Civil War, Crop Failure, and Child Stunting in Rwanda
Author(s): Richard Akresh, Philip Verwimp, Tom Bundervoet
Source: *Economic Development and Cultural Change*, Vol. 59, No. 4 (<month>July</month> 2011), pp. 777-810
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/10.1086/660003

Civil War, Crop Failure, and Child Stunting in Rwanda

RICHARD AKRESH
University of Illinois at Urbana-Champaign

PHILIP VERWIMP
Université Libre de Bruxelles

TOM BUNDERVOET
International Rescue Committee

I. Introduction

There is growing concern among economists and practitioners that economic conditions early in life may have persistent effects on child health, schooling, and socioeconomic outcomes later in life (Glewwe, Jacoby, and King 2001). In particular, the relationship between negative adult outcomes and stresses suffered when in utero has been popularized by Barker (1998). The Barker hypothesis that these shocks cause irreversible adaptations to the local food environment means that children cannot catch up even if they experience subsequent good years. As a result, negative shocks affecting a child's growth trajectory early on may lead to lower adult height, less cognitive achievement and human capital accumulation, lower productivity and wages, and higher mortality, particularly in low-income countries (Strauss and Thomas 2008). Policy makers are aware of the link between early childhood and adult well-being, making it one reason why the World Bank and other organizations view improvements in child health as a top priority.

In this article, we focus on how exposure to two different types of exogenous shocks at birth leads to worse health outcomes in the short run, several years after the shock. First, we examine civil conflict, a type of shock that has received surprisingly little attention in the literature despite the fact that two-thirds of all countries in sub-Saharan Africa experienced armed conflict during

We would like to thank the Department of Agricultural Economics at Michigan State University for making the data available and Ilana Redstone Akresh and seminar participants at Harvard's Weatherhead Center, University of Illinois at Urbana-Champaign, NEUDC 2006, the World Bank/PRIO 2006 Oslo conference, and the USAID/HICN Poverty Reduction in Conflict and Fragile States conference for helpful suggestions.

the past 30 years (Miguel, Satyanath, and Sergenti 2004; Bellows and Miguel 2006; Guidolin and La Ferrara 2007). Second, we analyze how a child's exposure to conflict differs in its impact on health compared with exposure to crop failure.

We examine the impact of these two types of shocks on the health of Rwandan children born between 1987 and 1991. We use an integrated household survey, combining health and agricultural data with event data from reports by nongovernmental organizations. We exploit the local nature of the crop failure (confined to provinces in southern Rwanda) and of the civil war (confined to provinces in northern Rwanda) to identify the causal effect of these exogenous shocks on child health; we use the variation across birth cohorts to capture the child's exposure to the shock. Our approach is to estimate the effect of these shocks on height-for-age while controlling for province of residence, month and year of birth, province-specific time trends, and household and child characteristics. Our results are robust to the use of alternative exposure measures for the affected cohorts, as well as to different geographic boundaries for the shock regions suffering war or crop failure. We use rainfall and household production shocks to confirm the robustness of the crop failure results for a subsample of children.

This essay establishes an intermediate step linking shocks at birth and adult outcomes; several years after the shock, children already have significantly lower height-for-age z-scores, and this impact may persist into adulthood. We find that crop failure and civil conflict negatively affect children's health, but the roles of gender and poverty differ for each shock. For crop failure, girls, from poor households in particular, are severely negatively affected, but boys (in either poor or nonpoor households) do not experience a significant negative health effect. However, for children exposed to conflict, the health status of boys and girls is negatively affected, and children in both poor and nonpoor households suffer these consequences.

There is a significant body of evidence establishing an association between health in utero and in early childhood and later life outcomes, including health status (for reviews, see Godfrey and Barker [2000] and Alderman and Behrman [2006]). The seminal work by Stein et al. (1975) finds that the cohort in utero during the 1944–45 Dutch famine exhibited a range of negative health outcomes as adults. Using Netherlands birth registry data, Van den Berg, Lindeboom, and Portrait (2006) find that poor macroeconomic conditions in infancy lead to higher adult mortality. Almond (2006) finds that individuals who were in utero during the 1918 influenza pandemic experienced as adults lower education attainment, increased rates of physical disability, and lower socioeconomic status compared with other birth cohorts.

Research using developing country data also provides consistent evidence linking early childhood stresses and later life outcomes. Maccini and Yang (2009) examine the effect of early-life environmental conditions for Indonesians on health and socioeconomic outcomes later in life and find that higher early-life rainfall leads to improved health, schooling, spousal quality, and socioeconomic status, but the impacts are only for women. Using a 1% sample of the 2000 Chinese census, Almond et al. (2007) find that fetal exposure to acute maternal malnutrition compromises literacy, labor market status, wealth, and marriage outcomes. Alderman, Hoddinott, and Kinsey (2006) use data from Zimbabwe and show that preschool malnutrition has a negative impact on subsequent human capital formation, measured by the number of grades completed. Yamauchi (2006) shows that healthier children in South Africa start school earlier, attain more grades, and repeat fewer classes.[1]

Consistent with our findings that, of the children exposed to crop failure, only girls suffer negative health impacts, the literature provides ample evidence of a gender bias in outcomes. Rose (1999), for example, shows that when districts experience higher rainfall, the gender bias in infant mortality in India (favoring boys over girls) narrows significantly. Alderman and Gertler (1997) find that demand for girls' medical care is more income and price elastic than demand for boys' medical care in rural Pakistani households. Behrman (1988) finds bias in favor of boys in the intrahousehold allocation of nutrition during the lean season in India. Also in line with our own findings, Mu and Zhang (2008) report evidence of a negative impact of the Chinese Great Famine for female, but not male, survivors. They also show that selective mortality explains two-thirds of the observed gender difference in health outcomes.[2]

The remainder of the article is organized as follows. Section II provides an overview of the Rwandan rural economy and describes in detail the spatial and temporal event data for the crop failure and armed conflict. Section III describes the household survey data and explains the key variables. Section IV discusses the empirical identification strategy, and Section V presents the main results as well as robustness tests. Section VI concludes.

[1] Few studies examine whether anything can be done to counter the negative health impacts of shocks; an exception is Yamano, Alderman, and Christiaensen (2005), who study whether food aid given to households in Ethiopia results in enhanced child growth.

[2] Recent work questions the perceived view that gender bias is more of problem in Asia than Africa. Verwimp and van Bavel (2005) find evidence that the usual sex differential in child survival (more girls than boys survive infancy) observed in Africa as well as elsewhere changes under severe living conditions. Dercon and Krishnan (2000) find that adults in poor Ethiopian households are unable to smooth their consumption and that women bear the brunt of adverse shocks.

II. Crop Failure and Armed Conflict in Rwanda

A. Rural Household Economy in Rwanda

Table 1 presents an overview of Rwanda's provinces as of 1992 and shows significant regional differences. The southern provinces of Butare and Gikongoro have lower average production than the northern, central, and eastern regions, reflecting the crop failure experienced in that area. Previous work has shown that regional and household income differences can be explained by farm size, soil fertility, soil suitability for high-yielding crops, rainfall, access to public infrastructure (such as roads and markets), availability of off-farm jobs, and coffee and tea prices for regions growing these crops (Justino and Verwimp 2006).

Nearly all rural households were engaged in farming, and 93% of Rwanda's population lived in rural areas. On average, households cultivated 0.89 hectares of land, with the vast majority of this being owner operated. Beans, bananas, potatoes, and sweet potatoes were the main food staples, although bananas and potatoes were also sold for cash. Coffee was grown as a cash crop. Farming was labor intensive, primarily using hoes and machetes, and animal traction was nonexistent. Women's labor was important in food crop production, while men's labor was crucial for cash crops and animal husbandry. The ideal growing conditions for many crops were between the altitude of 1,500 and 1,700 meters. The average household derived 60% of its income from subsistence crop production and 40% from beer sales, crop sales, off-farm income, and livestock sales (Clay, Reardon, and Kangasniemi 1998).

B. Crop Failure in Southern Rwanda

The late 1980s were a time of general economic decline for Rwanda. The country faced low tea and coffee prices, unfavorable weather conditions, and unresolved refugee issues. Crop yields dropped, with the decline for tubers, the main calorie source for poor families, being particularly strong (Clay 1996). Combined with population growth, this led to a 25% decline in per capita food production (World Bank 1998). Two distinct events mark this time period. The first is a localized extremely severe crop failure in southern Rwanda in the 1988–89 agricultural season. The second is an outbreak of civil conflict in northern Rwanda in October 1990. In figure 1, we indicate the crop failure and civil conflict areas on a map of Rwanda.

Kinyamateka, the most prominent independent newspaper in Rwanda, published information on the food crisis in 1989, making the famine known to the Rwandan public. André Sibomana, editor of the newspaper in 1989, expressed it as follows:

TABLE 1

OVERVIEW OF RWANDA, 1988–1992, BY PROVINCE

Province	Average Land Size per Household (hectares)	Value of Production[a]	Altitude (Meters)	Historical Rainfall Average, 1970–87 (mm/Year)	Height-for-Age *z*-Score[b]
Butare	.81	36,000	1,660	1,198	−2.22
Byumba	1.01	45,700	1,888	1,213	−2.60
Cyangugu	.66	32,200	1,917	1,549	−2.61
Gikongoro	.89	21,400	1,917	1,421	−2.32
Gisenyi	.45	33,000	1,946	1,305	−2.37
Gitarama	.92	50,000	1,630	1,129	−2.43
Kibungo	1.35	65,500	1,469	992	−2.19
Kibuye	1.16	25,700	2,100	1,366	−2.06
Ruhengeri	.79	45,200	2,115	1,263	−2.55
Rural Kigali	.95	67,500	1,581	1,103	−1.98
Rural Rwanda	.89	44,300	1,802	1,234	−2.32

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University. Rainfall and altitude information collected by Rwandan Meteorological Service.

Note. Crop failure occurred in certain districts in Gikongoro and Butare provinces in October 1988. Civil conflicts occurred in certain districts in Byumba and Ruhengeri provinces starting in October 1990.

[a] Average value of household crop production from 1988 to 1991 in Rwandan francs.

[b] Height-for-age *z*-score is averaged across all children born in that particular province between 1987 and 1991.

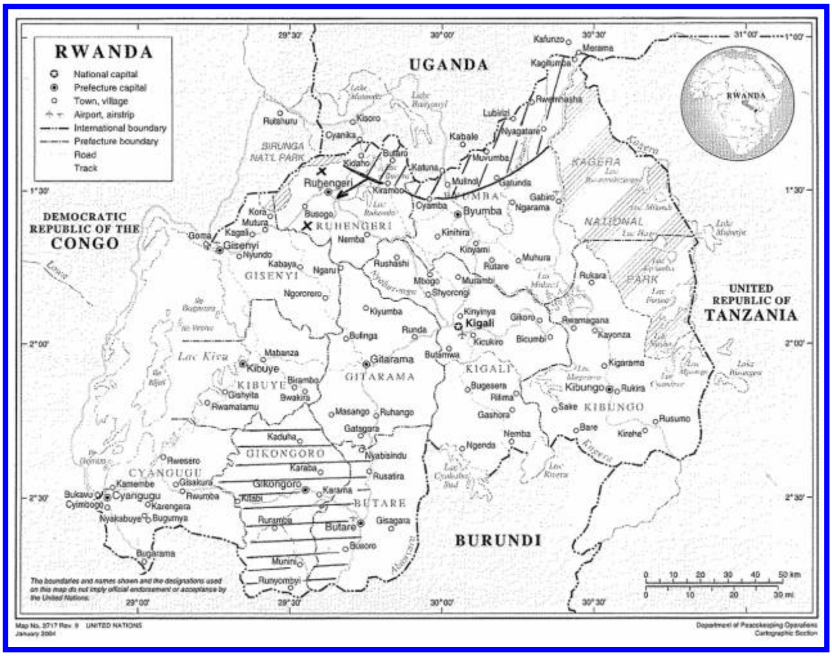

Figure 1. Map of Rwanda indicating crop failure and civil war regions. The shaded area in the south, which includes Gikongoro prefecture and the part of Butare prefecture bordering Gikongoro, was affected by a crop failure that started in October 1988. Information sources for this are the NGO reports discussed in the text. The shaded region in the north, bordering Uganda, was affected by the civil war in the period October 1990 to December 1991. This is also the case for the capital of Ruhengeri, attacked in January 1991, as well as for the areas marked with an "X," which were the scenes of local massacres in early 1991 (Reyntjens 1994, 92, 186). We remark that the latter area expanded in the 1992–94 period as the RPF troops advanced their positions in Byumba prefecture. That advance, however, took place after the collection of the UNICEF data that we use in our study.

> In 1989, a terrible famine struck the south of the country. There was a natural explanation for this phenomenon, but the authorities did nothing to improve the situation. Worse still, I had evidence that part of the government's assistance which was intended for the population at risk had been diverted. It was a scandal. I decided to publish this information. We were threatened and we were called liars, until I published photographs which were overwhelming. This had an immediate effect. Readers wrote in to express their satisfaction: at last the truth was being told. (Sibomana 1999)

Several nongovernmental organizations documented the extent and severity of the crop failure. In February 1990, the Centre de Formation et de Recherche Coopératives-Iwacu, a nongovernmental organization working in rural areas, produced a film, *Haguma Amagara* (You only live once). The film documents the food crisis in the south and was motivated by the Rwandan government's refusal to acknowledge the local famine. The footage depicts peasants in southern Rwanda with nothing to eat, markets without food, people deconstructing their homes to sell for food, hungry children, and adults telling the filmmaker they are too weak to work. The film convincingly documents hunger in southern Rwanda during the 1988–89 period.

Besides the film, at least three Rwandan organizations published reports on the famine. The first (Twizeyimana and Uwimana 1989) was written by a grassroots organization, Conseil de Concertation des Organisations d'Appui aux Initiatives de Base (CCOAIB) and denounces a hidden famine in Gikongoro province. The second, written by Bureau Social Urbain-Caritas in Kigali (1990), cites administrative and local sources documenting hunger and starvation in several communes of Butare (Nyakizu, Runyinya) and Gikongoro (Nyamagabe, Karama).[3] The report documents the number of deaths due to starvation in those areas, children dropping out of school, husbands temporarily migrating in search of income and food, crops being stolen at night, and several cases of suicide. In Gikongoro, the report noted that peasants hoped the next coffee harvest would be good, or else they would starve to death. This report concluded there was no longer anything to eat in the south, and peasants were already eating leaves and roots of plants. The third report describes a local agricultural survey of 300 households conducted by the Ministry of Agriculture in several communes in Gikongoro (Gascon 1992). The report stated that 25% of the surveyed households were indigent, and female-headed households suffered the most. Two of the three reports use the term *famine* to describe the situation in southern Rwanda, and the third speaks of starvation. Factors mentioned that contributed to the crop failure were rainfall variation as well as crop disease.

Based on the newspaper articles, the film, and the reports, we create a variable indicating which regions in Rwanda experienced crop failure during this time period. This crop failure area included all the districts of Gikongoro province and the districts of Butare province bordering Gikongoro, all of which are in the same agro-ecological zone (see fig. 1).

C. Civil Conflict in Northern Rwanda

The civil war is the second crucial event in this period. In October 1990, a group of rebels consisting of Tutsi refugees who left Rwanda during the 1959–62 revolution and their offspring attacked Rwanda from Uganda, entering via Byumba province. What followed was a civil war between the Rwandan armed forces (FAR) and the rebel army (Rwandan Patriotic Front [RPF]) in which civilians in the northern provinces of Byumba and Ruhengeri were the main

[3] Before the genocide, Rwanda's territorial administration was organized in prefectures (provinces), communes (districts), sectors, and cells. A commune had on average 50,000 inhabitants.

victims. A report by an international group of human rights experts documents the disruption in agricultural production and in the lives of northern villagers (Fédération Internationale des Droits de l'Homme 1993). Battles between both armies were paralleled by peace negotiations and third-party interventions. Before the war, relative to other regions in Rwanda, these northern provinces were areas of surplus production providing potatoes to the capital, Kigali. There are no existing household-level data on the extent of the disruption to crop production and income-generating activities in the north due to the war.

In an analogous manner to the crop failure measure, we use these reports to create a variable to indicate which Rwandan regions experienced armed conflict during this period. The civil war area includes parts of the northern province of Byumba and all of Ruhengeri (see fig. 1).[4] There are three principal reasons why we include all of Ruhengeri in the civil war region. First, in early 1991, the war front moved to Ruhengeri, and the rebels occupied the northern part of that province. Second, in January 1991, the rebels mounted a surprise attack against the city of Ruhengeri, the capital of Ruhengeri province, to liberate political prisoners from the government prison (Prunier 1995). Third, local massacres were committed in the north and south of Ruhengeri province between January 25 and February 4, 1991 (Reyntjens 1994).[5]

III. 1992 UNICEF and DSA Survey

A. Data Overview

In January 1992, UNICEF financed a survey on the health status of young children and mothers in Rwanda (UNICEF 1992). The UNICEF survey was nationally representative and collected detailed information on the exact date of birth and height of every child under age 5 in 2,496 rural households, yielding 1,879 children under age 5 with complete information.[6] Wealth data, such as the number of livestock, and basic information about the mother's demographic characteristics were also collected.

The UNICEF survey was linked to a prior agricultural survey that ran from October 1988 to September 1991 and was organized by the Rwandan De-

[4] In the empirical section, we test the robustness of our demarcation of the crop failure and civil war geographic regions.

[5] In 1992 and 1993 (after the collection of the survey data used in this article), the war front moved farther south in Byumba province, with thousands of people in Byumba leaving their homes and a buffer zone installed between the rebels and the government army.

[6] We adopt the approach of Alderman et al. (2006) in excluding 45 children who have a height-for-age z-score of less than -6 or greater than 6, as these extreme scores are probably due to measurement errors in either child height or age. These 1,879 children come from 1,293 distinct households.

partment of Agricultural Statistics (DSA) and Michigan State University.[7] The DSA survey was also nationally representative and collected agricultural and economic data (including household production, land holdings, and labor inputs) from half of the 2,496 rural households (see Clay [1996] for additional details about the DSA survey). For part of our analysis, we use the agricultural DSA survey to isolate the causal mechanism driving the crop failure results seen with the UNICEF data. We examine household-level production shocks and their impact on children's height-for-age *z*-scores, but given the smaller sampling frame (1,248 households) and the shorter 3-year window of household production information, there are only 501 children under age 5 in that analysis.

B. Ethnicity

Neither the UNICEF nor the DSA survey registered the ethnic affiliation of the survey respondents, so we are unable to test potential ethnic differences, although we do not think these are critical for the following two reasons. First, although Tutsi account for 10%–15% of the Rwandan population, in the northern conflict-affected provinces, they account for less than 3%. Given the civil war was confined to the north in the period under investigation, we do not expect ethnicity to be a factor influencing our results for the civil war shock.

Second, although Tutsi account for 15%–20% of the population in the southern crop failure provinces, Austin's (1996) review of the literature did not find evidence of inequality between the Hutu and Tutsi ethnic groups. Similarly, Verwimp (2005) did not find systematic differences between the two ethnic groups in income per adult equivalent, land size, or livestock holdings in several southern provinces. In 1990, there existed no exclusively Hutu or Tutsi villages in Rwanda; both lived as neighbors and were dispersed across the southern provinces. Thus, we have no a priori reason to expect that Hutu children would be differentially affected by crop failure compared to Tutsi children. In fact, part of the political economy of Rwanda under the Second Republic is that the southern region as a whole, Hutu as well as Tutsi, was disfavored by the government, whose leaders came from northern Rwanda

[7] To ensure survey quality, DSA and UNICEF had one supervisor in the field per prefecture. This supervisor monitored the performance of each of the interviewers in that prefecture. The supervisor collected completed questionnaires, screened for inconsistencies, and went back to the farm households with the interviewers if needed. The office staff made frequent field visits to see how the questionnaires were understood and completed. Data were checked again in the office, both visually for each questionnaire and with the help of data-cleaning programs.

(Prunier 1995). This is also the main reason why the government did not deliver aid to the crop failure region.

C. Health, Crop Failure, and Civil War Variables

Height-for-age is generally accepted as a good indicator of the long-run nutritional status of children (Thomas, Lavy, and Strauss 1996). Children with low height for their age are considered stunted, an indicator of chronic malnutrition, and are likely to be on a different growth trajectory for the rest of their lives. We compute z-scores for each child's height-for-age, where the z-score is defined as the difference between the child's height and the mean height of the same-aged international reference population, divided by the standard deviation of the reference population.[8] On average, across households in all regions of Rwanda, children were more than two standard deviations below the average height-for-age of a reference child, and over 33% of children were severely malnourished with a z-score below -3.

We construct two complementary measures for a child's exposure to the crop failure or armed conflict, both of which are based on the various reports discussed previously in Sections II.B and II.C. The first type of measure is defined as the district times birth cohort level, $crop\ failure\ district_j$ * $born\ during\ crop\ failure_t$ and $civil\ war\ district_j$ * $born\ during\ civil\ war_t$, which allow us to exploit variation across two dimensions: spatial (variation across regions that experienced the different shocks) and temporal (within a given region, the timing of which birth cohorts were born during the shock time period). The second complementary measure is defined similarly, $crop\ failure\ district_j$ * $alive\ during\ crop\ failure_t$ and $civil\ war\ district_j$ * $alive\ during\ civil\ war_t$, except instead of measuring a child's exposure as being born during the specific shock time period, it measures the exposure for any child alive at the time of the shock (meaning the child was born prior to the shock period).

The crop failure regions include all the districts of Gikongoro and the districts in Butare bordering Gikongoro, as these areas experienced severe crop failure in the 1988–89 harvest season that lasted from October 1988 to March 1989. During this time period, the other regions in Rwanda remained unaffected. The civil war region includes the northern districts in Byumba and all of the districts of Ruhengeri, as these areas experienced armed conflict beginning in October 1990 and continuing until the household survey data collection in January 1992. During the time frame of the survey, the civil conflict was exclusively confined to these northern provinces, while other regions in Rwanda did not experience any fighting.

[8] We use the World Health Organization growth charts for the reference population.

IV. Empirical Identification Strategy and Econometric Specification

A. Identification Strategy

The empirical identification strategy can be illustrated by examining the nonparametric relationship between height-for-age z-scores and children's birth cohort. We estimate a kernel-weighted local polynomial regression of height-for-age z-score on birth cohort using an Epanechnikov kernel. In the nonparametric regressions, we use precise information on the exact month and year of birth. Figure 2A compares girls from the crop failure region with girls from the rest of the country, while figure 2B makes a similar comparison for boys.[9] In the figures, we draw a vertical line at October 1988, the start of the 1988–89 agricultural season. For girls born during the crop failure period (October 1988–March 1989) in the crop failure region, they experience significantly lower height-for-age z-scores compared to girls in the rest of the country who are born during the same time period and compared to girls from the crop failure region, but born during a different time period. This result contrasts with the nonparametric regression in figure 2B for boys. In that figure, boys born during the crop failure period in the crop failure region are no worse off in terms of height-for-age z-scores compared to boys in the rest of the country born at the same time or compared to boys from the crop failure region, but born during a different time period. This gender difference in terms of impact on height-for-age z-scores for children exposed to crop failure will contrast with the results seen for civil war exposed children.

Figures 3A and 3B present similar nonparametric regressions comparing children in the civil war regions and the rest of the country. The vertical line, drawn at October 1990, represents the start of the conflict in the civil war region. Girls as well as boys born in the civil war region during the conflict (October 1990 until the survey date of January 1992) have significantly lower height-for-age z-scores compared to children born at the same time in the rest of the country. In developing countries in a nonshock environment, since height-for-age is a stock variable, reflecting current and past health investments, older children accumulate a larger deficit during their lives, resulting in lower height-for-age compared to younger children (Martorell and Habicht 1986; Duflo 2003). However, as the figures show, the civil war exposed girls have lower height-for-age z-scores even when compared to girls from the same region but born in an earlier cohort, a finding that contradicts the expected height-age relationship. Civil war exposed boys show a height-for-age z-score that is comparably low compared with boys from the same region born in an

[9] In all of the figures and subsequent tables, "rest of the country" excludes the crop failure and civil war regions.

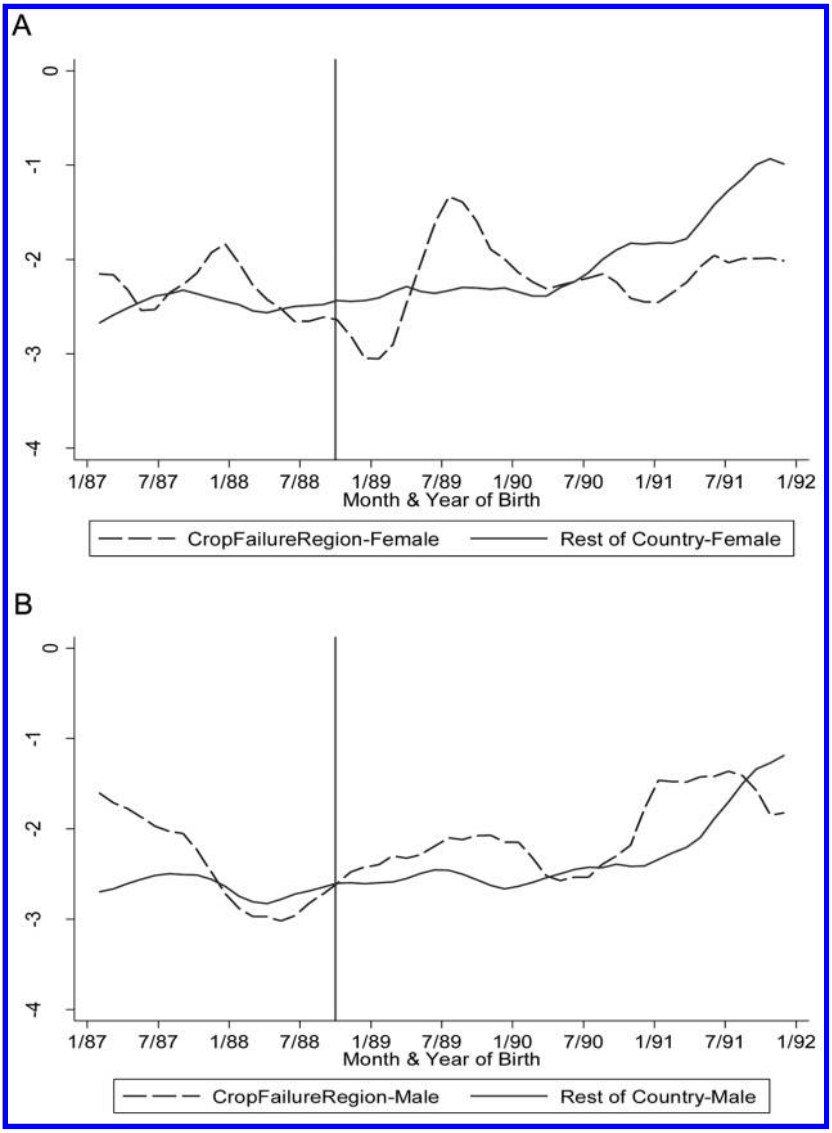

Figure 2. Height-for-age *z*-scores by crop failure region and birth cohort: (A) female and (B) male. Kernel-weighted local polynomial regression (using Epanechnikov kernel) of height-for-age *z*-score on birth cohort. Precise information on exact month and year of birth is used in the regressions, although for exposition clarity, only January and July are marked on the graph. Vertical line drawn at October 1988, start of crop failure in crop failure regions. *Source*: Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.

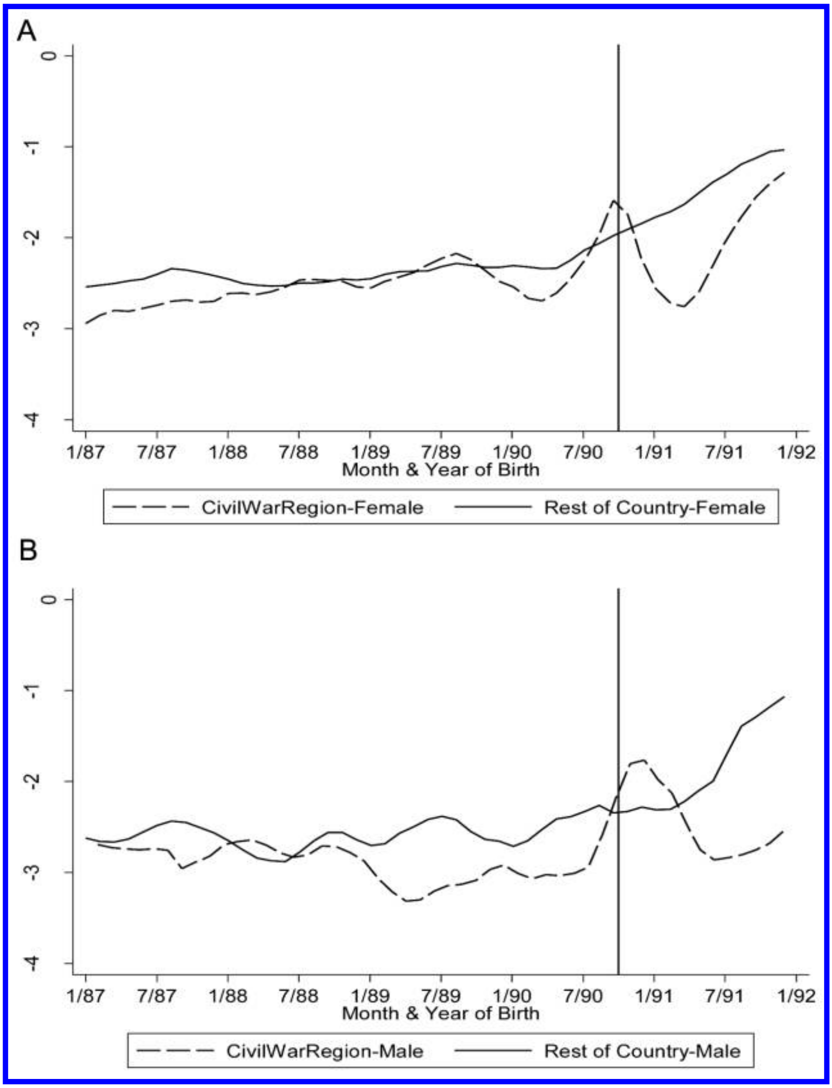

Figure 3. Height-for-age *z*-scores by civil war region and birth cohort: (A) female and (B) male. Kernel-weighted local polynomial regression (using Epanechnikov kernel) of height-for-age *z*-score on birth cohort. Precise information on exact month and year of birth is used in the regressions, although for exposition clarity, only January and July are marked on the graph. Vertical line drawn at October 1990, start of armed conflict in civil war regions. *Source*: Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.

TABLE 2
HEIGHT-FOR-AGE z-SCORES, BY REGION AND CROP FAILURE EXPOSURE

	Crop Failure Region	Rest of Country	Difference
A. All children:			
N	202	1,386	
Not born during crop failure shock period	−2.168	−2.260	.092
	(.122)	(.082)	(.123)
Born during crop failure shock period	−2.714	−2.557	−.157
	(.624)	(.163)	(.529)
Difference	−.546	−.297**	−.249
	(.503)	(.144)	(.435)
B. Boys:			
N	99	660	
Not born during crop failure shock period	−2.177	−2.377	.200
	(.135)	(.088)	(.136)
Born during crop failure shock period	−2.346	−2.652	.306
	(.630)	(.224)	(.579)
Difference	−.169	−.275	.106
	(.498)	(.184)	(.464)
C. Girls:			
N	103	726	
Not born during crop failure shock period	−2.158	−2.152	−.006
	(.112)	(.091)	(.122)
Born during crop failure shock period	−3.015	−2.477	−.538**
	(.248)	(.184)	(.271)
Difference	−.857***	−.325*	−.532**
	(.137)	(.189)	(.221)

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.
Note. Robust standard errors in parentheses, clustered at province level. Crop failure region denotes districts in Gikongoro and Butare provinces, and the crop failure shock occurred between October 1988 and March 1989. Rest of country excludes the region affected by the civil war.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

earlier cohort. The fact that both girls and boys exposed to armed conflict suffer negative health affects contrasts with the results for the crop failure exposed children, and we discuss these gender differences in more detail in the empirical results section.

The empirical identification strategy can be further illustrated using a 2 × 2 difference-in-differences table. Panel A in table 2 shows average height-for-age z-scores for children born during the crop failure period and not born during the crop failure period, in the affected and unaffected regions. The cross-sectional results show that children born in the crop failure region outside of the 1988–89 season have a statistically insignificant 0.092 standard deviations higher height-for-age z-score than children in the rest of the country, evidence that children's health in this region outside of the crop failure time period is similar to the rest of the country. Children born during the 1988–89 agricultural season in the affected region exhibited a statistically insignificant 0.157 standard deviations lower height-for-age *z*-scores than children in the rest of the country. Children born during the crop failure period in the crop failure region or the rest of the country have lower height-for-age *z*-scores of 0.546 and 0.297, respectively, compared to children not born during the crop failure period.[10] Calculating the difference-in-differences estimator shows that children born during the 1988–89 agricultural season in the crop failure region have 0.249 standard deviations lower height-for-age *z*-scores compared to children in the rest of the country, although the difference is not statistically significant, and this lack of a significant impact of crop failure on all children will contrast with that for war-exposed children. The difference-in-differences result can be interpreted as the impact of the crop failure on children's height-for-age *z*-scores under the assumption that, without the crop failure, children in the crop failure region born during the 1988–89 agricultural season would have experienced the same change in average height-for-age *z*-scores as children in the rest of the country.

Panels B and C in table 2 further explore these preliminary results and show the unequal effect of the crop failure by gender of the child. Only girls appear to suffer the negative consequences of a crop failure. The difference-in-differences results indicate that boys exposed to the crop failure experience no negative health impact, while girls born during the crop failure period in the crop failure region have 0.532 standard deviations lower height-for-age *z*-scores.

In table 3, we examine height-for-age *z*-scores for children exposed to the civil war. The cross-sectional results in panel A provide evidence that the children born outside of the civil war shock period in the civil war region have similar height-for-age *z*-scores (an insignificant 0.202 difference) compared to the rest of the country. Children from the civil war region born during the civil war shock period (October 1990–December 1991) have improved height-for-age *z*-scores compared to children not born during the civil

[10] Some of the decline in average height-for-age *z*-scores observed when comparing children born during the crop failure period and not born during the crop failure period is due to a difference in the average age for each cell in the table, as the children born in the 1988–89 agricultural season are on average older than children not born during that period. However, more importantly, in the cross section (for children born during the crop failure period), the average age for children in the crop failure region is actually younger than in the rest of the country, which would normally indicate an improved height-for-age *z*-score, but this is the opposite of what we observe. In the subsequent regression analysis, we control for potential age effects by including year and month of birth fixed effects.

TABLE 3
HEIGHT-FOR-AGE *z*-SCORES, BY REGION AND CIVIL WAR EXPOSURE

	Civil War Region	Rest of Country	Difference
A. All children:			
N	262	1,411	
Not born during civil war shock period	−2.660	−2.458	−.202
	(.160)	(.085)	(.133)
Born during civil war shock period	−2.336	−1.498	−.838***
	(.220)	(.146)	(.221)
Difference	.324	.960***	−.636**
	(.380)	(.143)	(.304)
B. Boys:			
N	125	674	
Not born during civil war shock period	−2.774	−2.569	−.205
	(.133)	(.088)	(.128)
Born during civil war shock period	−2.720	−1.686	−1.034***
	(.406)	(.211)	(.390)
Difference	.054	.883***	−.829*
	(.540)	(.203)	(.468)
C. Girls:			
N	137	737	
Not born during civil war shock period	−2.549	−2.359	−.190
	(.176)	(.093)	(.137)
Born during civil war shock period	−2.066	−1.302	−.764***
	(.056)	(.158)	(.160)
Difference	.483**	1.057***	−.574***
	(.232)	(.171)	(.215)

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.
Note. Robust standard errors in parentheses, clustered at province level. Civil war region denotes districts in Byumba and Ruhengeri provinces, and the conflict occurred between October 1990 and December 1991. Rest of country excludes the region affected by the crop failure.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

war shock period, but they do not improve as much as children born between October 1990 and December 1991 in the rest of the country.[11] Calculating the difference-in-differences estimator shows that children born during the civil war shock period in the civil war region have 0.636 standard deviations lower height-for-age *z*-scores compared to children in the rest of the country, a result that is significant at the 5% level.

[11] Some of the improvement in average height-for-age *z*-scores observed when comparing children born during the civil war period and not born during the civil war period is due to a difference in the average age for each cell in the table, as the children born between October 1990 and December 1991 are on average younger than children not born during that period. However, more importantly, in the cross section (for children born during the civil war period), there is no difference in the average age for children in the civil war region and in the rest of the country. In the regression analysis, we control for potential age effects by including year and month of birth fixed effects.

Panels B and C in table 3 examine whether the conflict impact varies based on a child's gender. Boys and girls born during the conflict period in the rest of the country show similar improvements in average height-for-age *z*-scores relative to children not born during that period, with an increase of 0.883 and 1.057 standard deviations for boys and girls, respectively. In the war region, boys and girls born during the conflict have a smaller improvement in height-for-age *z*-scores (0.054 and 0.483 standard deviations higher, respectively). The difference-in-differences estimate shows the impact of armed conflict on boys is a 0.829 standard deviation reduction in height-for-age *z*-scores and on girls is a 0.574 standard deviation reduction.

B. Econometric Specification

To build on figures 2 and 3 and the previous tables, we estimate province and birth cohort fixed effects regression. However, measuring the shock exposure variables at the region-level leads to the possibility that province-specific time trends are driving the health results. While we argued previously that the provinces across Rwanda were similar in terms of child health outside of the periods when shocks occurred (see discussion of tables 2 and 3), the identification strategy is valid as long as changes over time in average height-for-age *z*-scores would be similar across regions in the absence of the crop failure or civil conflict. Specifically, the strategy might be flawed if the timing of the shocks followed a particular pattern in terms of province-level characteristics that are related to changes in height-for-age *z*-scores. To address these potential differential time trends across provinces, we estimate the following equation that includes a province-specific time trend in addition to province and birth cohort fixed effects:

$$\begin{aligned} \text{HAZ}_{ijt} = {} & \alpha_j + \delta_t + \beta_1(\textit{shock region}_j * \textit{born during shock}_t) \\ & + \textit{province trend}_{jt} + \varepsilon_{ijt}, \end{aligned} \tag{1}$$

where HAZ_{ijt} is the height-for-age *z*-score for child i in region j who was born in time period t, α_j are the province fixed effects, δ_t are the cohort of birth (year and month) fixed effects, $\textit{shock region}_j * \textit{born during shock}_t$ indicates children born during the time period when the shock occurred in a region that experienced a crop failure or civil war, $\textit{province trend}_{jt}$ is a province-specific time trend to capture potentially different time patterns in each province, and ε_{ijt} is a random, idiosyncratic error term.[12] The coefficient β_1 measures the impact

[12] Correlation among the error terms of children in a given province experiencing the same shocks might bias the ordinary least squares standard errors downward, so in all regressions, we cluster the standard errors by birth province (Moulton 1986; Bertrand, Duflo, and Mullainathan 2004).

of crop failure or civil conflict on children's health status for a child born during the shock in a region experiencing these events. Identification of the impact comes from comparing children born during and not during the shock time period and from comparing regions affected by the shock to the rest of Rwanda. Including the province-specific time trend buttresses our argument that changes in average height-for-age z-scores in these provinces would have been similar in the absence of the shock (crop failure or civil war).

V. Empirical Results

A. Effect of the Crop Failure and Civil War Shocks

In table 4, we present results from estimating variations of equation (1). Each regression includes province and birth cohort (year and month of birth) controls, as well as province-specific time trends. Column 1 uses a shock exposure variable that measures whether a child was born during the crop failure time period in the affected regions (similar to table 2). Those crop failure exposed children have 0.173 standard deviations lower height-for-age z-scores, a reduction that is not statistically significant. However, in column 2, when the shock exposure measure is interacted with gender, results indicate that girls born during the crop failure have an additional 0.855 standard deviations lower height-for-age z-scores, and the coefficient is significant at the 5% level. In column 3, we explore an alternative shock exposure measure that considers a child to be exposed if the child was alive during the crop failure in the affected region, meaning that child had to be born either before or during the crop failure time period. Results are comparable, showing that these crop failure exposed girls have lower height-for-age z-scores, although the magnitude of the impact is much smaller compared with girls born during the crop failure period. This result is consistent with the idea that older children are somewhat protected from the negative impact of shocks, and the youngest children are the most vulnerable.

In columns 4, 5, and 6 of table 4, we examine the impact of civil war exposure. In contrast with the crop failure results, there is a large negative impact for all children born during the civil war in the war region, with these war-exposed children having 0.823 standard deviations lower height-for-age z-scores, and the coefficient is significant at the 1% level. Column 5 presents the results for when the war shock exposure measure is interacted with gender, and while there is a statistically significant main effect for being exposed to the war (1.046 standard deviations lower height-for-age z-scores), there is no additional impact of war exposure for girls. In column 6, we use the alternative exposure measure for a child alive during the civil war in the war region. Results indicate a main effect that is statistically significant at the 1% level but that is substantially smaller than the impact of the war on children born during the crisis. As in the case of children born during the war, there is no additional impact of exposure for girls. In Section V.C, we explore in more detail the possible reasons for this gender differential in shock exposure impacts in which both boys and girls born during a civil war in a war region are negatively affected, but only girls exposed to a crop failure experience lower height-for-age *z*-scores.[13]

In column 7 of table 4, we estimate a regression that includes both the crop failure and the civil war exposure measures, and the results are a composite of those in the separate regressions in columns 2 and 5. Girls born during the 1988–89 agricultural season in the crop failure region have 0.908 standard deviations lower height-for-age *z*-scores, and all children born during the civil war in the conflict region have 0.986 standard deviations lower height-for-age *z*-scores.

Although we find a negative impact of exposure to crop failure and civil war, not all children experience these shocks equally. We already saw that girls are more susceptible to the negative impact of crop failure than boys. In table 5, we extend the analysis to examine how wealth might mitigate the impacts of these shocks on children's health. As owning livestock in Rwanda is an asset and a sign of wealth, we measure wealth in terms of tropical livestock units (TLU) owned by the household.[14] Households owning less than or equal to 0.78 TLU, which is the average value of tropical livestock units owned, are considered to be poor, and 68.25% of households are classified this way.[15] Results in table 5 indicate that girls in poor households bear the brunt

[13] In results not shown, we create alternative exposure measures in which children who were in utero during the crop failure or during the civil conflict time period were considered exposed, but only the conflict in utero exposure measure is comparable and statistically significant, while the crop failure in utero measure now shows a positive and significant effect for girls. This result that crop-failure-born and crop-failure-conceived cohorts might have different exposure impacts is consistent with the findings by Razzaque et al. (1990), who study the impact of the 1974–75 Bangladesh famine on infant mortality and find that for postneonatal and second year of life children, the famine-born cohort has higher mortality rates than the famine-conceived cohort, but for neonatal mortality the results are reversed.

[14] The conversion from different types of livestock to TLU is calculated as follows: 1 cow = 1 TLU; 1 pig = 0.25 TLU; 1 sheep = 0.17 TLU; and 1 goat = 0.17 TLU.

[15] Unfortunately, the data on household livestock holdings are from 1991, which is subsequent to the civil conflict that started in October 1990 and the crop failure in 1988, and households might have adjusted their asset holdings in response to the shocks. To address this potential issue, we use the household head's educational attainment as an alternative wealth measure. Education is highly correlated with wealth but does not change in response to the shocks, as household heads have all completed their schooling. Education data are only available for households surveyed in the DSA survey, reducing the sample size in half. Results (not shown) are consistent with those in table 5.

TABLE 4

PROVINCE-BIRTH COHORT FIXED EFFECTS REGRESSIONS MEASURING THE IMPACT OF CROP FAILURE AND CIVIL WAR ON CHILDREN'S HEIGHT-FOR-AGE z-SCORES

Dependent Variable: Children's Height-for-Age *z*-Score	(1)	(2)	(3)	(4)	(5)	(6)	(7)
*Crop failure region * born during crop failure*	−.173	.300					.367
	(.502)	(.497)					(.488)
*Female * (crop failure region * born during crop failure)*		−.855**					−.908***
		(.340)					(.297)
*Crop failure region * alive during crop failure*			.312				
			(.335)				
*Female * (crop failure region * alive during crop failure)*			−.424***				
			(.103)				
*Civil war region * born during civil war*				−.823***	−1.046**		−.986**
				(.301)	(.425)		(.415)
*Female * (civil war region * born during civil war)*					.375		.364
					(.280)		(.299)
*Civil war region * alive during civil war*						−.234***	
						(.049)	

Female * (*civil war region* * *alive during civil war*)						.048	
						(.128)	
Female child	.183**	.193**	.212***	.245***	.234***	.225***	.211***
	(.079)	(.076)	(.078)	(.061)	(.060)	(.071)	(.061)
Province fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth cohort fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province specific time trend?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of children	1,588	1,588	1,588	1,673	1,673	1,673	1,879

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.

Note. Robust standard errors in parentheses, clustered at province level. The crop failure regressions in columns 1, 2, and 3 exclude the civil war regions, and the civil war regressions in columns 4, 5, and 6 exclude the crop failure regions. The variable *crop failure region * born during crop failure* indicates children born in the crop failure region during the period when crops failed (October 1988–March 1989). The variable *crop failure region * alive during crop failure* indicates children in the crop failure region who were alive when the crops failed (and therefore were born before March 1989). The variable *civil war region * born during civil war* indicates children born in the civil war region during the fighting (October 1990–December 1991). The variable *civil war region * alive during civil war* indicates children born in the civil war region who were alive during the fighting (and therefore were born before December 1991).

** Significant at 5%.

*** Significant at 1%.

TABLE 5

PROVINCE-BIRTH COHORT FIXED EFFECTS REGRESSIONS MEASURING THE IMPACT OF CROP FAILURE AND CIVIL WAR ON CHILDREN'S HEIGHT-FOR-AGE *z*-SCORES, BY HOUSEHOLD WEALTH AND GENDER

Dependent Variable: Children's Height-for-Age *z*-Score	Poor Households (1)	Nonpoor Households (2)	Poor Households (3)	Nonpoor Households (4)
*Crop failure region * born during crop failure*	.582	−.418		
	(.523)	(.277)		
*Female * (crop failure region * born during crop failure)*	−1.331***	.881		
	(.426)	(.639)		
*Civil war region * born during civil war*			−.978**	−2.204***
			(.427)	(.767)
*Female * (civil war region * born during civil war)*			−.089	1.449**
			(.310)	(.730)
Female child	.279*	−.015	.319**	.072
	(.156)	(.135)	(.129)	(.151)
Province fixed effects?	Yes	Yes	Yes	Yes
Birth cohort fixed effects?	Yes	Yes	Yes	Yes
Province specific time trend?	Yes	Yes	Yes	Yes
Number of children[a]	960	470	1,023	470

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.
Note. Robust standard errors in parentheses, clustered at province level. The crop failure regressions in columns 1 and 2 exclude the civil war regions, and the civil war regressions in columns 3 and 4 exclude the crop failure regions. All regressions also include province and birth cohort controls as well as province-specific time trends. Households that own less than .78 tropical livestock units, which is the average level of livestock holdings, are considered poor (68.25% of households), while households owning more than .78 tropical livestock units are considered nonpoor (31.75% of households).
[a] In columns 1 and 2, 158 children are dropped from the 1,588 observation regressions because of missing values for household wealth measures. In columns 3 and 4, 180 children are dropped from the 1,673 observation regressions because of missing values for household wealth measures. Results for the regressions in previous tables using this restricted observation sample are similar.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

of the crop failure shock, experiencing 1.331 standard deviations lower height-for-age *z*-scores. For boys in poor households and all children in nonpoor households, we do not find a statistically significant impact of the crop failure shock. However, in the civil war region, girls as well as boys who are born during the war period in both poor and nonpoor households are negatively affected. In poor households, there is no additional negative war impact for girls, whereas in nonpoor households, the negative war effect for girls is smaller than for boys.

There are two caveats on how representative our findings are, using the UNICEF data that were linked to the prior DSA survey. First, because of the DSA survey's focus on agriculture, households that did not own or cultivate land (mostly young wage laborers) were excluded from the sample. Given these households are generally poorer than average, this may underestimate the true relationship between poverty and child health. Second, since the prior DSA survey was panel data, we are concerned with possible attrition in the DSA sample. All households that were in the DSA survey as of 1990 are in the UNICEF sample. The main concern is households that were in the DSA sample in October 1988 but dropped out before the 1990 survey. Of all households interviewed during the first round of the DSA survey (starting in October 1988), 96.8% of them were still in the 1990 sample. In the crop failure region, only 14 out of 256 households (5.5%) dropped out, while in the civil war region, 3 out of 239 households (1.3%) dropped out. Almost all of the conflict-related migration in the war region occurred between 1992 and 1994, after the UNICEF survey was conducted. We did not find any significant differences in observable characteristics between the 17 dropped households and the remaining households in the crop failure and civil war regions. Given the low overall attrition rate and the lack of observable differences, we believe the UNICEF data are representative of Rwandan.

Our analysis also likely underestimates the shock's true health impact for several reasons. First, children's age could be mismeasured, and if this occurred, it would likely mean our estimates are lower bounds for the true impact, as parents would probably underreport the age of short children, making their malnutrition seem less severe than it actually is. The likelihood of mismeasurement is reduced, since the household roster collected the exact date of birth of all the household's children and misreporting on one child would be more difficult, as such misreporting would influence the dates of birth of all the household's other children. Second, related to the previously discussed issue of possible household attrition is the idea of selective child mortality during the shock periods in which more boys die than girls (Mu and Zhang 2008). If selective mortality was present in this environment, then boys exposed

TABLE 6

PROVINCE-BIRTH COHORT FIXED EFFECTS REGRESSIONS MEASURING THE IMPACT OF CROP FAILURE AND CIVIL WAR ON CHILDREN'S HEIGHT-FOR-AGE z-SCORES, ROBUSTNESS CHECKS

Dependent Variable: Children's Height-for-Age *z*-Score	Additional Controls (1)	Alternative Crop Failure Region (2)	Months of Shock Exposure (3)	Additional Controls (4)	Alternative Civil War Region (5)	Months of Shock Exposure (6)
*Crop failure region * born during crop failure*	.215	−.261				
	(.514)	(.260)				
*Female * (crop failure region * born during crop failure)*	−.740**	−.267***				
	(.373)	(.103)				
*Crop failure region * months of exposure*			−.033			
			(.085)			
*Female * (crop failure region * months of exposure)*			−.052			
			(.034)			
*Civil war region * born during civil war*				−1.160***	−1.273**	
				(.408)	(.613)	
*Female * (civil war region * born during civil war)*				.361	.474	
				(.449)	(.414)	
*Civil war region * months of exposure*						−.112**
						(.049)

*Female * (civil war region * months of exposure)*						.010
						(.024)
Female child	.181*	.188**	.186**	.207**	.232***	.241***
	(.095)	(.077)	(.078)	(.084)	(.059)	(.062)
Province fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Birth cohort fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Province specific time trend?	Yes	Yes	Yes	Yes	Yes	Yes
Number of children[a]	1,500	1,588	1,588	1,546	1,673	1,673

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.

Note. Robust standard errors in parentheses, clustered at province level. The crop failure regressions in columns 1–3 exclude the civil war regions, and the civil war regressions in columns 4–6 exclude the crop failure regions. The additional control variables included in the regressions in columns 1 and 4 are mother's age, mother's literacy, and whether the child received prenatal care. In column 2, the alternative crop failure region now includes all districts in Butare. In column 5, the alternative civil war region now is restricted to only those areas in northern Byumba and Ruhengeri that were directly occupied by the rebel group. The months of exposure variables measure the number of months of exposure to the given shock for a child born during the shock.

[a] One hundred and twenty-three children are dropped from the regression in column 1 due to missing values for the control variables; 127 children are dropped from the regression in column 4 due to missing values for the control variables. Results in the previous tables are consistent with the restricted sample.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

to the crop failure might have suffered the extreme negative health impact of death. Unfortunately, we do not have data on children who died prior to the 1992 survey, but these deceased children were likely the weakest and smallest. Therefore, the reported effects should be interpreted as the crop failure or war's impact on a child's health, conditional on the child surviving to be recorded in the survey.[16]

B. Robustness Tests

In this section, we use several alternative strategies to test the robustness of the crop failure and civil war exposure measures. First, in columns 1 and 4 of table 6, we add to the baseline regressions presented in table 4 additional control variables for mother's age, mother's literacy, and whether the child received prenatal care. Results do not change, and the coefficient estimates and statistical significance levels are similar.

Second, we test how sensitive our results are to the exact geographic boundaries between the crisis and noncrisis regions. To delineate the crop failure region, we now include all districts in Butare province, not just the districts that are bordering Gikongoro province. The magnitude of the negative effect of crop failure on girls born during that time period, reported in column 2 of table 6, is smaller (about one-third the size of the baseline regression) but still significant at the 1% level.[17] For the civil war region, as a robustness check, we limit the affected area to those districts in Ruhengeri and Byumba that were occupied by the rebel force. Results, in column 5, remain the same as in the baseline.[18]

Third, we explore whether the impact of the shock varies by the duration of exposure (Bundervoet, Verwimp, and Akresh 2009). To test for this, we use the number of months of exposure to the given shock (crop failure or civil war) for a child born during the shock. Results in column 3 of table 6 indicate that an additional month of exposure to the crop failure does not have a

[16] It is also possible that households experiencing crop failure sent out children to live with other relatives (see Akresh [2009] for evidence on the link between negative agricultural shocks and child fostering). Although we do not have any information in the survey about this, we are unable to tell which direction, if any, this might bias the results, depending on whether the most healthy or the least healthy child was fostered, and most of the child fostering literature finds the rate of fostering for children under age 5 to be extremely low.

[17] We also estimate the baseline regressions (results not shown) excluding districts that geographically border the crop failure region or the civil war region, areas that were previously considered part of the "rest of the country," and results are consistent.

[18] We also use a third demarcation of the war-affected area for Ruhengeri province, in which two districts located in the southeast of the province that were more distant from the massacre sites and the fighting in the province capital and the rebel occupation zone were excluded from the war region. Results (not shown) are consistent with those in col. 5 of table 6.

statistically significant effect on either boys or girls. However, an additional month of exposure to the civil war (col. 6) lowers height-for-age z-scores for all children by 0.112 standard deviations, and the result is significant at the 5% level.

Fourth, we test the robustness of the crop failure results using household-level agricultural production.[19] We use the DSA agricultural survey that was administered to a subset of the UNICEF households and that contains household-level production information for October 1988–September 1991. Using this production information, we can estimate the direct impact of a household production shock experienced at the time of birth on the child's health. Since the production data only cover 3 years, we exclude children born outside that time period. Of the 892 children under age 5 in the DSA households, 521 were born between October 1988 and September 1991. An additional 20 children were dropped from the regressions due to missing household production data in the year of the child's birth. The smaller sample of households in the DSA survey, the reduced number of birth cohorts to examine, and missing production data for some households reduce the sample size in the regression to 501 children. This smaller, but still nationally representative, sample of children provides insight into the mechanism driving the crop failure results seen using province-level variation.

We define the household production shock as the difference between the value of farm output during the year the child is born and the 3-year average of farm output. A positive value for this variable indicates production in the year of the child's birth is higher than the 3-year average production (i.e., a positive production shock). Results in column 1 of table 7 indicate that households that experienced positive production shocks at the time a child was born have children with better height-for-age z-scores (measured several years after the shock), and the coefficient is significant at the 10% level.

Fifth, we use rainfall data collected by the Rwandan Meteorological Service, which are available on a monthly basis for each province until December 1991. In column 2 of table 7, we estimate a reduced-form specification using province-level rainfall deviations (annual rainfall minus the long-run historical province average) that are grouped into quartiles in which the 1st quartile (omitted from the regression) indicates a large negative rainfall deviation (more than 100 millimeters below the long-run average), the 2nd quartile ranges from 99 millimeters below the long-run average to 45 millimeters above the

[19] To our knowledge, no household-level measures of the civil war's impact in northern Rwanda in the 1990–91 period exist that cover the entire region and are disaggregated (i.e., number of casualties, property damaged).

TABLE 7
REGRESSIONS MEASURING THE IMPACT OF ALTERNATIVE CROP FAILURE SHOCK MEASURES ON CHILDREN'S HEIGHT-FOR-AGE *z*-SCORES

Dependent Variable: Children's Height-for-Age *z*-Score	DSA Agricultural Production Sample (1)	UNICEF Sample (All Children) (2)	UNICEF Sample (Only Boys) IV Specification (3)	UNICEF Sample (Only Girls) IV Specification (4)
Positive household production shock	.015*			
	(.008)			
2nd quartile rainfall shock		.275**		
		(.120)		
3rd quartile rainfall shock		.023		
		(.158)		
4th quartile rainfall shock		.197		
		(.170)		
*Crop failure region * born during crop failure*[a]			.599	−1.165*
			(1.173)	(.607)
Number of children	501[b]	1,879	901	978

Source. Survey conducted by UNICEF, Rwandan Department of Agricultural Statistics, and Michigan State University.
Note. Robust standard errors in parentheses, clustered at province level. All regressions include province and birth cohort controls and province-specific time trends. Household production shock is defined as the difference between the value of farm output during the year the child is born and the 3-year average farm output. A larger value for this variable indicates production in the year of the child's birth is higher than the 3-year average production (i.e., a positive production shock). In column 2, province-level rainfall deviations (annual rainfall minus the long-run historical province average) are grouped into quartiles in which the 1st quartile (omitted from the regression) indicates a large negative rainfall deviation (more than 100 mm below long-run average), the 2nd quartile ranges from 99 mm below long-run average to 45 mm above long-run average, the 3rd quartile ranges from 45 mm to 142 mm above long-run average, and the 4th quartile indicates a large positive rainfall deviation (more than 142 mm above the long-run average).
[a] *Crop failure region * born during crop failure* is treated as endogenous and instrumented for with dummy variables indicating rainfall deviation quartiles.
[b] DSA production data were only collected between October 1988 and September 1991 and only for a subsample of the UNICEF-surveyed households, leaving only 501 children with complete information on the household production shock at the time of birth. Additional details in the text.
* Significant at 10%.
** Significant at 5%.

long-run average, the 3rd quartile ranges from 45 millimeters to 142 millimeters above the long-run average, and the 4th quartile indicates a large positive rainfall deviation (more than 142 millimeters above the long-run average). We find that, relative to a large negative rainfall shock, child height-for-age *z*-scores improve with better rainfall, although only the coefficient on the 2nd quartile deviation is statistically significant. Columns 3 and 4 present the results of an instrumental variables specification, where we use the rainfall shock quartiles as instruments for our crop failure shock variable. The result further strengthens our previous findings. Variation in rainfall is the exogenous shock explaining crop failure, which in turn affects child health, and the impact is observed for girls but not boys.

C. Discussion of Shock Impact Mechanisms

Our results suggest that crop failure and civil conflict affect child health differently, or, more accurately, they affect different children. The onset of the civil war in October 1990 in the northern regions of Rwanda was sudden and unexpected, which could explain why boys and girls in both poor and nonpoor households were negatively affected by the conflict. Parents could not protect the health status of any of their children from this type of event. Understanding the specific mechanisms by which the war affects child health is critical for developing policy responses to protect children from the negative conflict effects. However, due to data limitations, we have to use case studies conducted by local organizations to speculate on the actual mechanisms driving this war impact (Fédération Internationale des Droits de l'Homme 1993).[20] Theft of livestock and crops and violence-induced displacement (from the village into the surrounding area) were the principal mechanisms at work. These mechanisms negatively affect nutrition, and displacement also makes exposed children more vulnerable to water- and vector-borne diseases. This exposure to additional diseases could explain why all children exposed to conflict appear to suffer, and we would expect the adverse impact to be larger the longer the child is exposed, which is consistent with the months of war shock exposure results in table 6.

In contrast, the crop failure results indicate households were able to shield boys from experiencing the shock's negative impact, and children in nonpoor households also avoided the shock. This result is consistent with a gender discrimination story in which households reallocate scarce resources toward boys, and therefore only girls suffer the negative impact of being born during the crop failure in the affected regions, and it is consistent with the gender discrimination literature previously discussed. However, we cannot rule out two alternative explanations. First, as discussed above, selective mortality in the crop failure region would indicate we are underestimating the negative impact of crop failure on boys, which would mean that the crop failure exposure affected more people, but there was not additional discrimination against girls. Second, since we lack household production data from part of the civil war

[20] From a historic perspective, we also note that the civil war, which lasted from October 1990 to April 1994, was not even halfway completed by the time of data collection, meaning that many more households and children would become malnourished during the 2 years following data collection.

region for the war period, we cannot rule out that the civil war shock was larger in magnitude, and this explains why boys and children in nonpoor households were negatively affected in those regions, while a potentially smaller crop failure shock did not affect them. Future work, including data collection in conflict and postconflict zones, should attempt to more precisely measure the differences between these types of shocks and how households manage to respond to them.

VI. Conclusion

In this essay, we combine detailed event data about the timing and location of localized crop failure and armed conflict with Rwandan nationally representative household survey data (collected in January 1992 prior to the 1994 genocide) to examine the impact of these shocks on the health status of young children who were exposed to them. The empirical identification strategy exploits exogenous variation in the shocks' geographic extent and the variation in which birth cohorts of children were exposed to the crop failure or conflict. We focus on the height-for-age of children under age 5 and find these shocks have lasting impacts several years after the event. We find that children born during the civil war in the conflict region, girls as well as boys, from poor as well as nonpoor households, are negatively affected by this war exposure, with height-for-age z-scores over one standard deviation lower. Conversely, girls born during a crop failure in the affected regions are particularly vulnerable, with these girls having 0.86 standard deviations lower height-for-age z-scores, and the impact is even worse for girls in poor households. We find no evidence of a negative impact of crop failure exposure on the health status of boys or children in nonpoor households. These results are robust to using different geographic boundaries for the affected regions and alternative shock exposure measures.

We also test the robustness of the crop failure results with two alternative measures. First, using alternative survey data on household-level agricultural production for a subsample of these households, we confirm that positive crop production shocks improve a child's height-for-age z-score. Second, we use the deviation of rainfall from the long-run province average to show that positive rainfall shocks are correlated with improved height-for-age z-scores. We also use an instrumental variables approach to demonstrate the causal mechanism running from rainfall shocks to crop failure to child health. The findings are robust to these alternative specifications.

We speculate that the sudden and unexpected nature of the civil war is why we do not observe a gender or wealth difference in which exposed children were negatively affected by the shock. Parents were unable to protect the health status of any of their children from this war crisis. In contrast, the crop failure results indicate households were able to shield boys from the negative impacts of the shock, and children in nonpoor households were also protected.

These results have direct policy implications, as they indicate the importance of a quick response to crises on the part of governments and nongovernmental organizations. Children are at risk of worsened health due to their family experiencing an economic shock when they were born, and there is a gendered component to the impact depending on the type of shock. Recent evidence suggests that a child who has shorter than normal height by age 5 will not be able to catch up later in life, and the negative shock at birth will likely have long-run consequences for these affected children, leading to worse adult outcomes in terms of health, education, and socioeconomic status. Hence, it is likely that exposure to the crop failure, by negatively affecting girls' health, and the civil war, by negatively affecting all children's health, will reduce the future welfare levels of these exposed children. The evidence suggests that helping these children with early interventions may have a larger payoff than the present benefit to only short-run health.

References

Akresh, Richard. 2009. "Flexibility of Household Structure: Child Fostering Decisions in Burkina Faso." *Journal of Human Resources* 44, no. 4:976–97.

Alderman, Harold, and Jere Behrman. 2006. "Reducing the Incidence of Low Birth Weight in Low Income Countries Has Substantial Economic Benefits." *World Bank Research Observer* 21, no. 1: 25–48.

Alderman, Harold, and Paul Gertler. 1997. "Family Resources and Gender Differences in Human Capital Investments: The Demand for Children's Medical Care in Pakistan." In *Intrahousehold Resource Allocation in Developing Countries: Models, Methods and Policy*, ed. Lawrence Haddad, John Hoddinott, and Harold Alderman. Baltimore: Johns Hopkins University Press.

Alderman, Harold, John Hoddinott, and Bill Kinsey. 2006. "Long Term Consequences of Early Childhood Malnutrition." *Oxford Economic Papers* 58, no. 3: 450–74.

Almond, Douglas. 2006. "Is the 1918 Influenza Pandemic Over? Long-Term Effects of *In Utero* Influenza Exposure in the Post-1940 U.S. Population." *Journal of Political Economy* 114, no. 4:672–712.

Almond, Douglas, Lena Edlund, Hongbin Li, and Junsen Zhang. 2007. "Long-Term Effects of the 1959–1961 China Famine: Mainland China and Hong Kong." NBER Working Paper no. 13384, National Bureau of Economic Research, Cambridge, MA.

Austin, Gareth. 1996. "The Effects of Government Policy on the Ethnic Distribution of Income and Wealth in Rwanda: A Review of Published Sources." Unpublished manuscript, London School of Economics.

Barker, David J. P. 1998. *Mothers, Babies and Health in Later Life.* London: BMJ.

Behrman, Jere. 1988. "Intrahousehold Allocation of Nutrients in Rural India: Are Boys Favored? Do Parents Exhibit Inequality Aversion?" *Oxford Economic Papers* 40, no. 1:32–54.

Bellows, John, and Edward Miguel. 2006. "War and Institutions: New Evidence from Sierra Leone." *American Economic Review* 96, no. 2:394–99.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. "How Much Should We Trust Differences-in-Differences Estimates?" *Quarterly Journal of Economics* 119, no. 1:249–75.

Bundervoet, Tom, Philip Verwimp, and Richard Akresh. 2009. "Health and Civil War in Rural Burundi." *Journal of Human Resources* 44, no. 2:536–63.

Bureau Social Urbain-Caritas. 1990. "Les Retombées de la Famine dans les Préfectures de Butare et de Gikongoro." Report, Bureau Social Urbain-Caritas, Kigali, Rwanda.

Clay, Daniel. 1996. "Promoting Food Security in Rwanda through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation and Poverty." International Development Paper no. 17, Department of Agricultural Economics and Economics, Michigan State University.

Clay, Daniel, Thomas Reardon, and Jaakko Kangasniemi. 1998. "Sustainable Intensification in the Highland Tropics: Rwandan Farmers' Investments in Land Conservation and Soil Fertility." *Economic Development and Cultural Change* 46, no. 2: 351–77.

Dercon, Stephan, and Pramilla Krishnan. 2000. "In Sickness and in Health: Risk Sharing within Households in Rural Ethiopia." *Journal of Political Economy* 108, no. 4:688–727.

Duflo, Esther. 2003. "Grandmothers and Granddaughters: Old-Age Pensions and Intrahousehold Allocation in South Africa." *World Bank Economic Review* 17, no. 1:1–25.

Fédération Internationale des Droits de l'Homme. 1993. "Rapport sur la Commission d'enquête sur les violations des droits de l'Homme au Rwanda depuis le 1er Octobre 1990." Report, Fédération Internationale des Droits de l'Homme, Africa Watch, Paris.

Gascon, Jean-Francois. 1992. "Pauvreté a Gikongoro, Résultats de l'enquête réalisée auprès des ménages indigents." Document de travail no. 156, Projet de Développement Agricole de Gikongoro, Kigali, Rwanda.

Glewwe, Paul, Hanan Jacoby, and Elizabeth King. 2001. "Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis." *Journal of Public Economics* 81, no. 3:345–68.

Godfrey, Keith M., and David J. P. Barker. 2000. "Fetal Nutrition and Adult Disease." *American Journal of Clinical Nutrition* 71, no. 5:1344S–1352S.

Guidolin, Massimo, and Eliana La Ferrara. 2007. "Diamonds Are Forever, Wars Are Not: Is Conflict Bad for Private Firms?" *American Economic Review* 97, no. 5:1978–93.

Justino, Patricia, and Philip Verwimp. 2006. "Poverty Dynamics, Violent Conflict and Convergence in Rwanda." Working Paper no. 16, Households in Conflict Network, Institute of Development Studies, University of Sussex.

Maccini, Sharon, and Dean Yang. 2009. "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review* 99, no. 3:1006–26.

Martorell, Reynaldo, and Jean-Pierre Habicht. 1986. "Growth in Early Childhood in Developing Countries." In *Human Growth: A Comprehensive Treatise*, ed. Frank Falkner and James Tanner. New York: Plenum.

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. 2004. "Economic Shocks and Civil Conflict: An Instrumental Variables Approach." *Journal of Political Economy* 114, no. 4:725–53.

Moulton, Brent. 1986. "Random Group Effects and the Precision of Regression Estimates." *Journal of Econometrics* 32, no. 3:385–97.

Mu, Ren, and Xiaobo Zhang. 2008. "Gender Difference in the Long-Term Impact of Famine." Discussion Paper no. 760, International Food Policy Research Institute, Washington, DC.

Prunier, Gérard. 1995. *Rwanda: History of a Genocide*. New York: Columbia University Press.

Razzaque, Abdur, Nurul Alam, Lokky Wai, and Andrew Foster. 1990. "Sustained Effects of the 1974–5 Famine on Infant and Child Mortality in a Rural Area of Bangladesh." *Population Studies* 44, no. 1:145–54.

Reyntjens, Filip. 1994. *L'Afrique des Grands Lacs en Crise, Rwanda et Burundi (1988–1994)*. Paris: Karthala.

Rose, Elaina. 1999. "Consumption Smoothing and Excess Female Mortality in Rural India." *Review of Economics and Statistics* 81, no. 1:41–49.

Sibomana, André. 1999. *Hope for Rwanda: Conversations with Laure Guilbert and Hervé Deguine*. London: Pluto.

Stein, Zena, Mervyn Susser, Gerhart Saenger, and Francis Marolla. 1975. *Famine and Human Development: The Dutch Hunger Winter of 1944–1945*. New York: Oxford University Press.

Strauss, John, and Duncan Thomas. 2008. "Health over the Life Course." In *Handbook of Development Economics*, vol. 4, ed. Paul Schultz and John Strauss. Amsterdam: North-Holland.

Thomas, Duncan, Victor Lavy, and John Strauss. 1996. "Public Policy and Anthropometric Outcomes in the Cote D'Ivoire." *Journal of Public Economics* 61, no. 2: 155–92.

Twizeyimana, Prosper, and Véronique Uwimana. 1989. "Portrait de la Pénurie Alimentaire Actuelle au Rwanda: Dévoilement d'une Famine Cachée sous la Verdure." Report, Conseil de Concertation des Organisations d'Appui aux Initiatives de Base, Kigali, Rwanda.

UNICEF. 1992. "Statut Nutritionnel et Sécurité Alimentaire au Rwanda: Résultats de l'Enquête Nationale sur la Nutrition et la Sécurité Alimentaire des Enfants de 0 à 5 Ans et Leurs Mères." Working Paper no. 38, UNICEF, Kigali, Rwanda.

Van den Berg, Gerard, Maarten Lindeboom, and France Portrait. 2006. "Economic Conditions Early in Life and Individual Mortality." *American Economic Review* 96, no. 1:290–302.

Verwimp, Philip. 2005. "An Economic Profile of Peasant Perpetrators of Genocide: Micro-level Evidence from Rwanda." *Journal of Development Economics* 77, no. 2: 297–323.

Verwimp, Philip, and Jan van Bavel. 2005. "Child Survival and Fertility of Refugees in Rwanda after the Genocide." In "Demography of Violent Conflict," special issue, *European Journal of Population* 21, nos. 2–3:271–90.

World Bank. 1998. "Rwanda Poverty Update." Africa Document, annex I.

Yamano, Takashi, Harold Alderman, and Luc Christiaensen. 2005 "Child Growth, Shocks and Food Aid in Rural Ethiopia." *American Journal of Agricultural Economics* 87, no. 2:273–88.

Yamauchi, Futoshi. 2006. "Early Childhood Nutrition, Schooling and Sibling Inequality in a Dynamic Context: Evidence from South Africa." Discussion Paper no. 203, International Food Policy Research Institute, Washington, DC.