Associations between Food Scarcity during Pregnancy and Children's Survival and Linear Growth in Zambia

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ABSTRACT

A growing body of literature suggests that in utero exposure to hunger negatively affects children's survival and linear growth. In this paper, we retrospectively linked data on local agricultural output and household food reserves during the in utero period to children's health and nutritional status in the first five years of their life. We hypothesized that seasonal variations in agricultural yields and food reserves affect the quantity and diversity of food intake during pregnancy, and that pregnancies during periods with limited food reserves are associated with poorer child health outcomes. We generated a food reserve scarcity index (FRSI) based on reported food stocks at the household level reported in post-harvest surveys from 2001-2007 and estimated associations with child survival, birth size and World Health Organization (WHO) growth Z scores using multivariable regression model. We found negative and statistically significant associations between children's weight and height Z-scores (WAZ and HAZ) and food scarcity in all trimesters with largest associations for the first and third trimesters. While we found that food scarcity in the second trimester increases children's mortality risk, food scarcity in early gestation had protective effects on mortality. The results suggest that policies aimed at reducing vulnerability to food scarcity require targeting the vulnerable populations and proper timing of policies. Policy implications encompass two pathways: One is through nutrition such as food aid and supplements; And with the recurrence of food scarcity problem, the second more sustainable solution is through agriculture and extension such as proper food storage.

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INTRODUCTION

In most developing countries, farming remains the primary source of income and nutrition for a majority of rural households (Baiphethi and Jacobs, 2009). According to the latest Food and Agriculture Organization (FAO) estimates, 795 million of the global population is exposed to food insecurity or hunger, with 50% of which lives in smallholder subsistence farming communities (FAO-SOFI, 2015). Meanwhile, child undernutrition continues to be a major public health problem in most developing countries; 99 million children younger than 5 years are currently classified as underweight and 161 million classified as stunted (UNICEF Fact Sheet, 2015).

A growing body of literature suggests that in utero exposure to hunger negatively affects children's health later in life. Building on David Barker's original work on fetal programming (Barker, 1992; 1995; 1997; 1998), several recent studies have shown that undernutrition before and during pregnancy is associated with low birth weight (Karlberg and Albertsson-Wikland, 1995; Neelsen and Stratman, 2011), growth faltering (Neumann and Harrison, 1994; Norton, 1994), poor cognitive ability (Norton, 1994; Jyoti et al., 2005; Gluckman et al., 2005; Van den Berg et al., 2012), reduced income-earning capacity in adult life (Jyoti et al., 2005; Gluckman et al., 2005; Van den Berg et al., 2012; Scholte et al., 2012), and chronic diseases in adult life (Painter et al., 2005; Roseboom et al., 2001; Schulz, 2010).

However, these effects are dependent on the gestational stage during which the exposure to nutritional scarcity happens (Painter et al., 2005; Schulz, 2010). Painter el al (2005) found that women whose last trimester of pregnancy coincided with a food scarce period tended to deliver babies whose birth weight was significantly lower than normal, while Schulz (2010) found that the children of women who were exposed to hunger in first trimester grew up with higher rates of obesity and heart diseases. Susser and Stein (1994) have shown the effects of prenatal nutrition by stage of gestation using datasets from previous Dutch famine studies. Organic brain

defects and other psychological disorders were generally found in children in West Holland whose mothers were exposed to undernutrition during the periconception period (Susser and Stein, 1994). Exposure to maternal hunger in the first trimester was associated with preterm birth, still births, first week deaths and obesity later in life occurs. And finally, decrease in birth weight, mortality during the first 3 months of life and obesity were more likely to occurs in children whose mothers were exposed to hunger in the third trimester (Susser and Stein, 1994).
Even though agriculture has been widely acknowledged as a source of food and income, very few studies have tried to directly link agriculture to child nutrition and health. In this paper, we retrospectively linked data on local agricultural output and household food reserves during the in utero period to children's health and nutritional status in the first five years of their life. We hypothesized that seasonal variations in agricultural yields and food reserves affect the quantity and diversity of food intake during pregnancy, and that pregnancies during periods with limited food reserves are associated with poorer child health outcomes.

METHODS

Background

Zambia is among the countries with the highest burden of undernutrition in children under five globally (CSO, 2007; 2009). According to the 2013 Zambia Demographic Health Survey (DHS), 40% of children under the age of five are stunted, 15% are underweight and 6% are wasted (NFNC, 2008). The National Food and Nutrition Commission (NFNC, 2008) estimated that 54% of women and 13% of children are vitamin A deficient, and that anemia rates among children and women are 53% and 30%, respectively.

Eighty percent of Zambia's population depends on agriculture for food, income, and employment. Most farmers are small-scale, cultivating less than 2 hectares (ha) of land with generally low levels of productivity (Tembo and Sitko, 2013). The major food crop and main food staple grown is maize which is harvested in March or April. Other staples include cassava, sweet potatoes, millets and sorghum, as well as legumes, peanuts, beans, cowpeas and Bambara nuts (Tembo and Sitko, 2013). In the absence of irrigation, Zambia's climate allows only for one harvest per year. The availability of food reserves peak after the typical harvest month of March or April and thereafter gradually declines. Even in years of good harvests, many households are unable to consistently meet their basic nutritional needs, with particularly large and common food shortages in the December-February period preceding the next harvest (Fink et al., 2014). According to the National Food and Nutrition Commission (2008), only 36 percent of households in Zambia have enough food to eat throughout the year, while 19 percent of households seldom or never have enough to eat. In typical agricultural seasons, 60 percent of farmers face a hungry season of several months, which is particularly acute during November, December, January and February (NFNC, 2008). New crops usually become available after March, and have to provide farms with the reserves needed throughout the subsequent year.

Data and Study Sample

The Post-Harvest Survey (PHS) was used as the source of agricultural production and crop reserves data. The PHS are the most comprehensive and regionally representative source of information for the small- and medium- scale farm sector in Zambia (Zulu et al., 2000). PHS have been used to collect annual agricultural data since 1992/93. The survey covers areas planted with individual crops, production quantities, sales of produce and income realized, purchase and use of agricultural inputs, capital formation and other operational expenses, demographic characteristics of heads of rural households, farming practices and soil conservation methods used and access to agricultural loans (Food Security Research Project, 2001-2007). The PHS tracks households' reserves of all produced crops over time which allowed for the computation of the measures of food reserve scarcity at the household and district level for each month in the 2001-2007 period in this study. Because the paper aimed at looking at the direct impacts of changes in agricultural production and food reserves on agricultural households nutrition and health, the analysis was restricted to farmers who focus on growing food to feed themselves and their families (i.e. subsistence and semi-subsistence households). Thus, the analysis focused on small and medium farms by excluding farms with >5 hectares (52,361 observations or about 39.67% of the original PHS sample).

For the maternal and child health and nutrition information, the 2007 Zambia Demographic Health Survey (ZDHS) was used. In international public health research, DHS is one of the primary sources of health information, with a particularly focus on child health and survival (David and Haberlen, 2005). Since 1984, the DHS Program is responsible for collecting accurate, nationally representative data on health in more than 70 low and middle-income countries (David and Haberlen, 2005). ZDHS interviews were conducted between November 2001 and June 2002. The ZDHS survey collects information about children 0-5 years, including their weight, height, birth size and survival status. It also collects information about the parents and the socioeconomic characteristics of the household.

To analyze the associations of food reserves seasonality during pregnancy and children's survival and nutritional status young children, this study retrospectively merged the PHS to the ZDHS data. With the assumption of full term pregnancy (i.e. 9 months), month and year of birthdates of children from the ZDHS were matched with preceding month and year's reported crop reserves from PHS. After the merge the total sample size is 5,788 children. Figure 1 demonstrates how the variables in the two databases were matched and merged for data analysis.

MEASURES

Outcome measures

The primary outcome measures used in the study were binary variables for child survival and small birth size, and continuous variables for growth Z-scores (weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) Z-scores). Height and weight were standardized based on WHO child growth standards of 2006 (David and Haberlen, 2005) to create HAZ and WAZ Z-scores. 238 observations were eliminated due to biologically implausible values based on WHO (2006) recommended cutoffs at +/- 6SD.

Main independent variables

The main independent variables used were constructed food scarcity indexes; namely, food reserve scarcity index variable (FRSI) and low reserve trimesters (LRT). For the PHS survey, each farm reports the total production from each crop for each agricultural calendar year (i.e. April-March of each year pairs). Farmers are also asked if they still have the crop from last harvest in storage and if not, which month they ran out of stock. We used the responses to these questions to construct a food reserve scarcity index variable (FRSI). The FRSI is defined as the proportion of households without crop reserves from the previous harvest in a given month and district. We also generated a binary variable identifying pregnancy-trimesters occurring in particularly food-scarce periods. We defined pregnancy-trimester as low reserve trimesters (LRTS) if the FRSI>33%, that is if at least one third of households in the district did not have any food-reserves left during the respective trimester period.

Empirical Analysis

For the regression analysis, the following multi-variable models were estimated:

$$Outcome_i = \propto + FRSI_1\beta_1 + FRSI_2\beta_2 + FRSI_3\beta_3 + X_i\gamma + R_i\theta + M_i\delta + \varepsilon_i \qquad (1)$$

$$Outcome_i = \propto + LRT_i\beta_i + X_i\gamma + R_i\theta + M_i\delta + \varepsilon_i \qquad (2)$$

Where $Outcome_i$ is the health outcome measure (i.e. child still alive, small in birth size, WAZ, HAZ, WHZ) observed for child i during the DHS interview. X_i is a vector of child and household characteristics. And R_i and M_i are region and month indicators, respectively.

Recall that each child observation was matched to the monthly FRSI for when the child was conceived and in utero with the assumption that the pregnancy was complete or full term. $FRSI_i$ was derived as the average of food reserve scarcity index in the first, second, third trimesters while LRT_i was generated as the binary measure for low reserve trimester.

The multivariable model was adjusted for month fixed effects (to control for seasonality), regional dummies (to control for potential compositional differences related to regional food prices and diets), a dummy whether the mother works form home (to take into account peak of labor during the ‘hungry’ season), age groups and child’s gender (to take into account other potential compositional differences related to physiologic processes), a dummy whether the household has access to safe water and improved sanitation and if mother smokes tobacco (to take into account household’s health coping strategies), mother’s education in single years, mother’s marital status and household’s asset in quintiles. The asset quintiles were derived using principal components analysis, which include ownership of radio, television, refrigerator, bicycle, motor cycle/scooter, car/truck and telephone.

For the binary outcomes of child survival and small birth size, we used logistic models. While for the z-score outcomes, we used ordinary least squares to perform linear regression. We first estimated the model with only the food scarcity variables as independent variable, then included all of maternal controls, and then added regional and month controls. This procedure allowed us to gauge the extent to which the bivariate correlations can be explained by maternal and child characteristics as well as general country-wide seasonal patterns. Recall that in merging the month and year of birthdates of children from the ZDHS with preceding month and year’s reported crop reserves from PHS, it was assumed that all children were born full term (i.e. 9 months). Unfortunately, DHS does not contain any information on time of conception. This assumption induces possible measurement error in the regressions, potentially attenuating the estimated coefficient to zero. To check this assumption that the children were born full term, we ran the model for mothers who never had early pregnancy termination (87% of mothers) and found very similar results as in Supplemental Table 1. For robustness check of our model specifications, we also ran alternative linear regression models with *FRSI* for each trimester separately and one with all the trimesters. Both the robustness check regressions yielded similar trend in results presented in Supplemental Tables 2 and 3.

RESULTS

The proportion of households that ran out of food reserves during the 2001-2002 cropping season is presented in Figure 2. Food scarcity gradually increased after the harvest in May and June and peaks in the January to March period. Figure 3, 4 and 5 show the FRSI index for February of

2002, 2004 and 2007. The darker areas represent areas with higher predicted probability of food scarcity by December and/or February. Figures 6 and 7 show child mortality (deaths by 1000) and stunting prevalence by month. Child mortality was highest for months of January followed by June. On the other hand, the highest rates of stunting were around June through September. Note that children born in June are those children whose first trimester falls in typical hungry season.

Descriptive statistics of variables used in the study are presented in Table 1. About 20% of households lacked crop reserves in each trimester (20%, 19% and 19% for first, second and third trimester, respectively). No pregnancy was exposed to low reserve trimester (i.e. FRSI>33%) in all three trimesters. While 42.7% of the households were never exposed to low reserve in any of the trimesters. One-fifth of study subjects experienced low reserves in at least one trimester (21.1%, 16.3% and 17.3% in first, second and third trimester, respectively). About 90% of the children considered in the study were still alive at the time of the interview and had a mean birthweight of 3.24 kilograms.

The associations of food scarcity during pregnancy on children's nutritional outcomes are presented in Table 2. For WAZ and HAZ, we found negative and significant associations with food scarcity in all trimesters. Largest associations were found for the first and third trimesters. A one percentage point increase in the proportion of households without crop reserves from the previous harvest during pregnancy was associated with a weight-for-age z-score reduction of about 0.528 (95% CI -0.92, -0.14) in the first trimester, a reduction of 0.348 (95% CI -0.60, -0.09) in the second trimester and a reduction of 0.603 (95% CI -1.01, -0.20) in the third trimester. Moreover, children exposed to food scarcity in gestation have significantly lower height-for-age z scores compared to those not exposed at all (Beta -0.644; 95% CI -1.18, -0.10; Beta -0.357; 95% CI -0.71, -0.01 and Beta -0.885; 95% CI -1.44, -0.33 for first, second and third trimesters, respectively). We did not find any significant associations between food scarcity and birth size. Food scarcity during the second trimester was associated with increased odds of child mortality (OR 1.894; 95% CI 0.961, 3.733). The opposite was true for the first trimester where food scarcity was found to be protective (OR 0.708; 95% CI 0.237, 2.113).

Results for our binary independent variable – low resources trimesters - are presented in Table 3. Overall, results were similar to the results from using continuous measure of food scarcity (*FRSI*). Again, increased exposure to food scarcity during pregnancy had no significant effects on the births size. Similarly, children exposed to food scarcity at any time during gestation and different combinations of gestation have significantly lower weight-for-age z scores and height-for-age z scores compared to those not exposed at all. Odds ratio of child's death for first trimester exposure to food scarcity was also protective (OR 0.757, 95% 0.577, 0.993).

DISCUSSION

This study expands on a limited body of research examining the links between agriculture and nutritional as well as health outcomes. Because agricultural production is seasonal, temporal variations in food supply often place severe stress on the ability of households to maintain adequate food intake. Food insecurity can be particularly harmful for pregnant women, potentially causing not only miscarriages and birth complications but also long term developmental delays and poorer health and quality of life for the children in the long run.

We found negative and significant associations between WAZ and HAZ with food scarcity in all trimesters. Largest associations were found for the first and third trimesters. This result is in line with previous evidence in Khan et al (2013) and Cox (2013). Khan et al (2013) found that early supplementation during pregnancy reduced the occurrence of stunting among boys aged 0-54 months of age in Bangladesh. Cox (2013) showed that children conceived during the British blockade and War on Germany suffered slower growth rates in their heights and weights.

The results for child mortality were more surprising; while we found that food scarcity in the second trimester increases children's mortality risk, we found protective effects for food scarcity in early gestation. One possible explanation of the counter-intuitive result for early gestational food scarcity is selection. If mothers are severely malnourished in the first trimester, early miscarriage may become more likely, and only the most resilient fetuses may survive to the later gestational periods. Hart (1993) showed that the Dutch famine at conception was associated with a substantial increase in the risk of stillbirth and perinatal mortality in the famine area, with increases in fetal death or miscarriages of up 100 percent. Similarly large effects were found for the Chinese Great Leap forward Famine (Song, 2013; Huang et al., 2010), where both Song (2013) and Huang et al. (2010) show that exposure to famine increased the risk of stillbirth.

This paper is to our knowledge the first to retrospectively link local food production during the gestational period to children's nutritional status. While we view the direct linking of agricultural production with health outcome data as a major strength and contribution of the paper, our data does not allow us to directly look at food scarcity at the individual or household level, but rather identifies available resources at sub-regional level. As such, the FRSI is a valid measure of local food availability and reserves, but not necessarily a measure of hunger experienced by a given household or child. A second limitation of the data used is that the DHS does not contain information on the date of conception. While it is a reasonable assumption that most children were conceived 9 months prior the delivery, children born preterm will be misclassified; the resulting measurement error will likely bias our results towards zero.

The results of this paper suggest that policies aimed at reducing vulnerability to food scarcity require targeting the vulnerable populations (i.e. pregnant mothers and young children). In addition to targeting of the most vulnerable populations, our results also suggest that interventions are particularly important in the first and last trimesters of testation. In terms of policy, two potential approaches seem feasible: one option is to address food scarcity directly through nutrition such as food aid and supplements. A second option is to try to address food scarcity and nutritional deficits through agriculture and extension program, or a more broad set of poverty-alleviating program. Given the high prevalence of food scarcity in developing countries, both types of programs will require major resource commitments by government and other stakeholders in the area.

REFERENCES

Baiphethi, M. N., & Jacobs, P. T. (2009). The contribution of subsistence farming to food security in South Africa. *Agrekon*, *48*(4), 459-482.

Barker, D. J. (1992). Fetal and infant origins of adult disease. London. *Brit. Med. J.*

Barker, D. J. (1995). Fetal origins of coronary heart disease. *BMJ: British Medical Journal*, *311*(6998), 171.

Barker, D. J. (1997). Maternal nutrition, fetal nutrition, and disease in later life. *Nutrition*, *13*(9), 807-813.

Barker, D. J. P. (1998). *Mothers, babies, and health in later life*. Elsevier Health Sciences.

Central Statistical Office, Ministry of Health Zambia Tropical Diseases Research Centre, University of Zambia and Macro International Inc. Zambia demographic and health survey 2007, 2009.

Cox, M. E. (2013). *War, Blockades, and Hunger: Nutritional Deprivation of German Children 1914-1924* (No. 110).

David, P., & Haberlen, S. (2005). 10 best resources for… measuring population health. *Health policy and planning*, *20*(4), 260-263.

Fink, G., Jack, B. K., & Masiye, F. (2014). *Seasonal credit constraints and agricultural labor supply: evidence from Zambia* (No. w20218). National Bureau of Economic Research.

Food Agriculture Organization, International Fund for Agricultural Development, World Food Program. The State of Food Insecurity in the World: Meeting the 2015 International hunger targets, taking stock of uneven progress. Rome, Italy: Food Agriculture Organization, 2015.

Food Security Research Project. (2001-2007). Zambian Post Harvest Supplemental Survey. Lusaka: Government of the Republic of Zambia.

Gluckman, P. D., Hanson, M. A., Spencer, H. G., & Bateson, P. (2005). Environmental influences during development and their later consequences for health and disease: implications for the interpretation of empirical studies. *Proceedings of the Royal Society of London B: Biological Sciences*, *272*(1564), 671-677.

Hart, N. (1993). Famine, maternal nutrition and infant mortality: a re-examination of the Dutch Hunger Winter. *Population Studies*, *47*(1), 27-46.

Huang, C., Li, Z., Narayan, K. V., Williamson, D. F., & Martorell, R. (2010). Bigger babies born to women survivors of the 1959–1961 Chinese famine: a puzzle due to survival selection?. *Journal of developmental origins of health and disease*, *1*(06), 412-418.

Jyoti, D. F., Frongillo, E. A., & Jones, S. J. (2005). Food insecurity affects school children's academic performance, weight gain, and social skills. *The Journal of nutrition*, *135*(12), 2831-2839.

Karlberg, J., & Albertsson-Wikland, K. (1995). Growth in full-term small-for-gestational-age infants: from birth to final height. *Pediatric research*, *38*(5), 733-739.

Khan, A. I. (2013). Effects of pre-and postnatal nutrition interventions on child growth and body composition: the MINIMat trial in rural Bangladesh. *Global health action*, *6*.

National Food Nutrition Council. Pilot Zambia food and nutrition surveillance report: Surveillance report for four districts in Lusaka province. Lusaka: National Food and Nutrition Commission, 2008.

Neelsen, S., & Stratmann, T. (2011). Effects of prenatal and early life malnutrition: Evidence from the Greek famine. *Journal of Health Economics*, *30*(3), 479-488.

Neumann, C. G., & Harrison, G. G. (1994). Onset and evolution of stunting in infants and children. Examples from the Human Nutrition Collaborative Research Support Program. Kenya and Egypt studies. *European journal of clinical nutrition*, *48*, S90-102.

Norton, R. (1994). Maternal nutrition during pregnancy as it affects infant growth, development and health. *SCN News*, *11*(1), 0-4.

Painter, R. C., Roseboom, T. J., & Bleker, O. P. (2005). Prenatal exposure to the Dutch famine and disease in later life: an overview. *Reproductive toxicology*, *20*(3), 345-352.

Roseboom, T. J., Van Der Meulen, J. H., Ravelli, A. C., Osmond, C., Barker, D. J., & Bleker, O. P. (2001). Effects of prenatal exposure to the Dutch famine on adult disease in later life: an overview. *Molecular and cellular endocrinology*, *185*(1), 93-98.

Scholte, R., Van den Berg, G. J., & Lindeboom, M. (2012). Long-run effects of gestation during the Dutch hunger winter famine on labor market and hospitalization outcomes.

Schulz, L. C. (2010). The Dutch Hunger Winter and the developmental origins of health and disease. *Proceedings of the National Academy of Sciences*, *107*(39), 16757-16758.

Song, S. (2013). Prenatal malnutrition and subsequent foetal loss risk: Evidence from the 1959-1961 Chinese famine. *Demographic Research*, *29*, 707.

Susser, M., & Stein, Z. (1994). Timing in prenatal nutrition: a reprise of the Dutch Famine Study. *Nutrition reviews*, *52*(3), 84-94.

Tembo, S., & Sitko, N. (2013). Technical compendium: Descriptive agricultural statistics and analysis for Zambia.

United Nations Children's Fund. UNICEF Zambia Fact Sheet. Version current 1 June 2015. Internet: http://www.unicef.org/zambia/5109_8461.htm (accesssed 15 June 2015).

Van den Berg, G. J., Pinger, P. R., & Schoch, J. (2012). Instrumental variable estimation of the causal effect of hunger early in life on health later in life. *ZEW-Centre for European Economic Research Discussion Paper*, (12-019).

World Health Organization Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization, 2006.

Zulu, B., Nijhoff, J. J., Jayne, T. S., & Negassa, A. (2000). *Is the Glass Full or Half Empty? An Analysis of Agricultural Production Trends in Zambia* (No. 3). FSRP Working Paper.

Table 1. Summary Statistics of Continuous and Categorical Variables used in the Study

	Means (SD) or N (%) [1]	
Food Reserve Availability Indexes		
FRAI[2] in first trimester	0.20	(0.14)
FRAI[2] in second trimester	0.19	(0.14)
FRAI[2] in third trimester	0.19	(0.14)
LRT[3]: None of the trimesters	2533	42.7%
LRT[3]: First trimester only	1250	21.1%
LRT[3]: Second trimester only	967	16.3%
LRT[3]: Third trimester only	1029	17.3%
LRT[3]: First and Second trimesters	98	1.7%
LRT[3]: Second and Third trimesters	57	1.0%
LRT[3]: First and Third trimesters	0	0.0%
LRT[3]: All trimesters	0	0.0%
Child's Health and Survival		
Child's birthweight in kilograms	3.24	(0.60)
Weight-for-Age Z Score	-0.83	(1.20)
Height-for-Age Z Score	-1.67	(1.64)
Weight-for-Height Z Score	0.18	(1.41)
Child is alive (1=yes, 0=no)	5406	91.10%
Child's Characteristics		
Child's Age in Months	29.04	(16.20)
Child is Male (1=yes, 0=no)	2950	49.7%
Multiple Birth (1=yes, 0=no)	253	4.3%
Mother's Characteristics		
Mother's Height in cm	157.43	(6.81)
Mother finished primary school (1=yes, 0=no)	3732	62.9%
Mother finished secondary school (1=yes, 0=no)	1295	21.8%
Mother finished higher education (1=yes, 0=no)	133	2.2%
Mother smokes cigarettes or tobacco (1=yes, 0=no)	56	0.9%
Mother works from home (1=yes, 0=no)	790	13.3%
Asset[4] q1	1,408	23.7%
Asset[4] q2	1,721	29.0%
Asset[4] q3	1,504	25.4%
Asset[4] q4	296	5.0%
Asset[4] q5	1,005	16.9%
Access to safewater (1=yes, 0=no)	2827	47.6%
Access to improved sanitation (1=yes, 0=no)	1498	25.2%

[1] Means (SD): Means and standard deviations are reported for continuous variables. N (%): Number and percentage of observations valued at 1 (i.e. 1=yes) are reported for the binary variables.
[2] Food Reserve Availability Index (FRAI) is the proportion of households without crop reserves from the prvious harvest in a given month and district.
[3] Low Reserve Trimesters (LRT) is a binary variable identifying pregnancy-trimesters occurring in particularly food-scarce periods and call it low reserve trimesters
[4] The asset quintiles were derived using principal components analysis, which include ownership of radio, television, refrigerator, bicycle, motor cycle/scooter, car/truck and telephone.

Table 2. Effects of Food Scarcity during Pregnancy on Children's health Outcomes [1] ,Zambia 2007

	Deaths	Small at birth	Weight-for-Age Z Score	Height-for-Age Z Score	Weight-for-Height Z Score
	(Odds Ratios and 95% Confidence Intervals)		(Beta Coefficients, Standard Errors and 95% Confidence Intervals)		
FRSI[2] in 1st trimester	0.708**	0.978	-0.528***	-0.644**	-0.316*
	(0.237 , 2.113)	(0.323 , 2.958)	(0.20) , (-0.92 , -0.14)	(0.28) , (-1.18 , -0.10)	(0.24) , (-0.80 , 0.16)
FRSI[2] in 2nd trimester	1.894*	1.14	-0.348***	-0.357**	-0.13
	(0.961 , 3.733)	(0.556 , 2.339)	(0.13), (-0.60 , -0.09)	(0.18) , (-0.71 , -0.01)	(0.16) , (-0.44 , 0.18)
FRSI[2] in 3rd trimester	1.745	1.243	-0.603***	-0.885***	0.0465
	(0.593 , 5.132)	(0.384 , 4.025)	(0.21), (-1.01 , -0.20)	(0.29) , (-1.44 , -0.33)	(0.26) , (-0.45 , 0.55)

1 The multivariable model was adjusted for month fixed effects, regional dummies, a dummy whether the mother works form home, age groups, gender, child's gender, a dummy whether the household has access to safe water and improved sanitation and whether the mother smokes tobacco, mother's education in single years, mother's marital status and household's asset in quintiles.

2 Food Reserve Scarcity Index (FRSI) is the proportion of households without crop reserves from the previous harvest in a given month and district. FRSI is averaged per trimester.

*, **, *** stand for 0.10, 0.05 and 0.01 significance levels

Table 3. Effects of Food Scarcity during Pregnancy on Children's health Outcomes using binary measures [1], Zambia 2007

	Deaths	Small at birth	Weight-for-Age Z Score	Height-for-Age Z Score	Weight-for-Height Z Score
	(Odds Ratios and 95% Confidence Intervals)		(Beta Coefficients, Standard Errors and 95% Confidence Intervals)		
LRT[2]: First trimester only	0.757**	0.943	-0.224***	-0.125**	-0.123**
	(0.577 , 0.993)	(0.731 , 1.218)	(0.04) , (-0.21 , -0.03)	(0.06) , (-0.25 , 0.0)	(0.05) , (-0.20 , 0.02)
LRT[2]: Second trimester only	1.203	0.944	-0.208***	-0.107	-0.0891
	(0.928 , 1.559)	(0.711 , 1.252)	(0.05) , (-0.17 , 0.02)	(0.07) , (-0.24 , 0.03)	(0.06) , (-0.17 , 0.07)
LRT[2]: Third trimester only	1.267*	1.184	-0.269***	-0.265***	-0.0862
	(0.986 , 1.628)	(0.899 , 1.561)	(0.05) , (-0.30 , -0.11)	(0.07) , (-0.4 , -0.13)	(0.06) , (-0.13 , 0.11)
LRT[2]: First and Second trimesters	1.133	1.123	-0.307**	-0.115	-0.448***
	(0.555 , 2.312)	(0.574 , 2.195)	(0.13) , (-0.51 , 0.02)	(0.19) , (-0.48 , 0.25)	(0.16) , (-0.5 , 0.14)
LRT[2]: Second and Third trimesters	1.348	0.689	-0.567***	-0.514**	-0.509
	(0.555 , 3.274)	(0.236 , 2.014)	(0.18) , (-0.80 , -0.12)	(0.24) , (-0.99 , -0.04)	(0.21) , (-0.63 , 0.21)

1a The multivariable model was adjusted for month fixed effects, regional dummies, a dummy whether the mother works form home, age groups, gender, child's gender, a dummy whether the household has access to safe water and improved sanitation and whether the mother smokes tobacco, mother's education in single years, mother's marital status and household's asset in quintiles. 1b Reference Period is low reserve in none of the trimesters. No observations fell in the categories of LRT is all trimesters and LRT in first and third trimesters so they were dropped.

2 Low Reserve Trimesters (LRT) is a binary variable identifying pregnancy-trimesters occurring in particularly food-scarce periods and call it low reserve trimesters

*, **, *** stand for 0.10, 0.05 and 0.01 significance levels

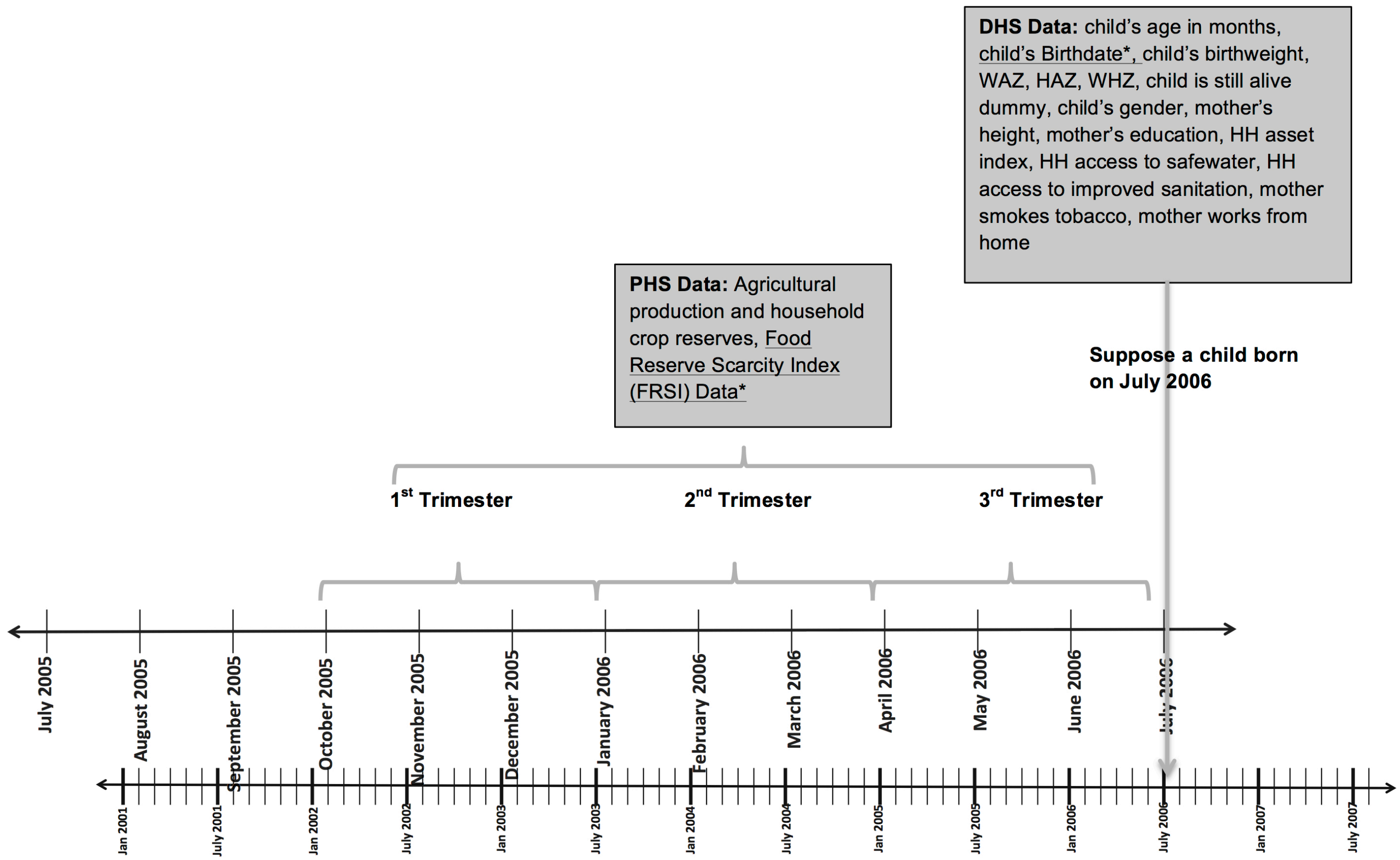

Figure 1. Merging of Post Harvest Survey (PHS) and Demographic Health Survey (DHS) Databases

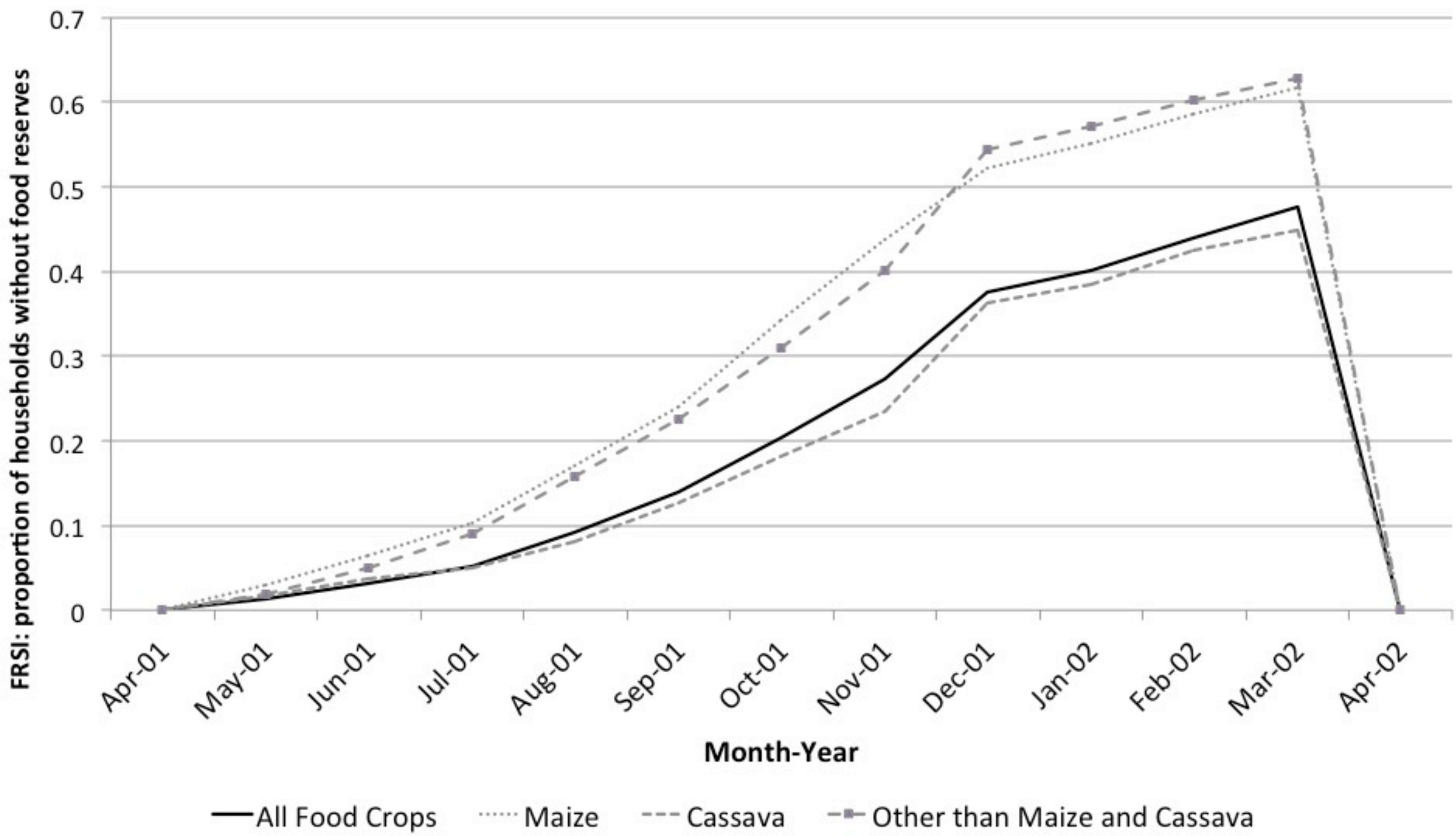

Figure 2. Proportion of households who ran out of food reserve by food type in Zambia, 2001-2002 Cropping Season

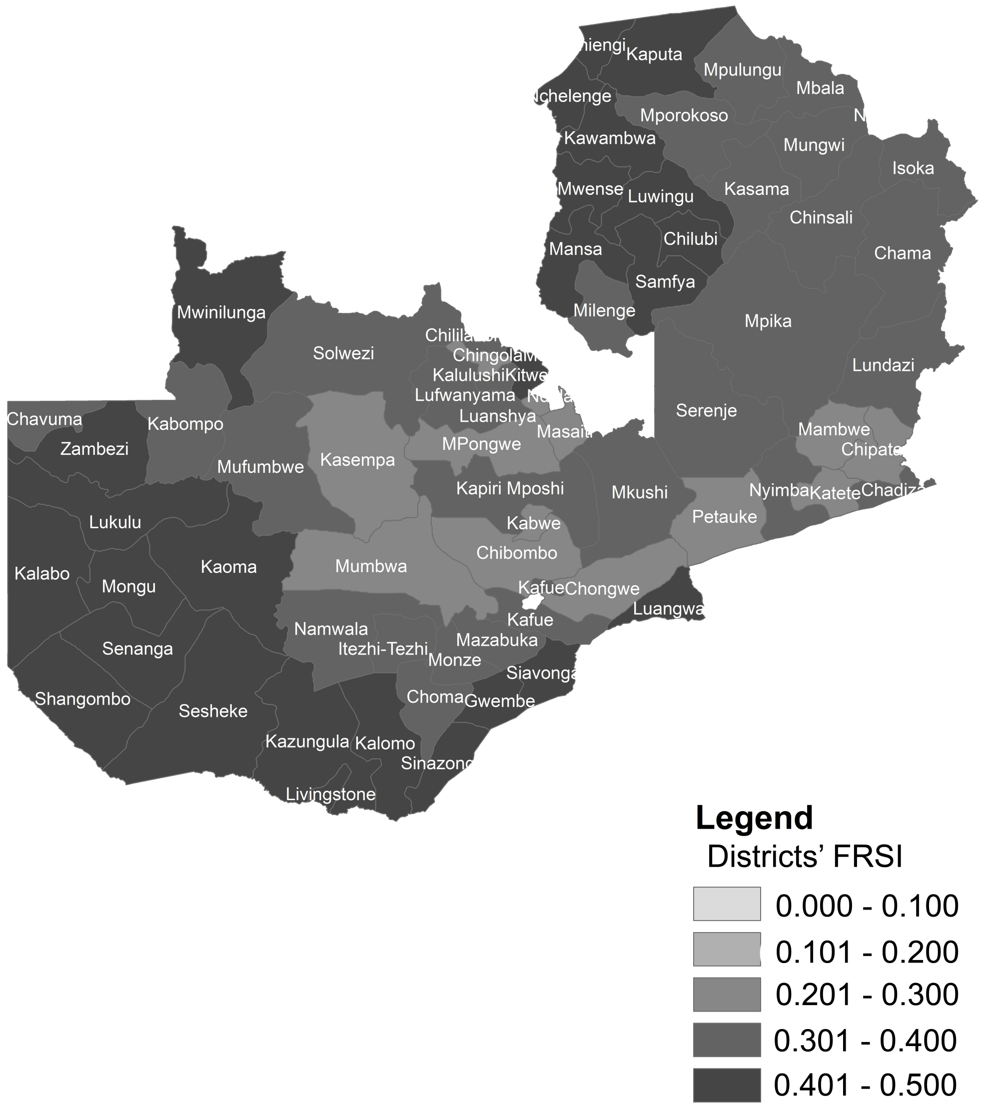

Figure 3. Food Reserve Scarcity Index by District, February 2002

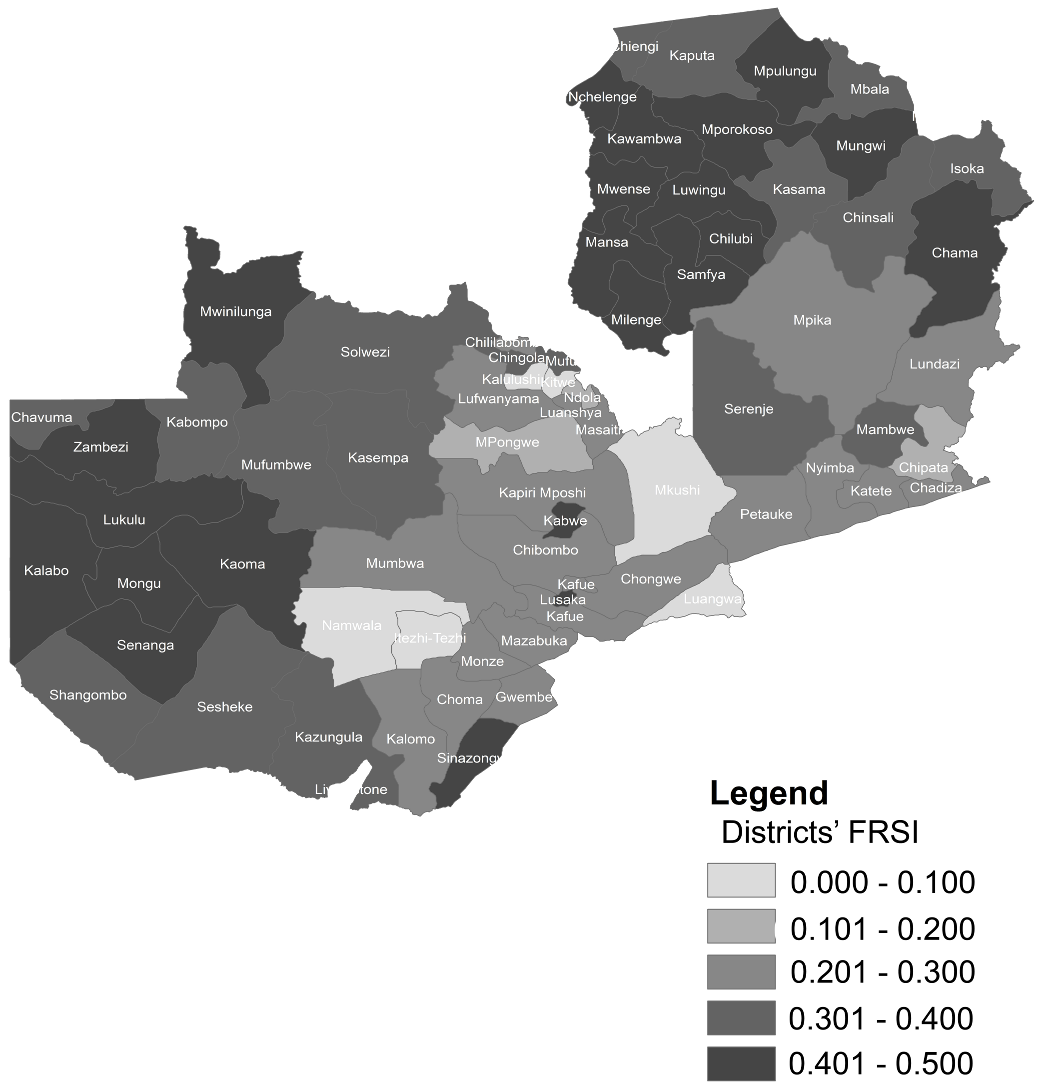

Figure 4. Food Reserve Scarcity Index by District, February 2004

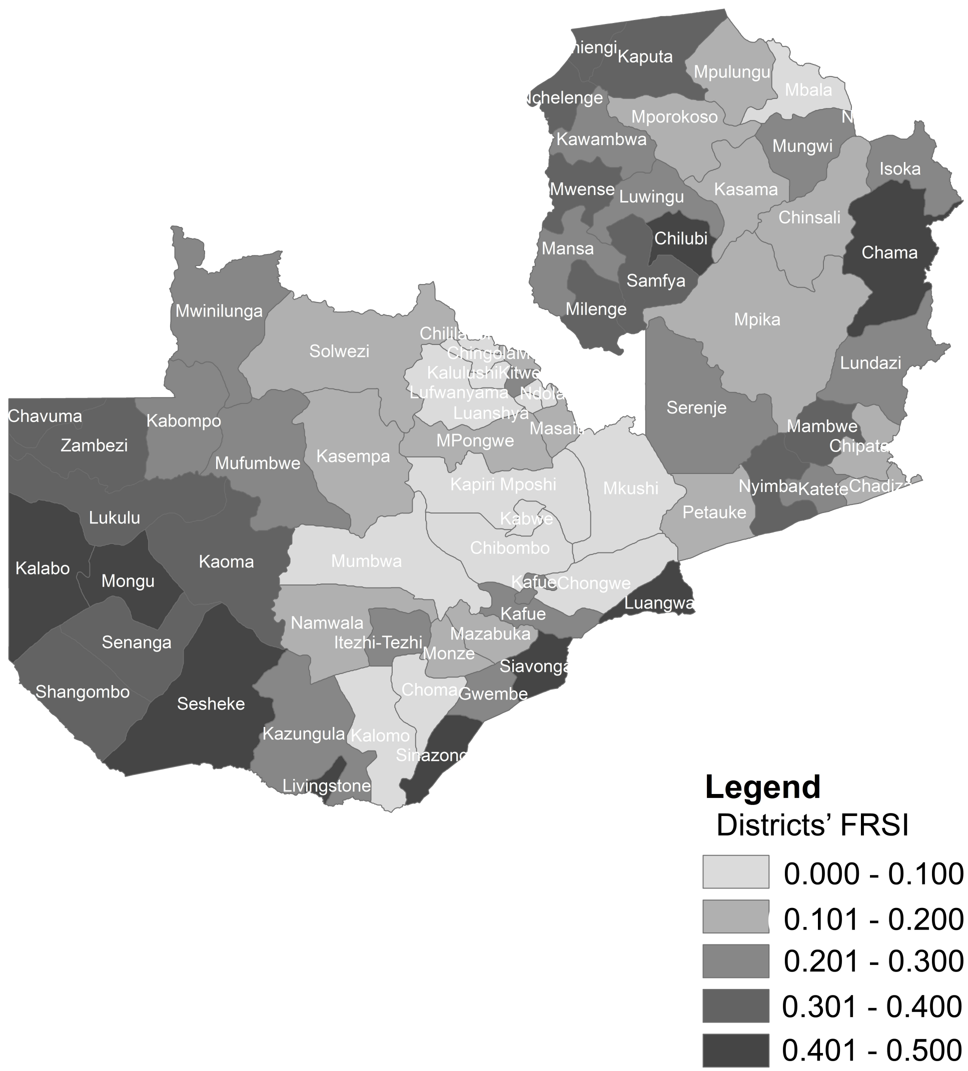

Figure 5. Food Reserve Scarcity Index by District, February 2007

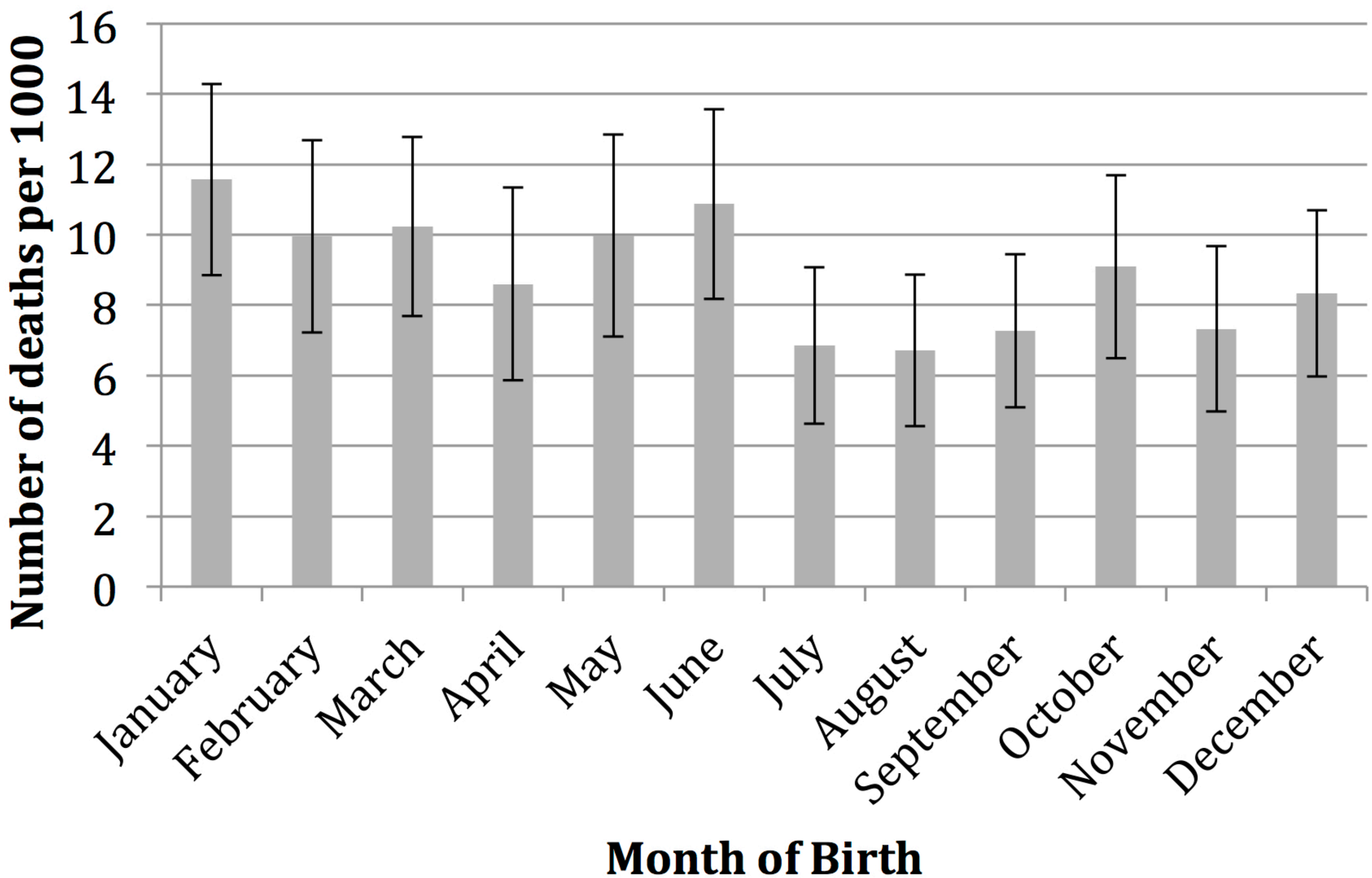

Figure 6. Child mortality (deaths per 1000) by month of birth in 2007

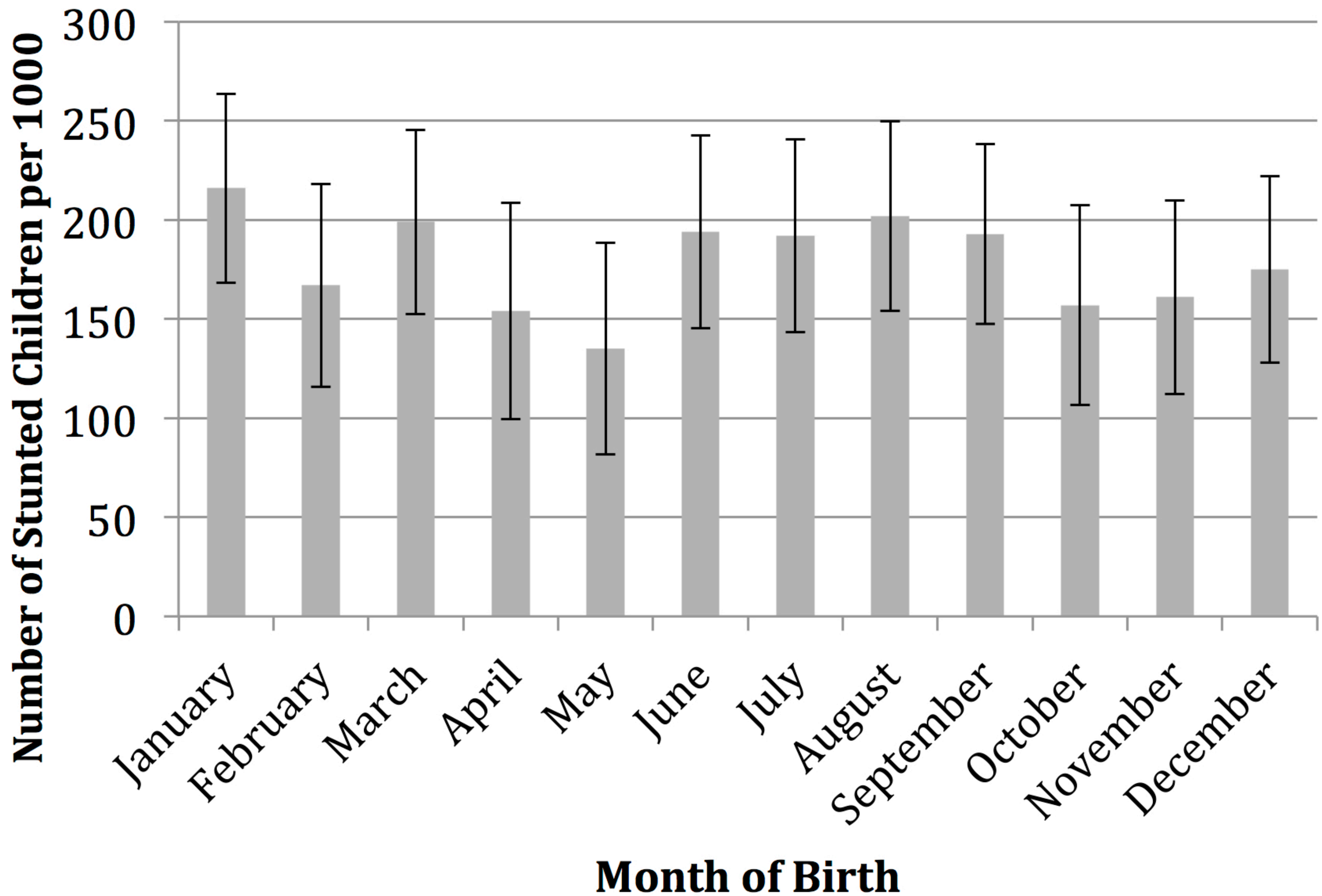

Figure 7. Stunted (HAZ<-2) children (per 1000) by month of birth in 2007