for the years 1995 and 2003 and limiting the sample to children aged 2-4, the summary statistics presented in this paper are slightly different than those presented in the EDHS reports.

show that in 1995, 35.6% of Egyptian children aged 2-4 were stunted. From 1995 until 2003, the stunting rate fell by 53% to reach 16.7%, and increased to 20.5% in 2014.

To account for the factors that impact the HAZ distribution, I include a set of proximate and distal covariates that impact stunting. The three proximate causes of stunting are mother's height, illness and malnutrition.In this analysis, I include the mother's height as a proximate cause. Due to data limitations, the two other proximate causes, illness and malnutrition are not accounted for. [6] More generally, I classify the covariates into child characteristics, maternal characteristics, household SES and access to health care.

The child's characteristics include gender, age in months and age squared, and where the child resides (geography). There are 27 governorates in Egypt and they are divided into 6 major governorate subdivisions. These subdivisions are metropolitan governorates, urban lower Egypt, rural lower Egypt, urban upper Egypt, rural upper Egypt, and frontier governorates. I limit the analysis to the first 5 governorate subdivisions since there is no data on frontier governorates in 2003 and include a dummy variable for each governorate subdivision. All the variables in this analysis are measured at the time the household is interviewed.

To account for maternal factors, I use data on the mother's height measured in centimeters (cm), height squared, height cubed, weight in kilograms (kg) and weight squared. [7] Table 2 shows that there exists significant changes in the mother's characteristics during the period of the study. Compared to 1995, there was a significant decline in the fraction of women who

[6]The DHS survey contains data on whether the child had any diarrhea, fever or acute respiratory infection (ARI) during the two weeks preceding the interview. This question however might not capture whether a child is stunted as stunting is a result of recurrent infection and is a long term process. If a child is stunted it could be a signal that the child is more frail and thus could potentially get sick more often than a non-stunted child. However being sick in the past two weeks does not change the stunting status. For malnutrition, data on mother's weight is present, however there is no data on the type of food consumed. Being underweight can be a sign of malnutrition, but being overweight/obese might or might not indicate malnutrition depending on whether the type of food consumed is nutritious or not. Also, I don't include data on breastfeeding as the fraction of children who are still breastfed after the age of 2 is almost negligible.For theses reasons, I don't include the

[7] I use the mother's height in levels, squared and cubed and mother's weight in levels and squared to control for the mother's height and nutritional status simultaneously. Alternatively, I use the mother's BMI, to keep the impact of the mothers height salient and find that the regression results are robust in both cases.

are underweight and a significant increase in the fraction of women who are overweight and obese. Being underweight is a proxy for malnutrition, hence the decline in fraction of women who are underweight implies that there is an improvement in mothers' nutrition over time. On the other hand, there has been minimal change in the mothers' height. The average mother's height was 157.44 centimeters (cm) in 1995, 158.45 in 2003 and 159.20 in 2014.

Measures of the household's SES include the mother's employment status, mother's education, household's wealth and sanitation. The mother's employment status is a dummy variable for whether she is employed or not. The mother's level of education is classified into the mother being illiterate, has primary educated, completed secondary education or higher education. The household's wealth is an index measured by the wealth quintile and sanitation is measured by quality of water and toilet facilities. Water facilities are classified as high quality if the water is piped and as intermediate quality otherwise. Toilet facilities were divided into modern flush toilet, pit/latrine and no facility. The statistics in tables 1 and 2 indicate that there was a significant increase in the number of households with access to piped water and flush toilets over time. Furthermore, mothers became more educated, with fewer women being illiterate and more women having secondary or higher education, with no clear pattern of how the return to income is changing.

The last category of covariates is access to health care and is a measure of whether the mother had prenatal care during pregnancy by visiting a doctor, a nurse or no prenatal care, and the number of antenatal visits. Access to health care facilities, measured by the percentage of women visiting a doctor has increased considerably to reach 89.5% by 2014, compared to 35.2% in 1995. In addition, the average number of antenatal visits increased (EIDHS, 2003). So increased access to health care might have reduced the mother's and child's susceptibility to chronic illness and improved the mother's knowledge about nutrition.

Overall, the summary statistics show that there has been a change in the distribution of of covariates over time. There has been a significant decline in children with diseases, improved mother's nutritional status, more prenatal care, improvement in water and toilet facilities, and an increase in the number of people who live in urban areas.

5 Methodology

5.1 Dinardo Fortin and Lemieux (DFL) Decomposition

I will use a semi-parametric decomposition approach proposed by DiNardo, Fortin and Lemieux (DFL,1996) and a recentered influence function (RIF) (Firpo et al. ,2009) to examine what factors led to the change in the HAZ distribution. I will assess the potential that changes in the HAZ distribution over the years 1995, 2003 and 2014 could be explained by differences in the level of covariates and/or differences in associations between covariates and height-for-age. The covariates include child characteristics, mother characteristics, household socioeconomic status (SES) and access to health care.

I use the above mentioned covariates in the DFL decomposition to analyze the marked changes in the HAZ distribution over time. The DFL decomposition, unlike the more widely used Blinder-Oaxaca decomposition, is a semi-parametric approach that focuses on the entire distribution of outcomes and covariates (Fortin, 2010). This entire distribution of covariates is used to estimate a corresponding distribution of HAZ across groups or time periods.

The DFL decomposes the HAZ differences into two components; one that is explained by the differences in the level of the covariates (covariate effect) and the other which is explained by differences in the effect of the covariates on a child's nutritional status (coefficient effect) across the whole HAZ distribution (Gummerson, 2011). In this study, I examine how the HAZ distribution for children in the 1995 sample would differ if the vector of covariates in 1995 were the same as the vector of covariates in 2003 and children were growing according to the growing schedule observed in 1995. I apply the same methodology for comparing the HAZ distribution in 2003 with the HAZ distribution in 2014, and the HAZ distribution in 1995 with the HAZ distribution in 2014. The same methodology is applied for examining stunting across the years.

The HAZ distribution prevailing in the years 1995 and 2003 can be expressed as

$$f_{1995}^{1995}(y) = \int f^{1995}(y|x)h(x|t = 1995)dx \tag{2}$$

$$f_{2003}^{2003}(y) = \int f^{2003}(y|x)h(x|t = 2003)dx \tag{3}$$

where the term $f_{1995}^{1995}(y)$ represents the HAZ distribution in the 1995. The term $f^{1995}(y|x)$ represents the returns to covariates, which converts the observable covariates to height, and the term $h(x|t = 1995)$ represents the density of covariates during 1995 (Gummerson, 2011).

To estimate the counterfactual distribution, instead of integrating over multiple covariates, the DFL method uses inverse probability to weight the vector of covariates in the year 2003 to match the covariate profile in 1995. The DFL approach assigns weights to the actual distribution to create a counterfactual distribution. The counterfactual distribution is the HAZ distribution in 1995 that would have prevailed if the distribution of the covariates was the same as that of 1995 and the returns to endowments was the returns of 2003.

Hence, the counterfactual distribution can be expressed as

$$f_{2003}^{1995}(y) = \int f^{2003}(y|x)h(x|t = 1995)dx \tag{4}$$

The difference between the 1995 actual HAZ distribution and the above counterfactual distribution is coefficient effect, which is the HAZ difference explained by the effect of the covariates on a child's nutritional status across the whole HAZ distribution. The difference between the 2003 actual distribution and the counterfactual distribution is the covariate effect, which is the HAZ difference explained by the differences in the level of the covariates.

To obtain the counterfactual distribution, the DFL uses functions of the estimated propensity score as weights in the weighted kernel density estimation (Dinardo, 2002). The propensity score is the probability that an observation will be from the 1995 or 2003 data given the observed covariates. This predicted probability is estimated using a logit model.

The logit model is estimated to construct the density function by replacing the propensity score ρ^{1995} with an estimate of $\hat{\rho}^{1995}$, and hence obtain an estimate of the propensity score using the predicted probability that an observation from the pooled sample is from the 1995 sample. The covariates that are used to compute the propensity score include the all the child's characteristics, mother's characteristics, household SES, and access to health care variables, mentioned in the data section.

The weights used in the kernal density estimation are assigned such that

$$\int f^{2003}(y|x)h(x|t=1995)dx = \int w f^{2003}(y|x)h(x|t=2003)dx \tag{5}$$

Therefore, using the inverse probability weighting, the counterfactual HAZ distribution can be estimated as

$$f^{1995}_{2003}(y) = \int w f^{2003}(y|x)h(x|t=2003)dx \tag{6}$$

$$f^{1995}_{2003}(y) = \int \frac{\rho^{1995}(x)}{1-\rho^{1995}(x)} \frac{P_{2003}}{P_{1995}} f^{2003}(y|x)h(x|t=1995)dx \tag{7}$$

where the weight is $\frac{\rho^{1995}(x)}{1-\rho^{1995}(x)} \frac{P_{2003}}{P_{1995}}$. P_{1995} is the fraction of the pooled sample that is from the 1995 data and P_{2003} is the fraction of the pooled sample that is from the 2003 data and $\frac{\rho^{1995}(x)}{1-\rho^{1995}(x)}$ is used to convert the 2003 group (control group) to the 1995 group (treated group) (Fortin, 2010; Dinardo, 2002). In other words, the propensity score is the probability of being treated conditional on covariates $P(D_i|X_i)$.

From this counterfactual, we visualize the difference in HAZ distributions that we expect in 2003 if covariates were jointly set to their 1995 distributions. After estimating the counterfactual distribution, I compare it to the actual 1995 distributions, and any differences would be attributed to the associations of covariates (coefficient effect) over time. I also compare the counterfactual distribution with the actual 2003 distribution, and any differences would be attributed to the level differences in covariates (covariate effect) (Dinardo, 2002).

5.2 Recentered Influence Function (RIF) and Concentration Index

The DFL decomposition and the RIF are two methods for modelling quantiles as a function of covariates. Whereas an OLS regression estimates the impact of an explanatory variable on the unconditional mean of the outcome variable. In the case of stunting, looking at the conditional means is restrictive as we are interested in the lower tail of the height for age distribution, and specifically about children that fall below the height for age z score threshold of negative 2, and hence we need to use estimation methods that go beyond examining the mean and looks at other parts of the distribution/quantiles of the outcome variable. A way of doing so is by modelling quantiles as a function of covariates to estimate how the distribution of the outcome variable changes in response to changes in covariates. This can be modelled through a DFL decomposition and/or the RIF.

The difference between the DFL decomposition and the RIF is as follows. Consider the cumulative distribution function (cdf) of the outcome variable Y, denoted by F_Y. F_Y is changing over time, and $v(F_Y)$ is a functional that uses the information in F_Y to estimate a distributional statistic of Y. Firpo, Fortin, and Lemieux (2009) (FFL) estimate unconditional partial effects (UPE) of small changes in the distribution of covariates on the distributional statistic v. This functional allows the estimation of statistics such as the mean, quantile, poverty, or inequality indices. For the special case of quantiles the UPE becomes the Unconditional Quantile Partial Effect (UQPE).

A change in $v(F_Y)$, denoted by Δv can be a result of either a large change in F_Y, such as the case of an income transfer to the whole population, leading to a shift in the whole distribution of F_Y to the right. This is a case where the DFL decomposition is used. In other cases, Δv might be a result of adding a new observation to the sample, where this new observation (with random covariate/income) leads to a change in the ranking of everyone in terms of their position in the distribution. The change in F_Y can be better explained by a RIF. In this paper, I apply the DFL decomposition mentioned above and the RIF mentioned below to to examine the change in F_Y (HAZ).

The RIF regression model is a commonly used method for analyzing the determinants of poverty and inequality (Rios-Avila, 2019). The RIF is used to analyze the impact that changes in the distribution of covariates have on quantiles of the unconditional distribution of Y (HAZ).Using the RIF regressions, I estimate the effect of covariates on inequality measures (Firpo et al., 2009). The method developed in FFL replaces the covariate by the corresponding RIF for the distributional statistics of interest.(Firpo et al., 2009).

The expected value of the RIF at a particular quantile conditional on X is known as the unconditional quantile regression (UQR).The UQR is a popular method for examining the distributional effects on outcomes in terms of changes in characteristics in the areas of income and inequality, labor economics, health economics, and public policy. By estimating the UQR, we know the partial effects of the covariates on any unconditional quantile of the HAZ (Rios-Avila, 2019). The UQR consists of running a regression of the RIF of the unconditional quantile of the HAZ on the covariates.

The recentered influence function ordinary least squares (RIF -OLS), the most common way of estimating the RIF, is estimated by running a regression of a transformation of the outcome variable (HAZ) on covariates, where

$$RIF(y_i, v(F_Y)) = v(F_Y) + IF(y_i, v(F_Y)) \tag{8}$$

and

$$IF(y_i, v(F_Y)) = \frac{\partial v}{\partial \epsilon} \tag{9}$$

where F_Y is the cumulative distribution function (cdf) and $v(F_Y)$ is a functional that uses the information in F_Y to estimate a distributional statistic of Y. The influence function (IF) is the influence of an individual observation on the distributional statistic (quantile) of Y. For instance, the IF of the mean $= E[Y]$, is Y, which is the demeaned value of the outcome variable. Adding back the statistic $v(F_Y)$ to the IF leads to the RIF.

The RIF is a regression of the estimated RIF of each observation y_i on the covariates.

$$RIF(y_i, v(F_Y)) = X`_i\beta + \epsilon_i \tag{10}$$

Taking expectations we have

$$v(F_Y) = E(RIF(y_i, v(F_Y))) = E(X`_i\beta) + E(\epsilon_i) = \bar{X'}\beta \tag{11}$$

Differentiating with respect to the covariates, we have the UPE which is

$$\frac{\partial v(F_Y)}{\partial \bar{X'}} = \beta \tag{12}$$

Using the RIF methodology above, I will estimate the observed changes in health inequality across different quantilies (10,25,50,75,90th) of the haz distribution, where the $UQPE(\tau) = CQPE(\tau, X) = \beta$.

Additionally, I apply the rif approach to the concentration index (a bivariate rank dependent index) to measure health inequality. The concentration index is the dominant measure of socioeconomic inequalities in health. The concentration index is a bivariate rank dependent index that summarizes the relationship between socioeconomic rank and health.

I use the same methodology applied by Heckley, Gerdtham, and Kjellsson (2016) who examine the use of RIFs to measure health inequality, in the case of bivariate rank-dependent concentration indices. The concentration index quantifies the degree of socioeconomic inequality in health variables and examines whether the inequality is more pronounced in one country or time period versus another. In this paper, I look at the socioeconomic inequality in child malnutrition (stunting) over time. The concentration index is zero when there is no socio-ecoeconomic inequality. In the case of ill health - in this case stunting - a negative concentration index indicates that stunting is higher among the poor and vice versa.

The RIF for a bivariate rank dependent index for socioeconomic related health inequality is expressed as:

$$v^I(F_{H,F_Y}) = \int RIF(h, F_Y(y); v^I)dF_H, F_Y(h, F_Y(y)) = E[RIF(H, F_Y; v^I) \tag{13}$$

Applying the law of iterative expectations to the equation above we have

v$^I(F_{H,F_Y}) = \int E[RIF(H, F_Y; v^I)|X = x]\Delta dF_X(x)(14)$

with F_x being the CDF of X, so that the conditional expectation of the RIF can be written as

E[RIF(H, F$_Y; v^I)|X = x] = \lambda(X, \epsilon)$,

where $\lambda(X, \epsilon)$ denotes a general function of covariates X and the error term ϵ.

The conditional expectation of the RIF will be estimated using the RIF-I-OLS method, similar to Heckley. The RIF-I-OLS assumes, as in the case of an OLS regression, that $\lambda(.)$ is linear (similar to the linearity in parameters functional form in OLS). So assuming the linearity of the parameters and and applying OLS to estimate the parameters in model 1, gives us the RIF -I- OLS.

6 Results

Figure 1 depicts the HAZ kernel density for Egyptian children aged 2-4 in the years 1995, 2003 and 2014. [8]

The figure shows that the 2003 HAZ distribution has a smaller standard deviation compared to the 1995 and 2014 HAZ distributions. More specifically, the frequency of children at the left tail of the 2003 HAZ distribution is much smaller compared to the 1995 distribution,

[8]Extensive work has been done to check the variance in HAZ in 2003. A cohort analysis was conducted where I looked at the distribution of mother's height who had children who were 2 years old in 2003 and mother's height who who had children who were 4 years old in 2005. These represent mothers of the same cohort and hence, if the 2003 data is correct, it is not anticipated that the mother's height should be different. The results indicated that the mother's height was almost the same for these mothers.

The height were not measured differently compared to the other years. 90% of the sample surveyed in 2003 were similar to those in 2000.

indicating that fewer children were stunted in 2003 than in 1995. Additionally, in 2003 more children had a HAZ closer to the median of the reference population compared to 1995 and 2014. The figure also shows that the whole HAZ distribution has shifted to the right in the year 2014 relative to 1995. This indicates that children became taller in 2014 across the whole HAZ distribution. So the stunting rate decreased from 1995 to 2003. From 2003 to 2014, there was an increased frequency of children who were taller than the median height.

This is also evident from the summary statistics presented in Table 1. The mean HAZ is -1.602 in 1995, -1.122 in 2003 and -0.529 in 2014. The negative mean HAZ means that Egyptian children are shorter than the WHO's reference population, which is indicative of a worse nutritional status. A mean HAZ of -1.602 in 1995 implies that Egyptian children were more than one and a half standard deviation shorter than the median height of WHO's reference population, while by 2014 they were only half a standard deviation shorter than the median. This implies that even though Egyptian children are shorter than the median, there is an improvement in their height over time. As Table 2 illustrates, the change in the mean HAZ represents a 30% and 67% increase in the average children's height in 2003 and 2014 relative to 1995 respectively.

To examine the effect of these covariates on the HAZ distribution, DFL kernal densities were constructed. The resulting DFL kernel densities for the HAZ distribution between 1995 and 2003, 2003 and 2014, and 1995 and 2014 are shown in figures 2-4 respectively. There are two panels in each figure. The left panel represents the coefficient effect and the right panel represents the covariate effect. The dashed line in the left panel of figure 2 represents the HAZ distribution in 1995. The solid line represents the weighted/counterfactual 1995 HAZ distribution, which is the HAZ distribution of the 1995 covariates and 2003 associations/returns. In other words, the weighted 1995 HAZ distribution is the 1995 distribution that would have prevailed if the returns to the 1995 covariates were the same as the returns to covariates in 2003. In the right panel, the dashed line represents the 2003 HAZ distribution, and the solid line represents the weighted/counterfactual 1995 HAZ distribution.

Based on the right panel, there is no significant change in covariates over time. Since the two densities are almost overlapping in the right panel, this means that holding the returns to covariates fixed, the HAZ densities don't change much over time as a result of covariates. This implies that the change in the HAZ distributions between 1995 and 2003 is explained mainly by the change in the return to covariates, which means that the coefficient effect is larger than the covariate effect. This can be seen from the left panel. In the left panel, the 1995 and weighted 1995 distributions are overlapping for HAZ greater than the median (children at the right tail of the distribution). The change in the HAZ distribution over time can be seen in the difference between the 1995 and counterfactual 1995 distribution for children with HAZ smaller than the median. Relative to the 1995 distribution, the counterfactual 1995 had fewer children with a HAZ between -5 and -2, and more children with a HAZ between -2 and 0, conditional on covariates. This means that holding covariates fixed, the returns to the covariates in 2003 led to fewer children being stunted, and more children with a HAZ close to the median HAZ of the new WHO reference population. Based on kernel density estimations, the difference between the 2 lines in the left panel is .246 and in the right panel is 0.002, which confirms the above results.

Figure 3 illustrates that the change in the HAZ distribution between 2003 and 2014 is driven mainly by the change in the return to covariates (top left panel). The coefficient effect, represented in the left panel is greater than the covariate effect in the right panel. Figure 4 shows a bigger change in the difference in densities between the weighted 1995 and 2014 HAZ distributions (covariate effect), compared to the previous figures. This suggests that between 1995 and 2014, the change in the HAZ distribution is still primarily driven by changes in the returns to covariates, with a bigger change in the difference in densities as a result of covariates in figure 4 relative to the previous figures. Based on kernel density estimations, the difference between the 2 lines in the left panel is .307 and in the right panel is 0.002, which confirms that the change in HAZ is driven by the change in the return to covariates.

To provide more insight into the causes of the changes in the HAZ distributions, I conducted a sequential analysis where I sequentially add covariates to assess what are the correlates of the changing HAZ distributions over time. For this analysis, I calculate several differences in the HAZ distribution. The 90-10 HAZ differential is the difference between the 90th and the 10th percentile of the HAZ distribution ($HAZ_{0.9} - HAZ_{0.1}$). Estimating the 90-10, 90-50,50-10 and 75-25 HAZ differentials, the results indicate that the returns to covariates drive the differences in HAZ across all parts of the distribution.

Results are represented in Table 3 for 1995 and 2003. In Table 3, model 1 represents the HAZ distribution using the child's characteristics in 1995 with the 2003 associations. Model 2 adds the mother's characteristics to model 1 and model 3 adds the household SES to model 2. Model 4 has all the covariates (child characteristics, mother's characteristics, household SES and access to health care). The unexplained column is the difference between model 4, which is the 1995 distribution with 2003 associations, and the 1995 actual distribution. Hence, the unexplained column represents the impact of the returns from 1995 to 2003 on the HAZ distribution of factors unaccounted for, which is the coefficient effect.

The estimates in Table 4 show the difference in the HAZ distribution resulting from differences in covariates between 1995 and 2003. Model 1 represents the HAZ distribution using the child's characteristics in 2003 with the 1995 associations. Model 2 adds the mother's characteristics to model 1 and model 3 adds the household SES to model 2. Model 4 has all the covariates (child characteristics, mother's characteristics, household SES and access to health care). The unexplained column is the difference between model 4, which is the 1995 distribution with 2003 covariates, and the 1995 actual distribution. Hence, the unexplained column represents the impact of the covariates from 1995 to 2003 on the HAZ distribution of factors unaccounted for, which is the covariate effect.

By comparing the estimates in Tables 3 and 4, I find that the coefficient effect is larger than the covariate effect. The difference between the actual 1995 and the 1995 distribution with 2003 associations (the coefficient effect) is greater than the difference between the 1995 and the 1995 distribution with 2003 covariates (the covariate effect). This suggests that the HAZ differences differ more as a result of the change in the returns to covariates relative to the the change in covariates.

Studying the DFL decomposition differences between 2003 and 2014, and 1995 and 2014, the results in tables 5-8 convey a similar pattern. A greater change is observed when the actual distributions are compared to the distribution with the associations of another year as opposed to the change in the covariates of another year. The results indicate that what matters more for children's height across the HAZ distribution is the returns to covariates, which raises the question of whether this result still holds when looking at stunted children.

The stunting rate declined from 35.6% in 1995 to 16.7% in 2003. The first row in table 9 shows the stunting rate that would prevail in 1995, if the covariates were that of 1995 with the 2003 associations according to each model. The second row shows the difference in the stunting rate between the actual 1995 distribution and the 1995 distribution with the 2003 associations according to each model. The percentage of total change in stunting rate explained by each model is in parenthesis underneath each estimate in the third row. The results indicate that the difference in the returns of all the covariates (child characteristics, mother's characteristics, household SES and access to health care) is correlated with a 0.19 decline in stunting. This means that if in 1995, the returns to covariates were those of 2003, the stunting rate in 1995 would be lower by 52.77%.

On the other hand, the difference in stunting rates between 1995 and 2003 that is correlated with a change in covariates is much smaller compared to the returns. The fourth row of table 9 shows the stunting rate that would prevail in 1995, if the 1995 covariates were that of 2003. The fifth row shows the difference in the stunting rate between the actual 1995 distribution and the 1995 distribution with the 2003 covariates according to each model. The results indicate that the difference in the covariates between 1995 and 2003 is correlated with a 0.02 decline in stunting. This means that if in 1995, the covariates were those of 2003, the stunting rate in 1995 would be lower by 5.56%. These results are consistent across all the models.

Similarly, tables 10 and 11 decompose the difference in the stunting rates between 2003 and 2014, and 1995 and 2014 respectively. The stunting rate increased from 16.7% in 2003 to 20.5% in 2014, and decreased from 35.6% in 1995 to 20.5% in 2014. The difference between the actual 2003 stunting rate and the stunting rate in 2003 with the 2014 associations is a 0.07 increase in stunting. This implies that the returns to covariates got worse from 2003 to 2014, which is associated with an increase in the stunting rate by 41.18%. If the covariates that prevailed in 2003 were those of 2014, the stunting rate would not have changed. For the difference in 1995 and 2014, the stunting rate would decline by 0.15, which represents a 41.67% decline in the stunting rate as a result of the change in the return to covariates. The difference in the covariates between 1995 and 2014 is correlated with a 0.04 decline in stunting, indicating that the stunting rate in 1995 would be lower by 11.11%.

Examining which covariates matter for the HAZ distribution, for the return to covariates, Table 3 shows that the biggest difference between the actual 1995 distribution and the counterfactual distribution (coefficient effect) at the 90-10, 90-50 and 75-25 HAZ difference occurs at model 4, when health care and sanitation are added to the model. At the 50-10 difference, however, model 1, which includes the child's age, age squared and geography is the model with the biggest coefficient effect. In Tables 5 and 7, model 1 has the highest coefficient effect at the 90-50 and 75-25 HAZ difference and the 90-10, 90-50 HAZ difference respectively. This shows that the return to child's gender, age, and geography (model 1) and health care and sanitation (model 4) are the covariates with the greatest change in return.

A limitation of this sequential decomposition is path dependence; the order of the covariates affects the magnitude of the covariates that affect stunting (Elder, 2011). Re-estimating the coefficient effects with a change in the ordering of the covariates leads to different covariates having the biggest coefficient effect. To overcome this limitation, I estimate a Shapley-Owen decomposition and a Blinder-Oaxaca decomposition. The Shapley decomposition assigns to each covariate it's marginal contribution (Shorrocks, 1999). Additionally, I estimate a Blinder-Oaxaca decomposition to examine which covariates cause the coefficient effect, where order of covariates doesn't matter.

For the covariate effect, across all the years, the biggest change in the HAZ distribution occur at the 50-10 percentile, as shown in Tables 4, 6 and 8. The biggest difference in the covariate effect at the 50-10 percentile between each model and the preceding one is seen in model 3. This implies that the change in the HAZ distribution is strongly correlated with the change in mother's employment, education and household wealth.

To examine whether differences in stunting is due to socioeconomic differences between households, I present the results on the RIF and concentration index. The results of the rif regression are presented in table 12. The rif examines the effect of a change in the distribution of the covariates on the nth quantile of the unconditional distribution of stunting. The influence function is is computed for each quantile of interest. the correct interpretation of the UPE is if the distribution of X_k changes such that the unconditional average increases by one unit ($\Delta X k \bar{=} 1$), the expected change in the distributional statistic is equal to β. The RIF regression estimates marginal contributions; how an equal marginal increase in one covariate for everyone would impact the bivariate rank dependent index

Tables 12-14 report the results of the RIF health inequality decomposition for the years 1995, 2003 and 2014 respectively. The RIF shows which covariates affect the different quantiles (10th,25th,50th,75th, and 90th) of the HAZ distribution.The results indicate that the same covariate can have different effects at different quantiles of the distribution, both within a time period and across time periods.

Child's characteristics, maternal characteristics, household SES and access to healthcare are used as covariates/explanatory variables. The results of the RIF-OLS represent the causal effect of a covariate on health inequality controlling for the other covariates.There is suggestive evidence that the covariate that has the most dominant effect on the τ th quantile of the HAZ distribution is household SES.Household SES is represented by the four lowest income quantiles; with the fifth quantile being omitted/the reference group. Household SES seems to affect most who are stunted; household ses has a significant impact on the 25th percentile of the HAZ distribution, which is the percentile closest to a HAZ of -2.

To examine further the impact of household SES on HAZ and what that means in terms of health inequality, I apply the rif approach to the concentration index (a bivariate rank dependent index). The concentration index is the joint distribution of health and socioeconomic rank.I decompose a concentration index based upon RIF regression. These measures are bivariate because they relate an individual's level of health to her relative socioeconomic status.

The results in table 15 show the results from applying the RIF approach to the concentration index. The results indicate that absolute poverty exists and contributes to the high levels of stunting. Households with a higher ses rank are also those who live in urban governorates, are educated, visit a doctor, have proper water and sanitation facilities, which are the variables significant to having a higher value of HAZ.

Additionally, looking at the joint distribution of health and socioeconomic, using the same methodology as Heckley (2016), I estimate the value of the concentration index to be 0.306. A positive concentration index implies that households with higher socioeconomic status, measured by income, have better health and vice versa. This indicates that inequality contributes vastly to poverty, where households with lower wealth are more likely to have stunted children.

7 Potential Mechanisms

As the results indicate that the change in the HAZ distribution and stunting rates in Egypt is mainly driven by the change in the return to covariates over time, I examine for which covariate(s) is the change in the return associated with the change in the HAZ distribution. Depending on the order in which the group of covariates are added into the decomposition (tables 3-11), the effect of each group may differ. To circumvent this I use the Shapley and Blinder-Oaxaca decompositions.

The Blinder-Oaxaca decomposition examines which covariates are associated with the biggest change in the coefficient effect. The results in Appendix Table 2 confirm the above findings that the difference in mean stunting over time explained by the return to covariates is larger than that explained by the covariates across all the years under study. For instance, there is a 20.4% difference in the stunting rate between 1995 and 2003. Of this 20.4%, 3.7% is explained by differences in covariates and 16.8% is explained by the difference in return to covariates. Additionally, the coefficient on the return to mother's height and weight are the highest across all the years, indicating that the return to mother's height and weight are driving the change in the stunting rate over time.

The Shapley decomposition is an additive decomposition of any inequality measure into its contributing factors. It identifies how much each group of covariates contributes to the overall variation in HAZ. The results presented in Appendix Table 1 show that almost all (93.98%) of the change in HAZ is associated with a change in the return to mother's weight and height.

To further explore the role of the return on covariates, a regression of HAZ on all the covariates is estimated, where the coefficient on the covariates represent the return to covariates (unexplained component or coefficient effect) (Elder, 2010). The results, presented in Appendix Table 3, indicate that the returns to mother's height has changed significantly over time. The coefficient on mother's height has a large magnitude and has the largest change over time.

The change in the return to mother's height implies that if a mother in 1995 had the same height as a mother in 2003, the likelihood of the child being stunted in 2003 is lower relative to 1995, ceteris paribus. This means that holding the mother's height constant, the child is less likely to be stunted over time since the factors that translate the mother's height into the child's height (the returns to mother's height) changed. As a robustness check, I estimate a regression of stunting on all the covariates separately for each year. The results in Appendix Table 4, confirms the results above. The magnitude of the return to mother's height and weight have a large magnitude and changes significantly over time.

The return to mother's height and weight could be changing over time due to the change in illness and malnutrition. The reasoning is that the proximate causes of stunting are mother's height, illness and malnutrition. The data shows that the distribution of the mother's height isn't changing over time, hence, I rule out mother's height as the factor associated with the change in stunting over time. Due to data limitations, illness and malnutrition are not accounted for in the above decomposition. Hence, illness and malnutrition are unobservables that are correlated with both HAZ and the distal factors which are household wealth, employment, education, access to health care, region and sanitation.

This indicates that the change in the distal causes of stunting, led to the change in the HAZ distribution through changes in illness and malnutrition. Therefore, the changes in illness and malnutrition over time could be potential factors driving the change in the coefficient value (return to mother's height and weight).

It is also the case that wealth contributes to socioeconomic inequality and health disparities. It is unfeasible to directly measure the distribution of wealth and allocation of resources within a household due to data inavailability. However, it is suggested that allocation of wealth and resources across different households leads to huge differences in HAZ and stunting rates.

Hence, to reduce stunting rates, policies should be targeted towards improving mother's employment, sanitation, and access to health care to reduce illness and malnutrition and consequently stunting. This is consistent with the literature that the improvement in socioeconomic conditions of the poor rural households improved children's health status and that economic growth in Egypt is an effective tool to lower child malnutrition and improve health. (Gummerson, 2011; Sharaf, 2016).

8 Conclusion

Stunting is a major threat to public health, affecting 2.1 million Egyptian children in 2014. With the huge variability in stunting rates among Egyptian children over time and across governorates, this paper examined, using a DFL decomposition, the factors that led to a change in children's height over the periods 1995, 2003 and 2014. The results indicated that the change in the HAZ distribution and stunting rates is driven by the returns to covariates. The return to mother's height and weight appear to be the major factors impacting the change in the HAZ distribution and stunting over time.

This change in the return to mother's height and weight could potentially be due to the change in change in illness and malnutrition. There is no one size fits all policy that will eradicate the stunting problem as stunting is not only a result of biological factors, but also a result of economic, behavioural and cultural factors. Better policies targeted at reducing illness and improving nutrition by increasing mother's employment, access to health care and sanitation are potential means to reduce childhood stunting in Egypt.

References

American Heart Association. "Tall men and women more likely to suffer deadly blood clots." (2017).

Aswaf, Abay. " Micronutrient deficiency and the prevalence of mothers' overweight/obesity in Egypt." Economics and Human Biology (2007): 471 -83.

Coffey, Diane. "Pre-pregnancy body mass and weight gain during pregnancy in India and sub-Saharan Africa." Proceedings of the National Academy of Sciences of the United States of America. (2015):302–3307.

Deaton, Angus and Dreze, Jean. "Food and nutrition in India: Facts and interpretations." Economic and Political Weekly. (2008): 42-65.

Dinardo, John. "Propensity Score Reweighting and Changes in Wage Distributions." University of Michigan and NBER (2002): 1-18.

Dinardo, John, Nicole Fortin and Thomas Lemieux. "Labor Market Institutions and the Distribution of Wages, 1973-1992:A Semiparametric Approach." Econometrica, Vol64, No.5 (1996): 1001-1044.

DHCS. "Anthropometric Measurements." California Department of Health Care Services, Systems of Care Division Child Health and Disability Prevention Program, Health Assessment Guidelines. (2016): 1-7.

Elder, Todd, John Goddeeris, and Steven Haider."Isolating the Roles of Individual Covariates in Reweighting Estimation." Journal of Applied Econometrics. (2011):1-44.

Elder, Todd, John Goddeeris, and Steven Haider."Unexplained Gaps and Oaxaca-Blinder Decompositions." Labor Economics 17 (2010): 284-290.

Easterly, William. "Life During Growth." Journal of Economic Growth. Vol.4, Issue 3.(1999):239–276

El-Zanaty, Fatma, Enas Hussein, Gihan Shawky, Ann Way, and Sunita Kishor. "Egypt Demographic and Health Survey 1995." Calverton, Maryland [USA]: National Population

Council [Egypt] and Macro International Inc. (1996): 1-348.

El-Zanaty, Fatma and Ann Way.“2003 Egypt Interim Demographic and Health Survey.”Cairo Egypt: Ministry of Health and Population [Egypt], National Population Council, E1-Zanaty and Associates, and ORC Macro. (2004):1-170.

El-Zanaty, Fatma and Ann Way. “Egypt demographic and health survey 2008.“ Cairo, Egypt: Ministry of Health and Population, National Population Council, ElZanaty and Associates, and ORC Macro. (2009).

Fenske, Nora, Jacob Burns, Torsten Hothorn, and Eva Rehfuess. “Understanding child stunting in India: A comprehensive analysis of socio-economic,nutritional and environmental determinants using additive quantile regression.“ PLOS. (2013).

Fortin,Nicole, Thomas Lemieux, and Sergio Firpo. “Decomposition Methods in Economics.” NBER (2010): 1-105.

Frongillo,Edward, Jr.Mercedes de Onis and Kathleen Hanson. ”Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting.” Journal of nutrition 127 (1997): 2302 -2309.

Gillespie,Stuart, John Mason and Reynaldo Martorell. “How Nutrition Improves.“ ACC/SCN State-of-the-Art Series, Nutrition Policy Discussion Paper 15. United Nations Administrative Committee on Coordination/Sub-Committe on Nutrition. (1996): 1-102.

“Global Panel. The cost of malnutrition. Why policy action is urgent. London, UK: Global Panel on Agriculture and Food Systems for Nutrition.“ (2016): 1-11.

Goudet, Sophie, Paula Griffiths, Barry Bogin, and Nyovani Madise.“Nutritional interventions for preventing stunting in children (0 to 5 years) living in urban slums.“Cochrane Database of Systematic Reviews. (2015): 1-52.

Gummerson, Elizabeth. “Moving on Up? Migration, Urbanization and the Dissolution of the Urban Health Advantage in South Africa.” Elsevier (2011): 1-40.

Headey, Derek. “ Developmental drivers of nutritional change: A cross-country analysis.“ Elsevier, Vol. 42 (2012): 76–88.

Jayachandran, Seema and Pande, Rohini. “Why are Indian children shorter than African children¿‘ American Economic Review. Vol. 107, No. 9 (2017):2600-2629

Keeton, Kimberly. “Once stunted always stunted? What’s up with catch-up growth¿‘ International Food and Policy Research Institute. (2015).

Mbuya,Mduduzi, Memory Chidem, Bernard Chasekwa and Vinod Mishra. “Biological, Social, and Environmental Determinants of Low Birth Weight and Stunting among Infants and Young Children in Zimbabwe.“ Zimbabwe Working Papers, No.7.(2010)

Menon,Purnima, Apurva Bamezai, Ali Subandoro, Mohamed Ag, and Ayoya Victor Aguayo. “ Age-appropriate infant and young child feeding practices are associated with child nutrition in India: Insights from nationally representative data.“ Maternal Child Nutrition.Vol.11 (2013):73–87.

Ministry of Health and Population [Egypt], El-Zanaty and Associates [Egypt], and ICF International. “Egypt Demographic and Health Survey 2014.“ Cairo, Egypt and Rockville, Maryland, USA: Ministry of Health and Population and ICF International. (2015):1-440.

Ministry of Health and Population Egypt, Partnership for Maternal, Newborn Child Health, WHO, World Bank and Alliance for Health Policy and Systems Research. “Success factors for women’s and children’s health: Egypt.“ Geneva: World Health Organisation. (2014): 1-32.

Onis, Mercedes and Francesco Branca. “Childhood stunting: a global perspective.“ Maternal and Child Nutrition. (2016): 12-26.

Prendergast, Andrew and Jean Humphrey. “The stunting syndrome in developing countries.“ Paediatrics and International Child Health. Vol34, No.4 (2014): 250–265.

Pritchett,Lant and Lawrence Summers. “ Wealthier is healthier.“ Vol.31, No.4 (1996): 841-868.

Rachmi, Novianti, Kingsley Agho , Mu Li and Louise Baur. “Stunting coexisting with overweight in 2·0–4·9-year-old Indonesian children: Prevalence, trends and associated risk factors from repeated cross-sectional surveys.“ Public Health Nutrition. Vol.19, No.15. (2016): 2698-2707.

Reinhard, Ines. “The use of stunting and wasting as indicators for food insecurity and poverty.“ Working paper (2002).

Rifas-Shiman,Sheryl, Janet MPH, Rich-Edwards ScD, Kelley Scanlon, Ken Kleinman, Matthew Gillman. “Misdiagnosis of Overweight and Underweight Children Younger Than 2 Years of Age Due to Length Measurement Bias.“ Medscape - Clinical Nutrition Obesity (2018).

Ruel, Marie and Alderman, Harold. “Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? “ The Lancet. (2013).

Sharaf,Fathy and Ahmed Rashad. “Regional inequalities in child malnutrition in Egypt, Jordan, and Yemen: a Blinder- Oaxaca decomposition analysis.“ Health Economics Review (2016) 6:23.

Sharaf,Fathy and Ahmed Rashad. “Economic Growth and Child Malnutrition in Egypt: New Evidence from National Demographic and Health Survey.“ Social Indicators Research. (2016):769–795

Sharaf,Fathy and Ahmed Rashad. “Economic and Socio-Demographic Determinants of Child Nutritional Status in Egypt: A Comprehensive Analysis using Quantile Regression Approach.“ Journal of Biosocial Science. (2018):1-22.

Shorrocks, Anthony. ”Decomposition Procedures for Distributional Analysis: A Unified Framework Based on the Shapley Value.” (1999).

Spears, Dean. “How much international variation in child height can sanitation explain¿‘ Policy research working paper.World Bank. (2013).

United Nations Children’s Fund. “Improving child nutrition: The achievable imperative for global progress.“ New York, USA: UNICEF (2013).

United Nations Children’s Fund, World Health Organization, and The World Bank. “UNICEF-WHO-World Bank Joint Child Malnutrition Estimates.“ (2016).

UNICEF. “Improving child nutrition: The achievable imperative for global progress.“ New

York, USA: UNICEF.

UNICEF. "Strategy for improved nutrition of women and children in developing countries. New York: United Nations Children's Fund." (1990).

USAID. "The 1000 day window of opportunity: Technical guidance brief." (2017).

World Food Programme."Hunger Costs Egypt Billions Of Pounds Yearly." (2013).

WHO. "Success Factors for Women's and Children's Health."(2017)

WHO. "Egypt - Nutrition ."(2018)

WHO. "Global Database on Child Growth and Malnutrition. The Z-score or standard deviation classification system." (2018)

WHO. "Infant and young child feeding."(2018)

WHO. "Nutrition - Stunting in a nutshell."(2018)

Zottarelli, LK, Sunil TS and Rajaram S. "Influence of parental and socioeconomic factors on stunting in children under 5 years in Egypt." Eastern Mediterranean Health Journal.Vol 13, No.6 (2007):1330-1342.

Table 1: Summary Statistics

Variable	1995 mean	2003 mean	2014 mean	2003-1995 Difference	2014-2003 Difference	2014-1995 Difference
HAZ	-1.602	-1.122	-0.529	0.481***	0.593***	1.073***
	(1.544)	(1.178)	(1.998)	(16.00)	(16.59)	(33.75)
Stunting	0.356	0.167	0.205	-0.189***	0.038***	-0.151***
	(0.479)	(0.373)	(0.404)	(-20.31)	(4.76)	(-19.99)
Gender	0.526	0.519	0.516	-0.006	-0.003	-0.009
	(0.499)	(0.500)	(0.500)	(-0.60)	(-0.28)	(-1.06)
Child's age (months)	41.717	41.148	40.937	-0.569**	-0.211	-0.780***
	(10.450)	(10.264)	(10.218)	(-2.60)	(-1.04)	(-4.40)
Child's age squared	1849.479	1798.491	1780.268	-50.99**	-18.22	-69.21***
	(872.411)	(854.368)	(849.918)	(-2.80)	(-1.08)	(-4.68)
Mother's height (cm)	157.437	158.451	159.204	1.014***	0.753***	1.767***
	(6.679)	(5.636)	(6.186)	(7.65)	(6.29)	(16.07)
Mother's weight (kg)	65.065	68.100	73.801	3.035***	5.701***	8.736***
	(13.796)	(11.965)	(13.539)	(10.99)	(21.94)	(37.22)
Underweight	0.021	0.011	0.003	-0.010***	-0.008***	-0.018***
	(0.142)	(0.105)	(0.056)	(-3.49)	(-10.05)	(-5.41)
Normal	0.468	0.320	0.184	-0.148***	-0.135***	-0.283***
	(0.499)	(0.466)	(0.388)	(-14.44)	(-16.44)	(-37.64)
Overweight	0.311	0.437	0.440	0.126***	0.003	0.129***
	(0.463)	(0.496)	(0.496)	(12.56)	(0.34)	(15.57)
Obese	0.200	0.232	0.372	0.032***	0.140***	0.172***
	(0.400)	(0.422)	(0.483)	(3.67)	(15.14)	(22.16)
Mother's employment	0.170	0.205	0.138	0.035***	-0.067***	-0.032***
	(0.376)	(0.404)	(0.345)	(4.27)	(-9.16)	(-5.14)
Prenatal Care: Doctor	0.352	0.613	0.895	0.261***	0.282***	0.544***
	(0.477)	(0.487)	(0.306)	(25.80)	(38.13)	(81.66)
Prenatal Care: No care	0.648	0.386	0.102	-0.262***	-0.284***	-0.546***
	(0.478)	(0.487)	(0.302)	(-25.91)	(-38.56)	(-82.38)
Number of antenatal visits	2.976	6.634	9.541	3.659***	2.907***	6.565***
	(8.744)	(13.967)	(9.881)	(15.70)	(12.91)	(40.52)

Table 1: Summary Statistics

Variable	1995 mean	2003 mean	2014 mean	2003-1995 Difference	2014-2003 Difference	2014-1995 Difference
Illiterate	0.496	0.390	0.179	-0.106***	-0.211***	-0.317***
	(0.500)	(0.488)	(0.383)	(-10.15)	(-25.36)	(-42.30)
Primary	0.211	0.150	0.084	-0.060***	-0.067***	-0.126***
	(0.408)	(0.357)	(0.278)	(-7.35)	(-10.90)	(-21.72)
Secondary	0.248	0.386	0.580	0.138***	0.194***	0.332***
	(0.432)	(0.487)	(0.494)	(14.48)	(19.82)	(41.20)
Higher Education	0.045	0.073	0.157	0.028***	0.084***	0.112***
	(0.208)	(0.261)	(0.364)	(5.74)	(12.57)	(21.04)
Water facility: High	0.791	0.861	0.991	0.070***	0.131***	0.200***
	(0.407)	(0.347)	(0.093)	(8.39)	(30.78)	(41.79)
Water facility: Intermediate	0.209	0.139	0.009	-0.070***	-0.131***	-0.200***
	(0.406)	(0.347)	(0.093)	(-8.33)	(-30.78)	(-41.72)
Toilet facility:Flush toilet	0.782	0.954	0.999	0.172***	0.0441***	0.216***
	(0.413)	(0.209)	(0.038)	(22.98)	(17.95)	(45.75)
Toilet facility: Pit or no facility	0.218	0.046	0.0009	-0.172***	-0.0447***	-0.217***
	(0.412)	(0.209)	(0.030)	(-22.98)	(-18.38)	(-45.95)
Wealth index: Lowest quintile	0.204	0.277	0.185	0.073***	-0.092***	-0.019**
	(0.403)	(0.448)	(0.388)	(8.03)	(-11.33)	(-2.79)
Wealth index: Second quintile	0.193	0.212	0.192	0.019*	-0.020*	-0.001
	(0.395)	(0.409)	(0.394)	(2.17)	(-2.51)	(-0.18)
Wealth index: Middle quintile	0.180	0.191	0.213	0.011	0.022**	0.033***
	(0.384)	(0.393)	(0.409)	(1.34)	(2.73)	(4.69)
Wealth index: Fourth quintile	0.189	0.179	0.199	-0.010	0.021**	0.010
	(0.392)	(0.383)	(0.399)	(-1.26)	(2.63)	(1.46)
Wealth index: Highest quintile	0.234	0.142	0.211	-0.092***	0.070***	-0.023**
	(0.423)	(0.349)	(0.408)	(-10.87)	(8.92)	(-3.10)
Urban-rural residence:Urban	0.334	0.344	0.390	0.011	0.046***	0.056***
	(0.472)	(0.475)	(0.488)	(1.06)	(4.77)	(6.82)
Metropolitan Governorates	0.142	0.124	0.154	-0.018*	0.030***	0.012
	(0.349)	(0.329)	(0.361)	(-2.57)	(4.34)	(1.93)
Lower Egypt: Urban	0.077	0.094	0.108	0.017**	0.015*	0.031***
	(0.027)	(0.292)	(0.311)	(2.86)	(2.39)	(6.18)

Table 1: Summary Statistics

Variable	1995 mean	2003 mean	2014 mean	2003-1995 Difference	2014-2003 Difference	2014-1995 Difference
Lower Egypt: Rural	0.224	0.216	0.291	-0.008	0.075***	0.067***
	(0.417)	(0.411)	(0.454)	(-0.92)	(8.53)	(8.85)
Upper Egypt: Urban	0.114	0.127	0.128	0.012	0.001	0.013*
	(0.318)	(0.333)	(0.334)	(-0.24)	(-13.12)	(-15.36)
Upper Egypt: Rural	0.442	0.440	0.316	-0.003	-0.124***	-0.126***
	(0.497)	(0.496)	(0.465)	(-0.24)	(-13.12)	(-15.36)
Observations	5826	3684	8070	9510	11754	13896

* $p < 0.05$, ** $p < 0.1$, *** $p < 0.01$

Table 2: Percentage change in covariates over time

Variable	2003-1995	2014-1995
HAZ	29.96%	66.98%
Stunting	-53.09%	-42.42%
Gender	-1.20%	-1.73%
Child's age (months)	-1.36%	-1.87%
Child's age squared	-2.76%	-3.74%
Mother's height (cm)	0.64%	1.12%
Mother's weight (kg)	4.66%	13.43%
Mother's employment	20.44%	-18.62%
Prenatal Care: Doctor	74.36%	154.69%
Prenatal Care: No care	-40.49%	-84.28%
Number of antenatal visits	122.95%	220.63%
Illiterate	-21.34%	-63.92%
Primary	-28.60%	-59.99%
Secondary	55.84%	134.04%
Higher Education	61.13%	245.17%
Mother's age at baby's birth	2.75%	8.24%
Water facility: Intermediate	-33.14%	-95.83%
Water facility: High	8.81%	25.35%
Toilet facility: Modern flush toilet	21.98%	27.63%
No facility	-77.80%	-99.13%
Urban-rural residence:Urban	3.15%	16.91%
Wealth index: Lowest quintile	35.48%	-9.48%
Wealth index: Second quintile	9.64%	-0.66%
Wealth index: Middle quintile	6.18%	18.39%
Wealth index: Fourth quintile	-5.52%	5.40%
Wealth index: Highest quintile	-39.32%	-9.68%
Urban Governorates	-12.99%	8.33%
Lower Egypt:Urban	21.59%	40.38%
Lower Egypt:Rural	-3.59%	29.83%
Upper Egypt:Urban	10.72%	11.70%
Upper Egypt:Rural	-0.56%	-28.56%

Notes: The first column shows the percentage change in each covariate between 1995 and 2003 divided by the base year (1995) mean. The second column shows the percentage change in each covariate between 1995 and 2014 divided by the base year mean.

Table 3: DFL Decomposition Differences:
Impact of return to covariates between 1995 and 2003

HAZ Distribution Measures	1995 Actual Distribution	1995 Distribution with 2003 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	3.72	2.63	2.89	2.57	2.49	1.23
90-50 Difference	1.68	1.14	0.99	0.75	0.65	1.03
50-10 Difference	2.04	1.50	1.89	1.82	1.84	0.20
75-25 Difference	1.87	1.14	1.15	1.09	1.01	0.85
Mean HAZ	-1.60	-1.14	-1.28	-1.04	-1.04	-0.56

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the coefficient effect at different percentiles of the HAZ distribution.

Table 4: DFL Decomposition Differences
Impact of covariates between 1995 and 2003

HAZ Distribution Measures	2003 Actual Distribution	1995 Distribution with 2003 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	2.61	2.63	2.89	2.57	2.49	0.12
90-50 Difference	1.13	1.14	0.99	0.75	0.65	0.48
50-10 Difference	1.48	1.50	1.89	1.82	1.84	-0.36
75-25 Difference	1.13	1.14	1.15	1.09	1.01	0.12
Mean HAZ	-1.12	-1.14	-1.28	-1.04	-1.04	0.08

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the covariate effect at different percentiles of the HAZ distribution.

Table 5: DFL Decomposition Differences:
Impact of the return to covariates between 2003 and 2014

HAZ Distribution Measures	2003 Actual Distribution	2003 Distribution with 2014 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	2.61	4.94	5.01	4.82	4.07	-1.46
90-50 Difference	1.13	2.52	2.31	1.92	1.43	-0.30
50-10 Difference	1.48	2.43	2.69	2.90	2.64	-1.16
75-25 Difference	1.13	2.23	2.06	1.68	1.13	0.00
Mean HAZ	-1.12	-0.64	-0.68	-0.72	-0.66	-0.46

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the coefficient effect at different percentiles of the HAZ distribution.

Table 6: DFL Decomposition Differences
Impact of covariates between 2003 and 2014

HAZ Distribution Measures	2014 Actual Distribution	2003 Distribution with 2014 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	5.01	4.94	5.01	4.82	4.07	0.94
90-50 Difference	2.8	2.52	2.31	1.92	1.43	1.37
50-10 Difference	2.21	2.43	2.69	2.90	2.64	-0.43
75-25 Difference	2.28	2.23	2.06	1.68	1.13	1.15
Mean HAZ	-0.53	-0.64	-0.68	-0.72	-0.66	0.13

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the covariate effect at different percentiles of the HAZ distribution.

Table 7: DFL Decomposition Differences:
Impact of return to covariates between 1995 and 2014

HAZ Distribution Measures	1995 Actual Distribution	1995 Distribution with 2014 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	3.72	4.94	4.62	3.51	3.55	0.17
90-50 Difference	1.68	2.53	1.90	1.01	1.09	0.59
50-10 Difference	2.04	2.42	2.72	2.50	2.47	-0.43
75-25 Difference	1.87	2.22	1.70	0.95	0.98	0.89
Mean HAZ	-1.60	-0.62	-0.76	-0.72	-0.99	-0.61

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the coefficient effect at different percentiles of the HAZ distribution.

Table 8: DFL Decomposition Differences
Impact of covariates between 1995 and 2014

HAZ Distribution Measures	2014 Actual Distribution	1995 Distribution with 2014 associations between the covariates and HAZ				
		Model 1	Model 2	Model 3	Model 4	Unexplained
90-10 Difference	5.01	4.94	4.62	3.51	3.55	1.46
90-50 Difference	2.8	2.53	1.90	1.01	1.09	1.71
50-10 Difference	2.21	2.42	2.72	2.50	2.47	-0.26
75-25 Difference	2.28	2.22	1.70	0.95	0.98	1.30
Mean HAZ	-0.53	-0.62	-0.76	-0.72	-0.99	-0.46

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3. The unexplained column is the difference between the actual distribution and model 4. This unexplained column represents the covariate effect at different percentiles of the HAZ distribution.

Table 9: Decomposing changes in stunting between 1995 and 2003

	Actual 1995 Distribution	Model 1	Model 2	Model 3	Model 4
Proportion stunted	0.36	0.17	0.21	0.17	0.17
Impact of return to covariates		-0.19	-0.15	-0.19	-0.19
		(-52.77)	(-41.67)	(-52.77)	(-52.77)
Proportion stunted	0.36	0.36	0.33	0.37	0.34
Impact of covariates		-0.00	-0.03	0.01	-0.02
		(-0.00)	(-8.33)	(2.78)	(-5.56)

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3.

The impact of the covariates and their return are calculated based on subtracting each model from the actual 1995 distribution. The percentage change in the stunting rates are expressed in parenthesis. The first column shows that 36% of the children were stunted in 1995. By including child's age, age squared and geography (model 1), the second column show that the stunting rate becomes 17% for 1995 covariates and 2003 associations. This implies that the stunting rate fell by 19%, which is a 52% decline in the stunting rate as a result of the 2003 associations. The fourth to sixth rows in column two show that the stunting rate will remain at 36% if there we had 1995 associations and 2003 covariates. This implies that there is a 0% change in the stunting rate as a result of covariates. For the rest of the columns, each one sequentially adds a group of covariates to the previous column, as mentioned above.

Table 10: Decomposing changes in stunting between 2003 and 2014

	Actual 2003 Distribution	Model 1	Model 2	Model 3	Model 4
Proportion stunted	0.17	0.21	0.22	0.24	0.24
Impact of return to covariates		0.05	0.06	0.07	0.07
		(29.41)	(35.29)	(41.18)	(41.18)
Proportion stunted	0.17	0.16	0.16	0.17	0.17
Impact of covariates		-0.01	-0.01	0.00	0.00
		(-5.88)	(-5.88)	(0.00)	(0.00)

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3.The impact of the covariates and their return are calculated based on subtracting each model from the actual 2003 distribution. The percentage change in the stunting rates are expressed in parenthesis. The first column shows that 17% of the children were stunted in 2003. By including child's age, age squared and geography (model 1), the second column show that the stunting rate becomes 17% for 2003 covariates and 2014 associations. This implies that the stunting rate fell by 5%, which is a 29% decline in the stunting rate as a result of the 2014 associations. The fourth to sixth rows in column two show that the stunting rate will decline to 16% if there we had 2003 associations and 2014 covariates. This implies that the stunting rate will fall by 1%, there is a 5.88% decline in the stunting rate as a result of covariates. For the rest of the columns, each one sequentially adds a group of covariates to the previous column, as mentioned above.

Table 11: Decomposing changes in stunting between 1995 and 2014

	Actual 1995 Distribution	Model 1	Model 2	Model 3	Model 4
Proportion stunted	0.36	0.21	0.23	0.22	0.21
Impact of return to covariates		-0.15	-0.13	-0.14	-0.15
		(-41.67)	(36.11)	(38.89)	(-41.67)
Proportion stunted	0.36	0.35	0.30	0.35	0.32
Impact of covariates		-0.01	-0.06	-0.01	-0.04
		(-2.78)	(-16.67)	(-2.78)	(-11.11)

Notes: Model 1 includes the child's gender, age, age squared and geography. Model 2 adds mother's weight, weight squared, mother's height, height squared and height cubed to model 1. Model 3 adds to mother's employment status, education and household wealth to model 2. Model 4 adds health care and sanitation to model 3.
The impact of the covariates and their return are calculated based on subtracting each model from the actual 1995 distribution. The percentage change in the stunting rates are expressed in parenthesis. The first column shows that 36% of the children were stunted in 1995. By including child's age, age squared and geography (model 1), the second column show that the stunting rate becomes 21% for 1995 covariates and 2014 associations. This implies that the stunting rate fell by 15%, which is a 42% decline in the stunting rate as a result of the 2003 associations. The fourth to sixth rows in column two show that the stunting rate will decline to 35% if we had 1995 associations and 2014 covariates. This implies that the stunting rate feel by 1%, which is a 2.78% decline in the stunting rate as a result of covariates. For the rest of the columns, each one sequentially adds a group of covariates to the previous column, as mentioned above.

Table 12: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 1995

Variable	10th Quantile	25th	50th	75th	90th
Gender	-0.188	-0.131	-0.098	-0.069	-0.050
	(0.084)	(0.059)	(0.044)	(0.049)	(0.062)
Child's age	-0.043	-0.054	-0.044	-0.082	-0.093
	(0.036)	(0.025)	(0.019)	(0.021)	(0.028)
Child's age squared	0.001	0.001	0.001	0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lower Egypt: Urban	-0.577	-0.327	-0.083	-0.076	-0.271
	(0.184)	(0.116)	(0.095)	(0.121)	(0.164)
Lower Egypt: Rural	-0.283	-0.36	-0.174	-0.133	-0.378
	(0.137)	(0.096)	(0.077)	(0.096)	(0.127)
Upper Egypt: Urban	0.137	-0.211	-0.305	-0.412	-0.605
	(0.142)	(0.107)	(0.087)	(0.104)	(0.135)
Upper Egypt: Rural	-0.073	-0.444	-0.381	-0.510	-0.524
	(0.096)	(0.129)	(0.076)	(0.090)	(0.120)
Mother's weight	0.027	0.034	0.018	-0.001	-0.015
	(0.017)	(0.013)	(0.010)	(0.012)	(0.018)
Mother's weight squared	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's height	-0.484	-1.112	-0.239	-1.104	-1.581
	(1.072)	(1.239)	(0.669)	(0.617)	(0.495)
Mother's height squared	0.004	0.008	0.003	0.008	0.011
	(0.007)	(0.008)	(0.004)	(0.004)	(0.003)
Mother's height cubed	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's employment	-0.040	0.077	0.122	-0.005	-0.060
	(0.127)	(0.082)	(0.061)	(0.073)	(0.094)
Illiterate	-0.034	0.056	-0.191	-0.559	-0.700
	(0.210)	(0.146)	(0.113)	(0.148)	(0.219)
Primary	0.021	0.086	-0.142	-0.622	-0.690
	(0.214)	(0.148)	(0.116)	(0.150)	(0.224)
Secondary	-0.075	0.043	-0.201	-0.505	-0.684
	(0.193)	(0.134)	(0.107)	(0.143)	(0.214)
Wealth Index: Lowest quintile	0.264	0.123	0.024	0.131	0.308
	(0.157)	(0.120)	(0.092)	(0.104)	(0.143)
Wealth Index: Second quintile	0.229	0.249	0.205	0.106	-0.027
	(0.113)	(0.092)	(0.071)	(0.080)	(0.099)
Wealth Index: Middle quintile	0.024	-0.029	-0.001	-0.033	-0.039
	(0.123)	(0.085)	(0.062)	(0.068)	(0.086)
Wealth Index: Fourth quintile	0.070	0.087	0.034	0.001	0.016
	(0.114)	(0.078)	(0.058)	(0.066)	(0.082)

Table 12: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 1995

Variable	10th Quantile	25th	50th	75th	90th
Prenatal Care: Nurse	0.821	0.954	1.418	0.685	2.588
	(0.194)	(0.132)	(0.096)	(1.445)	(2.565)
Prenatal Care: No care	-0.105	-0.071	-0.128	-0.189	-0.097
	(0.103)	(0.074)	(0.056)	(0.063)	(0.080)
Number of antenatal visits	0.003	0.004	0.001	-0.002	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Toilet facility: Modern flush toilet	0.209	0.375	0.152	0.058	0.030
	(0.174)	(0.124)	(0.084)	(0.085)	(0.101)
Toilet facility:Latrine	-0.148	0.170	-0.025	0.023	0.070
	(0.211)	(0.145)	(0.099)	(0.100)	(0.119)
Water facility: Intermediate	-0.066	0.043	0.070	0.045	-0.056
	(0.122)	(0.085)	(0.060)	(0.063)	(0.073)
Intercept	14.333	44.361	0.658	51.642	78.480
	(58.413)	(67.551)	(36.036)	(32.297)	(26.359)

Standard errors are in parenthesis

Table 13: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 2003

Variable	10th Quantile	25th	50th	75th	90th
Gender	0.072	-0.049	-0.026	0.019	-0.086
	(0.090)	(0.059)	(0.034)	(0.035)	(0.073)
Child's age	-0.022	0.035	0.044	-0.020	-0.025
	(0.041)	(0.021)	(0.015)	(0.015)	(0.032)
Child's age squared	0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Lower Egypt: Urban	0.134	0.047	0.023	0.002	-0.200
	(0.179)	(0.095)	(0.076)	(0.079)	(0.152)
Lower Egypt: Rural	0.238	-0.006	0.057	0.141	0.045
	(0.163)	(0.089)	(0.068)	(0.071)	(0.147)
Upper Egypt: Urban	0.010	-0.005	-0.014	0.077	0.144
	(0.181)	(0.093)	(0.071)	(0.074)	(0.162)
Upper Egypt: Rural	-0.235	-0.210	-0.086	0.054	0.156
	(0.175)	(0.089)	(0.067)	(0.069)	(0.148)
Mother's weight	0.096	0.079	0.031	0.008	0.005
	(0.034)	(0.017)	(0.011)	(0.012)	(0.024)
Mother's weight squared	-0.001	-0.001	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's height	8.946	1.301	0.634	-0.370	0.585
	(3.825)	(1.999)	(1.325)	(1.453)	(3.554)
Mother's height squared	- 0.053	-0.007	-0.004	0.002	-0.004
	(0.023)	(0.012)	(0.008)	(0.009)	(0.022)
Mother's height cubed	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's employment	0.116	0.054	0.026	0.031	-0.015
	(0.109)	(0.059)	(0.043)	(0.046)	(0.095)
Illiterate	-0.017	0.027	0.063	0.091	0.110
	(0.218)	(0.113)	(0.083)	(0.086)	(0.175)
Primary	0.129	0.060	0.123	0.094	0.006
	(0.221)	(0.117)	(0.087)	(0.091)	(0.183)
Secondary	0.221	0.143	0.119	0.126	0.160
	(0.190)	(0.100)	(0.074)	(0.078)	(0.157)
Wealth Index: Lowest quintile	0.041	-0.042	-0.242	-0.154	-0.392
	(0.204)	(0.106)	(0.080)	(0.083)	(0.173)
Wealth Index: Second quintile	-0.005	-0.071	-0.209	-0.133	-0.203
	(0.187)	(0.073)	(0.076)	(0.080)	(0.159)
Wealth Index: Middle quintile	-0.065	-0.116	-0.145	-0.075	-0.135
	(0.091)	(0.069)	(0.072)	(0.068)	(0.151)
Wealth Index: Fourth quintile	0.077	-0.049	-0.129	0.003	-0.009
	(0.157)	(0.083)	(0.064)	(0.069)	(0.142)

Table 13: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 2003

Variable	10th Quantile	25th	50th	75th	90th
Prenatal Care: Nurse	0.024	-0.023	0.034	0.066	0.301
	(0.177)	(0.091)	(0.066)	(0.070)	(0.155)
Prenatal Care: No care	-0.031	-0.024	0.006	0.016	0.308
	(0.113)	(0.041)	(0.042)	(0.063)	(0.088)
Number of antenatal visits	-0.004	0.002	0.000	0.002	0.005
	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)
Toilet facility: Modern flush toilet	0.035	-0.021	-0.145	-0.469	0.030
	(0.364)	(0.181)	(0.121)	(0.131)	(0.306)
Toilet facility:Latrine	-0.088	0.170	-0.224	-0.069	-0.609
	(0.464)	(0.153)	(0.099)	(0.165)	(0.354)
Water facility: Intermediate	0.460	0.084	0.024	-0.055	-0.045
	(0.135)	(0.055)	(0.055)	(0.063)	(0.116)
Intercept	-505.780	-84.521	-39.553	18.234	-27.764
	(211.242)	(71.902)	(36.036)	(78.375)	(190.730)

Standard errors are in parenthesis

Table 14: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 2014

	10th Quantile	25th	50th	75th	90th
Gender	-0.134	-0.048	0.017	-0.064	-0.106
	(0.080)	(0.052)	(0.046)	(0.063)	(0.117)
Child's age	0.037	0.003	-0.043	-0.069	0.016
	(0.036)	(0.023)	(0.020)	(0.027)	(0.050)
Child's age squared	0.000	0.000	0.001	0.001	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Lower Egypt: Urban	-0.424	-0.167	-0.196	-0.141	0.168
	(0.148)	(0.099)	(0.093)	(0.140)	(0.280)
Lower Egypt: Rural	-0.417	-0.164	-0.170	-0.244	-0.123
	(0.161)	(0.101)	(0.077)	(0.151)	(0.293)
Upper Egypt: Urban	-0.971	-0.651	-0.708	-1.049	-1.544
	(0.168)	(0.105)	(0.092)	(0.126)	(0.226)
Upper Egypt: Rural	-0.596	-0.540	-0.708	-1.332	-1.515
	(0.173)	(0.114)	(0.092)	(0.152)	(0.286)
Mother's weight	0.018	0.029	0.026	0.052	0.090
	(0.020)	(0.014)	(0.012)	(0.017)	(0.028)
Mother's weight squared	0.000	0.000	0.000	0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's height	-1.961	-2.110	-2.567	-1.398	-1.629
	(1.217)	(0.459)	(0.395)	(0.529)	(1.030)
Mother's height squared	0.013	0.014	0.017	0.010	0.011
	(0.008)	(0.003)	(0.003)	(0.004)	(0.003)
Mother's height cubed	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother's employment	-0.180	-0.197	-0.163	-0.111	-0.412
	(0.124)	(0.080)	(0.070)	(0.095)	(0.167)
Illiterate	-0.464	-0.230	-0.145	-0.057	-0.114
	(0.162)	(0.105)	(0.092)	(0.126)	(0.238)
Primary	-0.276	-0.310	-0.254	-0.178	-0.457
	(0.178)	(0.120)	(0.104)	(0.143)	(0.261)
Secondary	-0.070	0.009	-0.066	-0.162	-0.227
	(0.117)	(0.078)	(0.072)	(0.102)	(0.197)
Wealth Index: Lowest quintile	0.293	0.158	0.123	0.277	0.248
	(0.195)	(0.126)	(0.114)	(0.159)	(0.293)
Wealth Index: Second quintile	0.235	0.172	0.280	0.345	0.254
	(0.191)	(0.125)	(0.158)	(0.080)	(0.295)
Wealth Index: Middle quintile	0.263	0.258	0.280	0.356	0.391
	(0.179)	(0.115)	(0.106)	(0.149)	(0.279)
Wealth Index: Fourth quintile	0.091	0.098	0.126	0.211	0.607
	(0.143)	(0.091)	(0.082)	(0.115)	(0.223)

Table 14: RIF Regression - Unconditional Quantile Regression Coefficients on HAZ - 2014

Variable	10th Quantile	25th	50th	75th	90th
Prenatal Care: Nurse	0.085	-0.024	-0.151	-0.384	-0.661
	(0.085)	(0.056)	(0.050)	(0.068)	(0.126)
Prenatal Care: No care	-0.193	-0.425	-0.364	-0.371	-0.685
	(0.160)	(0.103)	(0.104)	(0.063)	(0.172)
Number of antenatal visits	0.000	0.001	0.002	0.003	0.007
	(0.004)	(0.003)	(0.002)	(0.003)	(0.007)
Toilet facility: Modern flush toilet	-1.367	1.020	-0.145	0.249	1.592
	(0.152)	(0.649)	(0.548)	(0.832)	(0.300)
Toilet facility:Latrine	0.102	1.386	-0.096	-0.091	1.130
	(0.240)	(0.661)	(0.557)	(0.843)	(0.373)
Water facility: Intermediate	-0.090	0.146	0.208	0.308	-0.058
	(0.462)	(0.289)	(0.254)	(0.352)	(0.602)
Intercept	94.000	98.178	122.921	62.606	68.269
	(57.359)	(21.262)	(18.687)	(24.187)	(47.371)

Standard errors are in parenthesis

Table 15: RIF -I-OLS Regression - Concentration Index

Variable	Observed Coefficient
Gender	-0.020
	(0.017)
Child's age	-0.007
	(0.007)
Child's age squared	0.001
	(0.001))
Lower Egypt: Urban	-0.102*
	(0.041)
Lower Egypt: Rural	-0.359***
	(0.030)
Upper Egypt: Urban	-0.318***
	(0.034)
Upper Egypt: Rural	-0.191***
	(0.029)
Mother's weight	-0.002
	(0.004)
Mother's weight squared	0.000
	(0.000)
Mother's height	-0.132
	(0.283)
Mother's height squared	0.001
	(0.002)
Mother's height cubed	0.000
	(0.000)
Mother's employment	0.025
	(0.022)
Illiterate	-0.071*
	(0.051)
Primary	-0.077**
	(0.037)
Secondary	-0.070**
	(0.034)
Prenatal Care: Nurse	0.090***
	(0.194)
Prenatal Care: No care	-0.060***
	(0.027)
Number of antenatal visits	-0.000
	(0.000)
Toilet Facility: Modern Flush Toilet	0.149 ***
	(0.045)

Table 15: RIF -I-OLS Regression - Concentration Index

Variable	Observed Coefficient
Toilet Facility: Latrine	0.118**
	(0.057)
Water Facility: Intermediate	-0.046*
	(0.027)
Constant	4.977
	(14.937)

* p<0.05 , ** p<0.1,*** p<0.01

Bootstraped standard errors are in parenthesis.

Figure 1: HAZ Kernal Density

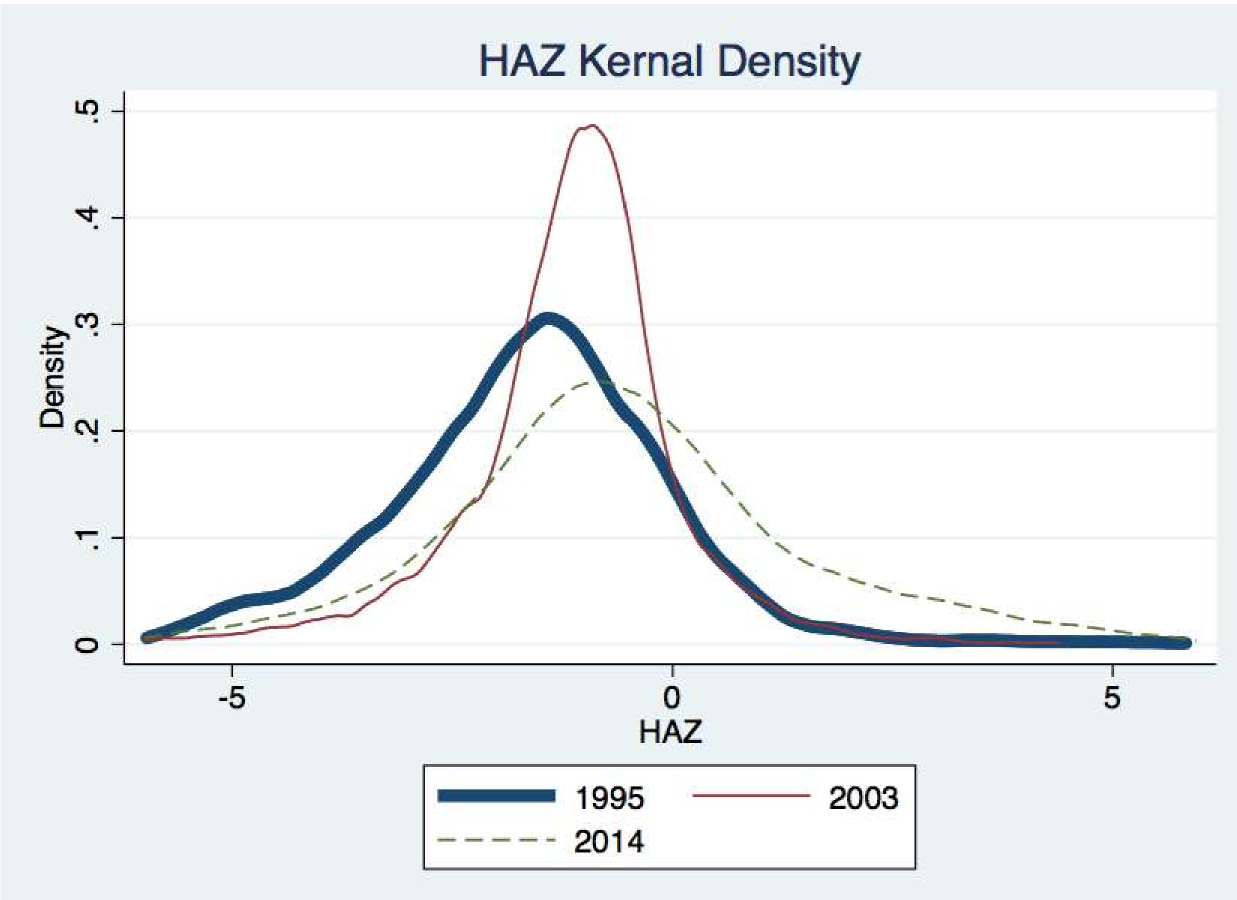
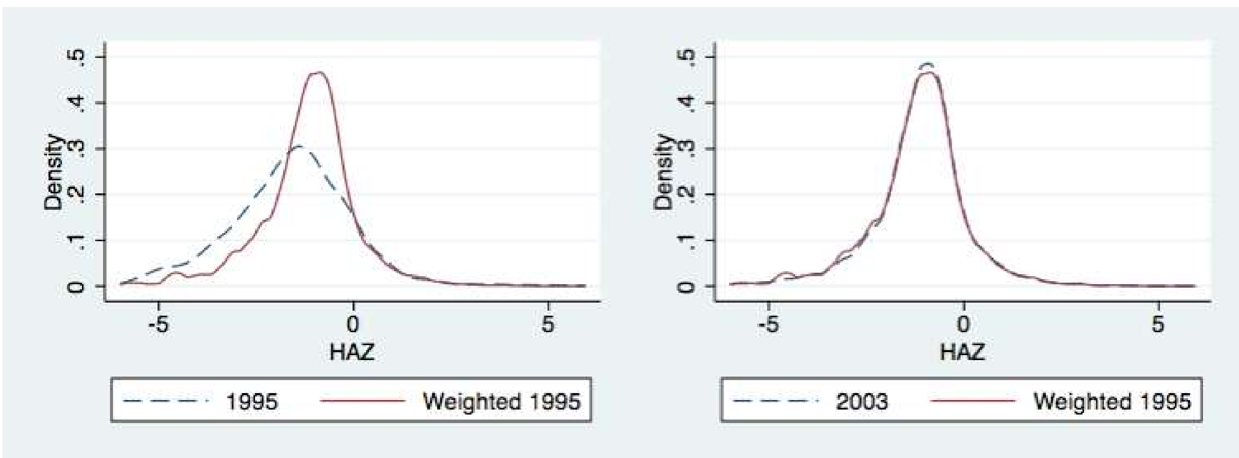
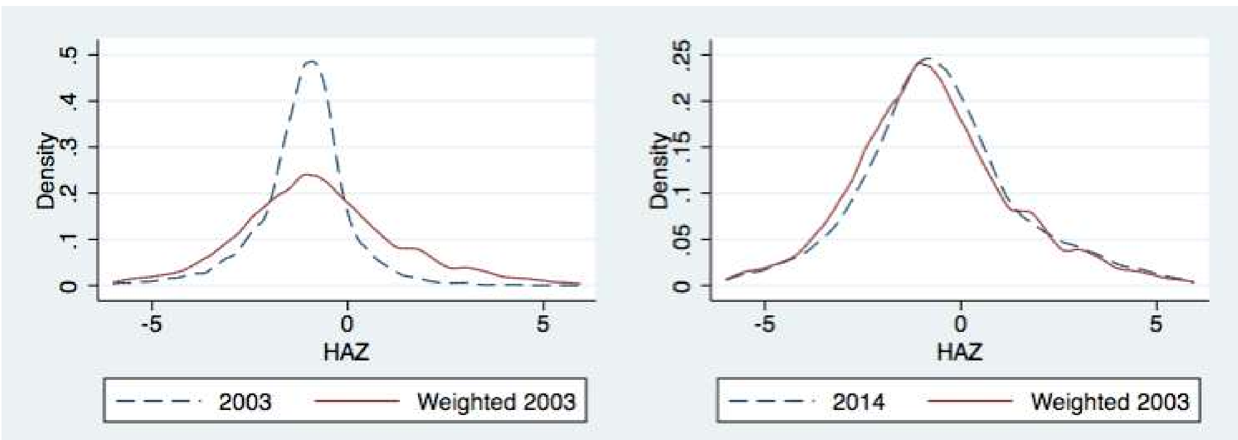


Figure 2: DFL Decomposition for the HAZ distribution in 1995 and 2003



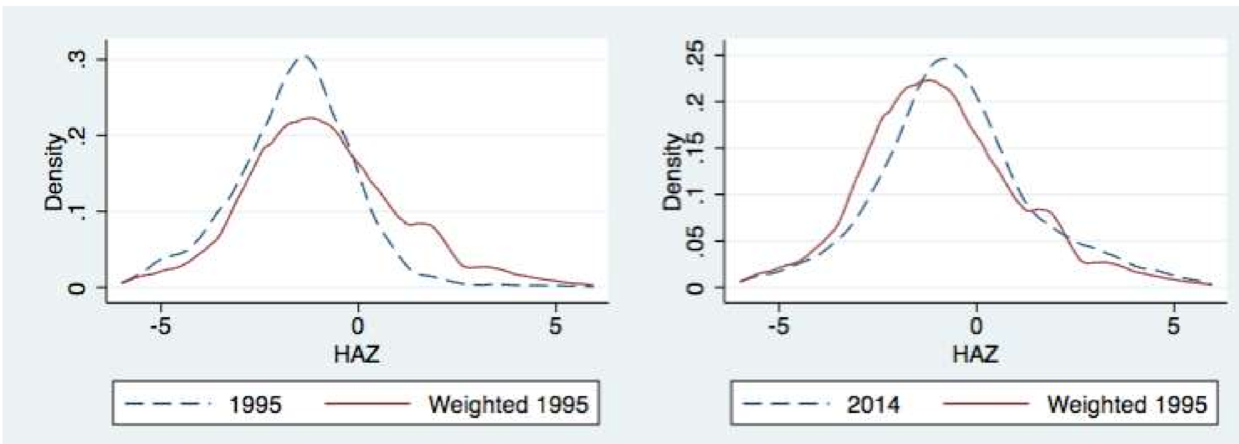
The top left panel represents the actual 1995 HAZ distribution (dashed line) and the weighted/counterfactual 1995 HAZ distribution (solid line). The weighted 1995 HAZ distribution is the 1995 covariates with 2003 associations. The difference between the 2 distributions reflects the impact of change of the return to covariates between 1995 and 2003 on the HAZ distribution, which is the coefficient effect. The covariates include child's characteristics, mother's characteristics, household SES and access to health care. The top right panel shows the actual 2003 HAZ distribution (dashed line) and the weighted/counterfactual 1995 HAZ distribution (solid line). The difference between the 2 distributions reflects how the change in covariates between 1995 and 2003 affected the HAZ distribution, which is the covariate effect.

Figure 3: DFL Decomposition for the HAZ distribution in 2003 and 2014



The top left panel represents the actual 2003 HAZ distribution (dashed line) and the weighted/counterfactual 2003 HAZ distribution (solid line). The weighted 2003 HAZ distribution is the 2003 covariates with 2014 associations. The difference between the 2 distributions reflects the impact of change of the return to covariates between 2003 and 2014 on the HAZ distribution, which is the coefficient effect. The covariates include child's characteristics, mother's characteristics, household SES and access to health care. The top right panel shows the actual 2014 HAZ distribution (dashed line) and the weighted/counterfactual 2003 HAZ distribution (solid line). The difference between the 2 distributions reflects how the change in covariates between 2003 and 2014 affected the HAZ distribution, which is the covariate effect.

Figure 4: DFL Decomposition for the HAZ distribution in 1995 and 2014



The top left panel represents the actual 1995 HAZ distribution (dashed line) and the weighted/counterfactual 1995 HAZ distribution (solid line). The weighted 1995 HAZ distribution is the 1995 covariates with 2014 associations. The difference between the 2 distributions reflects the impact of change of the return to covariates between 1995 and 2014 on the HAZ distribution, which is the coefficient effect. The covariates include child's characteristics, mother's characteristics, household SES and access to health care. The top right panel shows the actual 2014 HAZ distribution (dashed line) and the weighted/counterfactual 1995 HAZ distribution (solid line). The difference between the 2 distributions reflects how the change in covariates between 1995 and 2014 affected the HAZ distribution, which is the covariate effect.

Appendix Table 1: OLS regression of stunting on covariates

HAZ	Coefficient	Shapley R-Squared
Child's Characteristics	0.0001	0.233
	(0.0001)	
Mother's Characteristics	0.0001***	93.979
	(0.0000)	
Household SES	0.0058***	4.387
	(0.0015)**	
Access to health care	0.007*	1.401
	(0.0003)	

* $p < 0.05$, ** $p < 0.1$, *** $p < 0.01$

Note: The Shapley R-squared is the share of explained variance (measured by R-squared) decomposed into contributions by the four groups of regressors (child characteristics, mother characteristics, household socioeconomic status (SES) and access to health care). The Shapley R- squared values are expressed as percentages of the overall R-squared.

Appendix Table 2: Stunting -Oaxaca Decomposition

Group 1 (Year)	1995	2003	1995
Group 2 (Year)	2003	2014	2014
Group 1 stunting mean	0.369***	0.165***	0.369***
Group 2 stunting mean	0.165***	0.205***	0.205***
Mean Difference	0.204***	-0.04	0.164***
Mean difference explained by covariates	0.037***	0.005	0.069***
Mean difference explained by returns to covariates	0.168***	-0.045	0.096***
Effect of covariates			
Gender	0.0004	0	0.0004
Age	-0.004	-0.0006	-0.005***
Mother's height	0.008***	0.003**	0.013***
Mother's weight	0.016***	0.0004	0.038***
Mother's employment	0.0006	-0.001	-0.0003
Health Care	0.004**	-0.002	0.005
Education	0.0009	0.005	0.005
Sanitation	0.005	-0.006*	0.004
Wealth	0.003	-0.0005	-0.001
Geography	0.004**	0.007***	0.011***
Effect of the return to covariates			
Gender	0.015	-0.007	0.008
Age	0.109	-0.022	0.088
Mother's height	-0.347	0.415	0.067
Mother's weight	0.300	-0.387*	-0.109
Mother's employment	0.002	-0.008**	-0.007*
Health Care	-0.018	0.015	-0.008
Education	0.044	-0.022	0.024
Sanitation	0.005	-0.0003	-0.00004
Wealth	0.002	0.022	0.028
Geography	0.056*	-0.051*	0.005
Observations	8542	10990	12564

* $p < 0.05$, ** $p < 0.1$, *** $p < 0.01$

Notes: Child's age and age squared are grouped into the variable age. The variable mother's height includes the mother's height, height squared and height cubed. The variable mother's weight includes the mother's weight and weight squared. The variable health care is a grouped variable that includes whether the mother had prenatal care with a nurse, no prenatal care, and number of antenatal visits. The variable education is a grouped variable that includes whether the mother is illiterate, has primary, or secondary education. The variable sanitation included intermediate water quality, latrine or no toilet facility. The variable wealth includes the lowest four wealth quintiles, and geography includes lower urban, lower rural, upper urban and upper rural governorates.

Appendix Table 3: OLS regression of HAZ on covariates

HAZ	1995	2003	2014
Gender	-0.086*	-0.016	-0.074
Child's age in months	-0.065***	0.014	-0.006
Child's age squared	0.001***	-0.00005	0.0002
Mother's height	-0.471***	1.467	-0.321*
Mother's height squared	0.004***	-0.009	0.002
Mother's height cubed	-0.000009***	0.00002	-0.000004
Mother's weight	0.002	0.037**	0.046***
Mother's weight squared	0.00008	-0.0002**	-0.0003***
Mother's employment	-0.009	0.053	-0.206**
Prenatal Care: No care	-0.070	0.048	-0.289***
Number of antenatal visits	0.002	0.0005	0.001
Illiterate	-0.382**	0.048	-0.181*
Primary	-0.354**	0.120	-0.277**
Secondary	-0.350**	0.155	-0.079
Toilet facility: Flush toilet	0.149**	-0.070	0.216
Water facility: Intermediate	0.020	0.061	0.256
Wealth index: Lowest quintile	0.213**	-0.114	0.226*
Wealth index: Second quintile	0.152*	-0.083	0.233*
Wealth index: Middle quintile	-0.064	-0.069	0.331**
Wealth index: Fourth quintile	-0.063	-0.012	0.183*
Lower Egypt:Urban	-0.174	-0.025	-0.217*
Lower Egypt:Rural	-0.174*	0.028	-0.250**
Upper Egypt:Urban	-0.177	-0.042	-0.936***
Upper Egypt:Rural	-0.293***	-0.128	-0.923***
Constant	15.23**	-86.39	13.23*
Observations	4892	3454	7506

* $p < 0.05$, ** $p < 0.1$, *** $p < 0.01$

Notes: Each column represents a separate regression. The first column is an OLS regression of HAZ on covariates for the year 1995. The second column is for the year 2003 and the third column is for 2014.

Appendix Table 4: OLS regression of stunting on covariates

Stunting	1995	2003	2014
Gender	0.0283*	0.00008	0.013
Child's age in months	0.011	0.0002	-0.0003
Child's age squared	-0.0002**	-0.00004	-0.00001
Mother's height	0.101**	-0.780	0.058
Mother's height squared	-0.0008**	0.005	-0.0004
Mother's height cubed	0.000002**	-0.000009	0.000001
Mother's weight	-0.006*	-0.018***	-0.006*
Mother's weight squared	0.00002	0.0001***	0.00003
Mother's employment	-0.013	-0.021	0.038**
Prenatal Care: No care	0.003	0.019	0.062***
Number of antenatal visits	-0.0005	0.0009	-0.0004
Illiterate	0.045	0.005	0.045*
Primary	0.021	0.001	0.054**
Secondary	0.039	-0.020	-0.005
Toilet facility: Modern flush toilet	-0.042*	-0.002	0.066
Water facility: Intermediate	-0.028	-0.050*	-0.019
Wealth index: Lowest quintile	-0.029	-0.006	-0.038
Wealth index: Second quintile	-0.020	-0.007	-0.029
Wealth index: Middle quintile	0.011	0.006	-0.050*
Wealth index: Fourth quintile	0.037	-0.016	-0.021
Lower Egypt:Urban	0.036	-0.019	0.035
Lower Egypt:Rural	0.065*	-0.015	0.046*
Upper Egypt:Urban	0.071*	0.009	0.118***
Upper Egypt:Rural	0.103***	0.048*	0.088***
Constant	-2.680	44.37	-2.066
Observations	5058	3484	7506

* $p < 0.05$, ** $p < 0.1$, *** $p < 0.01$

Notes: Each column represents a separate regression. The first column is an OLS regression of stunting on covariates for the year 1995. The second column is for the year 2003 and the third column is for 2014.