Public Disclosure Authorized

Public Disclosure Authorized

WPS7196

Policy Research Working Paper 7196

Orphans and Ebola

Estimating the Secondary Impact of a Public Health Crisis

David K. Evans
Anna Popova

WORLD BANK GROUP
Africa Region
Office of the Chief Economist
February 2015

Policy Research Working Paper 7196

Abstract

The 2014 Ebola Virus Disease outbreak in West Africa is the largest to date by far. Ebola Virus Disease causes disproportionate mortality among the working-age population, resulting in far more mortality for parents of young children than other health crises. This paper combines data on the age distribution of current and projected mortality from Ebola with the fertility distribution of adults in Guinea, Liberia, and Sierra Leone, to estimate the likely impact of the epidemic on the number of orphans in these three countries. Using the latest mortality estimates (from February 11, 2015), it is estimated that more than 9,600 children have lost one or both parents to Ebola Virus Disease. The absolute numbers of orphans created by the Ebola epidemic are significant, but represent a small fraction (1.4 percent) of the existing orphan burden in the affected countries. Ebola is unlikely to increase the numbers of orphans beyond extended family networks' capacities to absorb them. Nonetheless, the pressures of caring for increased numbers of orphans may result in lower quality of care. These estimates should be used to guide policy to support family networks to improve the capacity to provide high quality care to orphans.

This paper is a product of the Office of the Chief Economist, Africa Region. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at devans2@worldbank.org and apopova@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Produced by the Research Support Team

Orphans and Ebola:
Estimating the Secondary Impact of a Public Health Crisis

David K. Evans
World Bank

Anna Popova
World Bank

Keywords: Ebola, orphans, epidemics, health economics

JEL Codes: I15, O15, J13

Acknowledgments: This work benefited from valuable comments from Kathleen Beegle, Mapi Buitano, Jed Friedman, Camila Galindo Pardo, Markus Goldstein, and Eleni Yitbarek.

Introduction

Every health crisis creates orphans, defined here as children under 15 years of age who lose a mother, a father, or both. This concern was particularly acute with the HIV/AIDS epidemic because of the disproportionate mortality among working-age adults, who are also the most likely to have young children.[1] The Ebola Virus Disease (EVD) has a similar age profile. Across Guinea, Liberia, and Sierra Leone, individuals under 15 years of age make up the same proportion of the population as individuals between 15 and 44 years of age, yet people between 15 and 44 make up almost three times as many of the EVD patients and deaths (Table 1). As a result, EVD is likely to create a much greater number of orphans than other health challenges like malaria, which are not concentrated among parents of minor children.

Table 1: Age Distribution of EVD Patients and Deaths across the Population

	All EVD patients[2]	Proportion of Patients who died[2]	Population[3]
<15 years	19.8%	19.6%	39.0%
15-44 years	57.0%	53.3%	46.9%
>=45 years	23.2%	27.2%	14.2%

Note: For "patients who died", we combine the country-level distribution of cases by age with the country-level deaths (not available by age), and then adjust for age-differential mortality using the three-country distributional data reported in October 2014.[2]

Parent mortality has the potential to multiply the impacts of Ebola by driving poorer human capital outcomes in future generations. Previous work elsewhere in Sub-Saharan Africa has demonstrated that even losing one parent is associated with significant reductions in short-term educational outcomes[4, 5] as well as adverse impacts on health and education that persist into adulthood.[6] This is true despite the fact that most orphans live with surviving relatives.[7] Across studies, these negative impacts are concentrated among maternal orphans (i.e., children who lose a mother).

With the AIDS epidemic, the question arose again and again: Will extended family networks be capable of caring for these orphans? Earlier analysis across Africa has found that even in countries that undergo large increases in the proportion of orphans, these surviving children are much more likely to remain with relatives than with non-relatives.[7] The same question applies in the context of the Ebola epidemic.

How many orphans is the Ebola epidemic actually creating? News media have, over the course of one month alone (November 2014), reported estimates ranging from 500 to 25,000.[8, 9] The most recent estimate from one international organization (UNICEF) is between the two, with 16,600 children having lost either a parent or a primary caregiver, but without a detailed published analysis.[10]

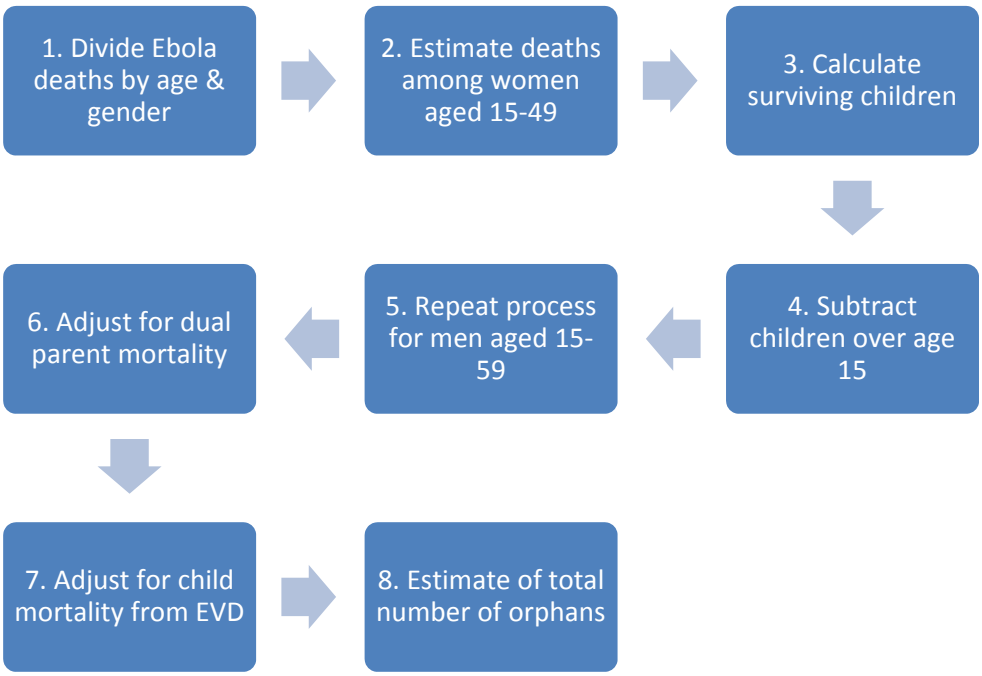
This paper provides estimates of the likely number of orphans already created by EVD and contextualizes those numbers in terms of the existing orphan burden in the most affected countries, Guinea, Liberia, and Sierra Leone. This should inform both the gravity of this aspect of the Ebola epidemic and the steps to provide support in filling the human capital gaps created by the ongoing EVD epidemic in West Africa.

Methods

This paper infers orphan numbers using data on (1) the gender and age distribution of cases and mortality from Ebola, (2) the number of living children for adults, and (3) data from previous epidemics on the probability of infection for spouses and children of Ebola patients. The process of calculating the number of orphans is presented in Figure 1.

First, we apply the country-level distribution of cases by gender and age to the most recent country-level mortality estimates (not available by gender and age), and then adjust for the gender- and age-specific mortality/infection differential using the three-country distributional data reported in October 2014[2] to estimate, for a given number of EVD deaths, how many are likely to be male and female in the following age groups: under 15 years old, 15-44 years old, and 45 and older. Second, we use these results to estimate how many of the deaths in each country occur among women aged 15-49. For example, because 52% of Guinea's EVD cases were female and 57% were aged 15-44, we multiply the total 1,995 EVD deaths in Guinea to date [11] by 52%*57%, and adjust by 0.99*0.93, the mortality/infection differential for women times that for 15-44 year olds [2] to find that 540 or 27% of deaths in Guinea would be women aged 15-44. Repeating this for each of the most affected countries, of the 1,995 deaths in Guinea, 3,826 deaths in Liberia, and 3,341 deaths in Sierra Leone as of February 11, 2015, [11] 27% would be women between the ages of 15 and 44.

Figure 1: Process of Estimating the Number of Children Orphaned by Ebola



Third, we use data from recent demographic and health surveys (DHS) in the three countries (2012 in Guinea and 2013 in Liberia and Sierra Leone) to inform the mean number of living children for women aged 15-49. [12, 13, 14] Fourth, adult children and children over age 15 are subtracted from the total number of orphans, since they are the least dependent on their parents. Fifth, the same process is repeated for men aged 15-59.

Sixth, the estimates are adjusted for dual parent mortality. If an individual dies of EVD, it is significantly more likely that his or her spouse will also die of EVD. Given that, simply summing the maternal and paternal orphans will overstate the total number of orphans.[a] No data on spousal infection are available for the current epidemic. However, evidence from an outbreak of EVD in the Democratic Republic of Congo in 1995 showed that 45% of spouses of EVD patients developed the fever, [15] much higher than the probability of contagion for the general population. The fatality rate in the current epidemic, as calculated by the number of deaths divided by the number of confirmed, probable and suspected cases (as of February 11, 2015) ranges from 31% to 66% across the three countries. [11] Thus, if one parent dies in Guinea, for example, the probability that both will die may be estimated at 30% (45% chance of spousal infection * 66% chance of fatality).

Seventh, some proportion of children who lose parents will be among the dying themselves. As Table 1 shows, a relatively small proportion of children die from EVD, particularly given their high share in the population. No data from the current epidemic are available on the likelihood that a child contracts EVD from a parent. Returning to estimates from the 1995 outbreak, it is estimated that household members under age 18 had a 4% chance of contracting EVD, conditional on an adult in the household contracting it. [15] Thus, if a parent dies in Guinea, the probability of a child dying is about 2.6% (4% chance of child infection * 66% chance of fatality). If both of a child's parents die, the probability of the child dying is then 5.2%. Unconditionally, the probability of a child dying of EVD is extremely low, ranging from 0·007% in Guinea to 0·043% in Liberia (i.e., even in Liberia, the probability is only 4 children in 10,000). So although having a parent with Ebola dramatically increases a child's probability of contracting Ebola, the absolute probability is still low, most likely because children are less likely to handle the dead or care for the sick.

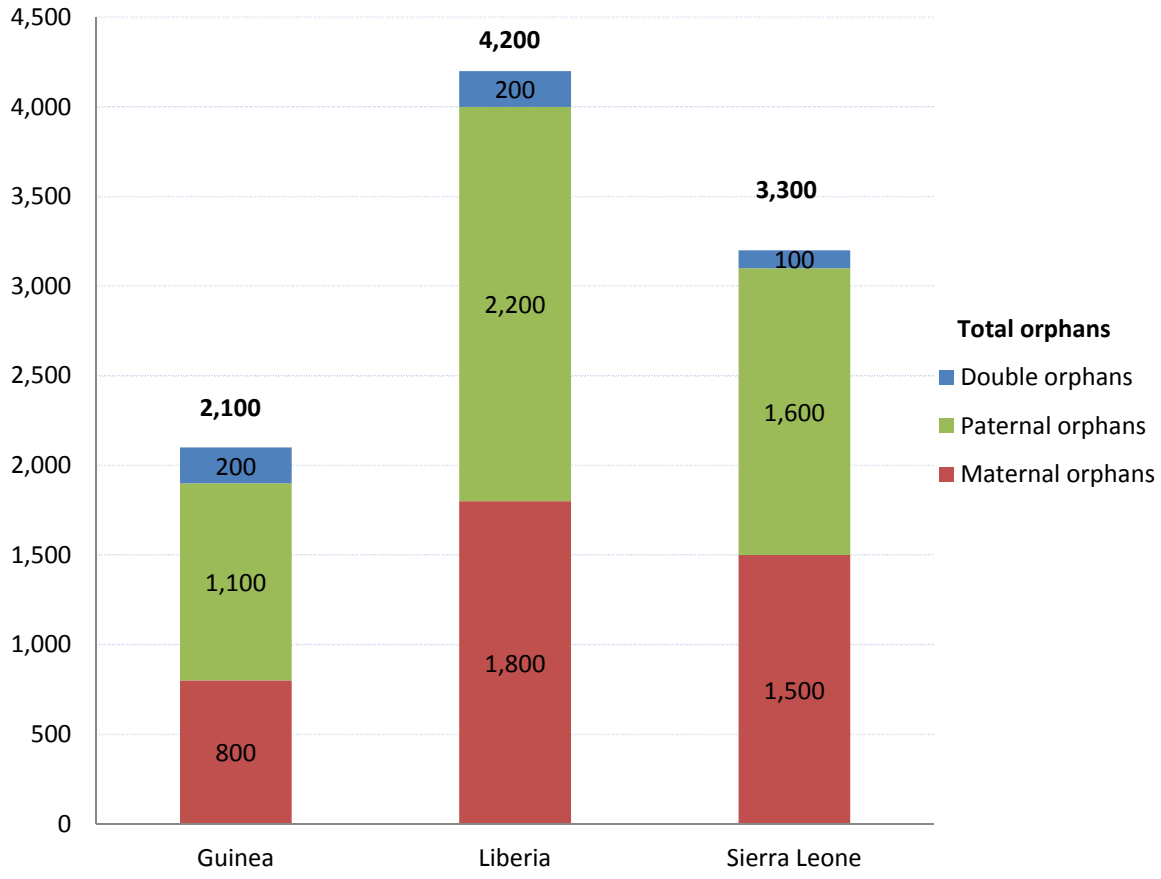
These calculations result in an estimate of the number of orphans created directly by Ebola deaths. The calculations are laid out in greater detail in the methodological appendix. Ethical review committee approval was not obtained because all analysis was based on publicly available data.

Results

Our calculations suggest that the number of orphans under 15 years of age created to date reaches over 9,600, as illustrated in Figure 2. As of February 11, 2015, an estimated 4,100 children across the three countries most affected by Ebola had lost a mother to the virus, 4,900 had lost a father, and 600 had lost both. Despite a recent slowdown in the spread of EVD in Liberia, the most children have been affected there, with almost as many orphans created as a result of Ebola in Liberia as in Guinea and Sierra Leone combined.

[a] Maternal orphans are children who lose a mother. Paternal orphans are children who lose a father.

Figure 2: Ebola Orphan Count for Guinea, Liberia, and Sierra Leone



Discussion

The results presented here provide important information on the scale of impact of the current Ebola epidemic on the lives of children who lose their parents to the virus. To date, over 9,600 children under 15 years in the three most affected countries have been left orphaned as a direct result of the 2014 Ebola epidemic. While in absolute terms this represents a large number of children facing personal tragedy, it amounts to only 1.4% of the total 702,000 orphans in the same countries, calculated using parent mortality data from the DHS [16] and population data from the United Nations. [3] This represents a relatively small increase in the orphan burden. Across the three countries analyzed, 8% of 15 year olds had lost either one or both parents for some reason before the Ebola epidemic, but only 0.11% of children have been left orphaned as a result of Ebola.

Two factors suggest that 9,600 Ebola orphans could be an underestimate. First, it is believed that the number of EVD cases to date has been underreported: Estimates range from 0.17-2.5 unreported cases for each reported case. [17, 18] Second, our estimates reflect only the direct effects of Ebola on orphan numbers, i.e., the number of children orphaned as a result of one or both of their parents dying because they contracted EVD. The media reports that the already fragile health care systems of the three most affected countries are collapsing under the strain of the epidemic. [19] This may cause children to lose parents to preventable or treatable conditions unrelated to Ebola. If this is the case, the true number of orphans created by the Ebola epidemic is again likely to be higher. Few systematic data are available regarding the deterioration of non-Ebola health services.

While the true number of Ebola orphans created to date by the epidemic may be higher than 9,600 for the reasons discussed above, this number gives a useful order of magnitude arrived at by exploiting the best available data.

There are concerns that this increase in orphan numbers as a consequence of Ebola will overwhelm the capacity of extended family networks, the traditional care provider to orphans in the region. However, there is increasing evidence that family networks in Sub-Saharan Africa are resilient to absorbing even large numbers of orphans. Country studies from Tanzania, Malawi, South Africa, and cross-country studies across Sub-Saharan Africa find no evidence that increases in rates of orphanhood increase the prevalence of child-headed households or even that orphans will live with non-relatives. [7, 20, 21]

Fostering even non-orphan children is a pre-existing mechanism in many Sub-Saharan African countries, reducing uncertainty and realizing opportunity by smoothing access to income and education across extended family members. [22] Household survey data show that 9.5% of children across West Africa are in foster care, with the proportion being as high as 16.8% in Liberia. [23] Family networks in the region have been able to cope with increases in orphan numbers due to the earlier HIV/AIDS epidemic, which resulted in much greater numbers of orphans than those currently being caused by Ebola, with the most affected countries experiencing increases as large as 150% but still without displacement of orphans to non-relatives. [7] Household data on 14 countries in Sub-Saharan Africa showed that traditional non-orphan fostering practices were not displaced by the large surge in orphan numbers resulting from HIV/AIDS; communities in most regions were able to absorb the demand for fostering both orphans and non-orphans. [22] Evidence therefore suggests that family networks in the region are likely to be able to absorb the relatively small increase in orphans created by Ebola. This is consistent with at least one recent report suggesting that most Ebola orphans have been placed with extended family members. [10]

A second concern, much reported in the news media, has been that stigma affecting Ebola orphans may lead to their rejection by households that would traditionally have fostered them. [24, 25, 26] This reflects a similar narrative around HIV/AIDS orphans in the early 2000s. However, both direct analysis based on household data and a systematic review find no evidence of HIV/AIDS stigma on fostering arrangements. [7, 27]

This says little about the quality of care, however. Theory provides several reasons why living with a caregiver who is not a parent may lead to worse outcomes for children in terms of health and education. Households caring for more children may have fewer resources to invest in each child. [28, 29] Altruism may be motivated by biological connectedness such that more closely related caregivers provide higher quality care to children. [30] The expectation of old-age support may encourage households to invest more in their

biological children's human capital. In the case of grandparents becoming the caregivers of orphans, they may have fewer financial resources to support their grandchildren. [7]

Longitudinal case-studies from countries with high orphan prevalence (Kenya, South Africa, and Tanzania, among others) reveal large negative impacts of orphanhood on health and education outcomes, especially for orphans who have lost their mother. [5, 6, 31, 32, 33] Evidence from Senegal also suggests that fostered children are more likely to be involved in domestic work or the labor market during school age. [23]

While extended family networks seem capable of absorbing large numbers of orphans, the ability of communities to meet rapidly growing fostering demands may indicate a dilution in the quality of the fostering arrangements. [22] If orphaned children are increasingly living in households that are less willing or able to invest in their human capital, this may have major long-run implications for the children's human development. Evidence from Sub-Saharan Africa shows a trend towards non-traditional and usually poorer-quality fostering relationships in areas with high numbers of HIV/AIDS orphans. [34, 35, 36] In many countries across the region there has been a shift towards grandparents taking on increasing responsibility in caring for orphans and away from younger relatives and non-relatives, especially in countries where the orphan rate has increased rapidly. Orphans living with a grandparent are substantially more likely to live in a poor household. [7]

Every child who loses a parent faces a tragedy. However, the current Ebola epidemic is unlikely to increase orphan numbers beyond the capacity of extended family networks to absorb them. The pressure of increased orphan numbers may lower the quality of care that these family networks are able to provide, however. Rather than creating new institutions to deal with increased numbers of orphans, governments and non-government organizations alike can provide material support to family networks to improve their capacity to provide high quality care. Beyond monetary resources, caregivers can receive training on how to care for a potential Ebola patient safely and to seek medical care quickly if the child develops early signs of infection, as well as help in accessing schools, and counseling to support their emotional well-being, as well as that of the orphans. [10, 26] Formal reintegration programs can target worries about communities potentially turning Ebola orphans away because of concerns regarding Ebola transmission risks. Such programs can provide continued education, dispelling rumors regarding Ebola orphans and providing a first step in the necessary psychosocial support for survivors. Children and the families looking after them are given cash and material assistance. Following up with children who are in new families is an important focus, as the children may be emotionally vulnerable as they grieve the loss of loved ones.

At the same time, many non-orphan children are experiencing significant economic shocks due to the Ebola crisis, [37] and economic differences can dwarf the differences between orphans and non-orphans. [38] Thus, while we must be mindful of the support needed by orphans and those who care for them, broader attention to the needs of all vulnerable children in the wake of the Ebola crisis will be equally important for the long-term health and welfare of the affected countries.

Works Cited

1. UNICEF. *Africa's Orphaned and Vulnerable Generations: Children Affected by AIDS*. New York: UNICEF; 2006. Africa's Orphaned and Vulnerable Generations.

2. WHO Ebola Response Team. Ebola Virus Disease in West Africa -- The First 9 Months of the Epidemic and Forward Projections. *The New England Journal of Medicine*. 2014:1481-1495.

3. United Nations. *World Population Prospects: The 2012 Revision.*: United Nations, Department of Economic and Social Affairs, Population Division; 2013.

4. Case A, Ardington C. The Impact of Parental Death on School Outcomes: Longitudinal Evidence from South Africa. *Demography*. 2006:401-420.

5. Evans DK, Miguel E. Orphans and Schooling in Africa: A Longitudinal Analysis. *Demography*. 2007:35-57.

6. Beegle K, De Weerdt J, Dercon S. Orphanhood and Human Capital Destruction: Is There Persistence into Adulthood? *Demography*. 2010:163-180.

7. Beegle K, Filmer D, Stokes A, Tiererova L. Orphanhood and the Living Arrangements of Children in Sub-Saharan Africa. *World Development*. 2010;47(1):163-180.

8. Morgan TC. Over 25,000 Ebola Orphans at Risk. *Christianity Today*. November 2014:http://www.christianitytoday.com/ct/2014/november-web-only/ebola-orphans.html.

9. BBC News Africa. In pictures: Ebola orphans. *BBC News Africa*. November 2014:http://www.bbc.com/news/world-africa-30019892.

10. UNICEF. More than 16,000 children lost parents or caregivers to Ebola - many are taken in by the communities: UNICEF. February 2015.

11. WHO. Ebola Situation Report. *World Health Organization*. February 11, 2015. http://apps.who.int/iris/bitstream/10665/152219/1/roadmapsitrep_11Feb15_fre.pdf?ua=1&ua=1. Accessed February 12, 2015.

12. Liberia Institute of Statistics and Geo-Information Services (LISGIS); Ministry of Health and Social Welfare [Liberia]; National AIDS Control Program [Liberia]; ICF International. *Liberia Demographic and Health Survey 2013*. Monrovia, Liberia 2014.

13. Statistics Sierra Leone (SSL); ICF International. *Sierra Leone Demographic and Health Survey 2013*. Freetown, Sierra Leone and Rockville, Maryland, USA 2014.

14. Institut National de la Statistique, Ministère du Plan (Guinée); ICF International. *Enquête Demographique et de Santé et à Indicateurs Multiples (EDS-MICS 2012)*. Conakry (Guinée) and Calverton (USA) 2013.

15. Dowell SF, Mukunu R, Ksiazek TG, Khan AS, Rollin PE, Peters C. Transmission of Ebola Hemorrhagic Fever: A Study of Risk Factors in Family Members, Kikwit, Democratic Republic of the Congo, 1995. *Journal of Infectious Diseases*. 1999:S87-91.

16. The DHS Program. STATcompiler. Available at: http://www.statcompiler.com/. Accessed October 2014.

17. Scarpino SV, Iamarino A, Wells C, et al. Epidemiological and Viral Genomic Sequence Analysis of the 2014 Ebola Outbreak Reveals Clustered Transmission. *Clinical Infectious Diseases*. December 2014.

18. Meltzer MI, Atkins CY, Scott S, et al. Estimating the Future Number of Cases in the Ebola Epidemic — Liberia and Sierra Leone, 2014–2015. *Morbidity and Mortality Weekly Report: Supplements*. September 2014;63(3):1-14.

19. Bernstein L. With Ebola crippling the health system, Liberians die of routine medical problems. *The Washington Post*. September 2014.

20. Hosegood V, Floyd S, Marston M, et al. The effects of high HIV prevalence on orphanhood and living arrangements of children in Malawi, Tanzania, and South Africa. *Population Studies*. 2007;61(3):327-336.

21. Monasch R, Boerma JT. Orphanhood and childcare patterns in sub-Saharan Africa: an analysis of national surveys from 40 countries. *Aids*. 2004;18(S55-S65).

22. Grant MJ, Yeatman S. The relationship between orphanhood and child fostering in sub-Saharan Africa, 1990s–2000s. *Population Studies*. 2012;66(3):279-295.

23. Beck S, Vreyer PD, Lambert S, Marazyan K, Safir A. *Child Fostering in Senegal*: UNICEF & Paris School of Economics.

24. UNICEF. *Thousands of children orphaned by Ebola*: United Nations Children's Fund; 2014.

25. Gettleman J. An Ebola Orphan's Plea in Africa: 'Do You Want Me?'. *The New York Times*. December 2014.

26. Bitchell RE. After Losing Parents To Ebola, Orphans Face Stigma. *Goats and soda, NPR*. October 03, 2014. Available at: http://www.npr.org/blogs/goatsandsoda/2014/10/03/353473707/after-losing-parents-to-ebola-orphans-face-stigma. Accessed December 17, 2014.

27. Deacon H, Stephney I. *HIV/AIDS, Stigma and Children: A literature review*. Cape Town: Human Sciences Research Council; 2007.

28. Rosenzweigh MR, Wolpin KI. Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment. *Econometrica*. January 1980;48(1):227-240.

29. Li H, Zhang J, Zhu Y. The Quantity-Quality Trade-Off of Children in a Developing Country: Identification Using Chinese Twins. *Demography*. February 2008;45(1):223-243.

30. Hamilton WD. The genetical evolution of social behaviour. *Journal of Theoretical Biology*. 1964;7(1):1-16.

31. Ainsworth M, Semali I. The impact of adult deaths on children's health in northwestern Tanzania. *World Bank Publications*. 2000;2266.

32. Ardington C, Leibbrandt M. Orphanhood and schooling in South Africa: Trends in the vulnerability of orphans between 1993 and 2005. *Economic development and cultural change*. 2010;58(3):507.

33. Case A, Ardington C. The impact of parental death on school outcomes: Longitudinal evidence from South Africa. *Demography*. 2006;43(3):401-420.

34. Foster G. The capacity of the extended family safety net for orphans in Africa. *Psychology, Health & Medicine*. 2000;5(1):55-62.

35. Nyambedha EO, Wandibba S, Aagaard-Hansen J. Changing patterns of orphan care due to the HIV epidemic in Western Kenya. *Social Science and Medicine*. 2003;301–311(51).

36. Beard BJ. Orphan care in Malawi: Current practices. *Journal of community health nursing*. 2005;22(2):105-115.

37. World Bank. *The Socio-Economic Impacts of Ebola in Liberia: Results from a High Frequency Cell Phone Survey*. Washington: World Bank; 2014. The Socio-Economic Impacts of Ebola in Liberia.

38. Ainsworth M, Filmer D. Inequalities in children's schooling: AIDS, orphanhood, poverty, and gender. *World Development*. 2006;34(6):1099-1128.

39. World Bank. *The Economic Impact of the 2014 Ebola Epidemic: Short- and Medium-Term Estimates for West Africa*. Washington, DC: World Bank; 2014.

40. WHO. *Ebola Response Roadmap. August 28.*: World Health Organization; 2014.

41. Serra R. Child fostering in Africa: When labor and schooling motives may coexist. *Journal of Development Economics*. 2009;88(1):157-170.

42. Crowe S. I want Ebola to leave Liberia, so I can go to school. *UNICEF Connect*. November 2014.

43. UNICEF. Impact of Ebola. *UNICEF*. December 8, 2014. http://www.unicef.org/emergencies/ebola/75941_76129.html. Accessed December 19, 2014.

Methodological Appendix

This appendix describes the calculation of the number of Ebola orphans in detail. It follows the eight steps outlined in the main body of the paper:

1. Divide Ebola deaths by age and gender
2. Estimate deaths among women aged 15-49
3. Calculate surviving children
4. Subtract children over age 15
5. Repeat process for men aged 15-59
6. Adjust for dual parent mortality
7. Adjust for child mortality from EVD
8. Resulting estimate of the total number of orphans

1. Divide Ebola deaths by age and gender

Fatality rates are not uniform across gender and age; however, the most recent country-level mortality estimates from the WHO are not available by gender and age. [11] Thus to calculate country-level EVD deaths for these sub-populations we apply the country-level distribution of cases by gender and age to the most recent country-level mortality estimates, and then adjust for the gender- and age-specific mortality/infection differential using the three-country distributional data reported in October 2014. [2]

The country-level EVD deaths are distributed by age and gender according to case proportions, adjusted by the mortality/infection differential across the sub-groups recorded in Table A1.

Table A1: Gender and age distribution of EVD cases

	Country			Mortality / Infection Differential across Sub-Groups
	Guinea	Liberia	Sierra Leone	
Male	48%	50%	48%	1.01
Female	52%	50%	52%	0.99
	0%	0%	0%	
0-14	16%	19%	21%	1.03
15-44	57%	59%	56%	0.93
45+	27%	23%	22%	1.15

2. Estimate deaths among women aged 15-49

The consequent distribution of deaths by gender and age distribution is presented in Table A2.

Table A2: Estimated EVD Deaths by Age & Gender

		Guinea	Liberia	Sierra Leone
Total Deaths **11**		1,995	3,826	3,341
Female deaths	<15 years old	167	360	380
	15-44 years old	540	1,028	895
	≥45 years old	322	490	444
Male deaths	<15 years old	159	373	359
	15-44 years old	514	1,064	847
	≥45 years old	306	507	420

Source: Total mortality by country is from WHO (2014). Distribution by age and gender is inferred by the author based on WHO Ebola Response Team (2014).

3. Calculate surviving children

The age distribution of Ebola deaths among women age 15-44 is assumed to reflect the age distribution of women age 15-44, in five-year age groups. For example, in Sierra Leone, 23% of women age 15-44 are between the ages of 15 and 19, so 23% of the 895 female deaths are applied to women age 15-19.[b] The same process is applied for women age 45-49, using the distribution of deaths for women over age 45. These five-year age group mortality counts are then multiplied by the mean number of living children (MNLC) for women in the same age groups, from the most recent DHS for the three countries, **12**, **13**, **14** to calculate the total surviving children of female EVD victims age 15-49. Age 49 is the upper limit because the DHS only calculates the mean number of living children for women up to age 49.[c]

4. Subtract children over age 15

This number is then adjusted to subtract children who are likely over the age of 15. For example, for a woman currently in the age range of 40-44, we subtract the number of living children she had when she was in the 25-29 range, since those children would now be over 15. (In fact, this is a simplification: Since this is a cross-sectional survey, the number of living children for women currently in the 25-29 range is subtracted from the number of living children currently in the 40-44 age range. If women have begun to have children later over successive cohorts, then this will underestimate the total number of orphans.) The calculations for Steps 3 and 4 are demonstrated in Table A3.

These calculations suggest that, to date, over 4,800 children under age 15 have lost a mother.

[b] Obviously, EVD mortality within the 15-44 age range may follow an age distribution that is disproportionate to the population in that range (e.g., concentrated among adults age 25-29); but finer data are not available.

[c] This will result in an underestimate of the orphans under age 15, as – in the most recent DHS – women between the ages of 35 and 49 accounted for 16% of births across the three countries, mostly concentrated in the 35-39 age range. **12**, **13**, **14**

Table A3: Calculation of Maternal Orphans (Before Adjusting for Child EVD Deaths)

	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
Guinea								
Female deaths	134.7	114.6	95.5	78.4	64.0	53.2	79.2	
Mean number of living children	0.3	1.2	2.3	3.5	4.3	4.6	5.0	
Total maternal orphans	41.7	138.7	218.6	277.6	273.1	246.4	397.0	
Maternal orphans <15 years old	41.7	138.7	218.6	253.3	195.7	124.5	116.5	1,089
Liberia								
Female deaths	238.8	212.1	186.7	156.4	128.5	105.5	126.4	
Mean number of living children	0.3	1.3	2.3	3.2	4.0	4.6	5.0	
Total maternal orphans	66.9	267.3	420.0	503.5	507.5	489.3	634.6	
Maternal orphans <15 years old	66.9	267.3	420.0	459.7	345.6	252.0	227.5	2,039
Sierra Leone								
Female deaths	204.9	183.5	164.3	139.5	113.4	89.4	119.0	
Mean number of living children	0.2	1.1	2.2	3.2	3.9	4.3	4.6	
Total maternal orphans	47.1	207.4	363.1	443.8	436.7	384.3	552.3	
Maternal orphans <15 years old	47.1	207.4	363.1	411.7	308.5	186.8	173.8	1,698
Total maternal orphans < 15								4,826

5. Repeat process for men aged 15-49

The same process is carried out for men (see calculations in Table A4), with the difference that the DHS calculate the mean number of living children for men through age 59, due to higher fertility at later ages. Note one exception: The Liberia DHS data for men, unlike those for Sierra Leone and Guinea, only calculate men's MNLC through age 49. The MNLC for men in Liberia at age 45-49 is closest to that of Guinea, so the growth in MNLC from 45-49 to 50-54 and then to 55-59 is assumed to follow the same percentage growth path as that in Guinea, starting from Liberia's 45-49 base.

These calculations suggest that, to date, over 5,600 children have lost a father.

Table A4: Calculation of Paternal Orphans (Before Adjusting for Child EVD Deaths)

	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	Total
Guinea										
Male deaths	129.2	109.4	90.7	74.1	60.2	50.0	79.6	67.7	55.9	
Mean number of living children	0.0	0.2	0.8	2.0	3.4	4.6	6.0	7.0	7.6	
Total paternal orphans	1.3	17.5	75.3	144.5	204.0	230.2	473.5	476.6	425.3	
Paternal orphans <15 years old	1.3	17.5	75.3	143.8	194.4	188.6	318.3	247.1	168.2	1,354
Liberia										
Male deaths	250.0	220.9	193.5	161.3	131.9	106.1	137.1	109.5	84.6	
Mean number of living children	0.0	0.4	1.4	2.6	3.9	4.3	5.6	6.6	7.2	
Total paternal orphans	7.5	88.4	272.8	420.9	510.6	458.2	767.8	725.6	606.2	
Paternal orphans <15 years old	7.5	88.4	272.8	416.1	457.9	308.6	409.9	301.8	240.6	2,504
Sierra Leone										
Male deaths	195.3	175.3	156.5	131.8	105.7	82.3	114.0	89.3	69.6	
Mean number of living children	0.0	0.3	1.1	2.3	3.5	4.4	5.3	5.7	6.2	
Total paternal orphans	3.9	52.6	167.4	301.8	368.0	365.6	605.2	508.9	427.9	
Paternal orphans <15 years old	3.9	52.6	167.4	299.2	336.2	277.5	344.2	198.2	119.0	1,798
Total paternal orphans < 15 (gross)										5,656

6. Adjust for dual parent mortality

The above calculations suggest a certain number of children who have lost a mother and who have lost a father, but they do not account for spousal infection. If a woman dies of EVD, is it not more likely that her spouse will also die of EVD? If this is the case, then simply summing the maternal and paternal orphans will overstate the total number of orphans. No data are available for the current epidemic on spousal infection. However, evidence from an outbreak of EVD in the Democratic Republic of Congo in 1995 showed that 45% of spouses of EVD patients developed the fever. [15] The fatality rate, as calculated by the number of deaths divided by the number of confirmed, probable and suspected cases (as of February 11, 2015) ranges from 31% to 66% across the three countries. [11] So, if one parent dies in Guinea, for example, the probability that both will die is about 30% (45% * 66%), assuming that the probability of the spouse contracting EVD when the other spouse dies of EVD is the same as when the other spouse contracts EVD. The equivalent probabilities in Liberia and Sierra Leone are 19% and 14%, respectively.

This paper uses the DHS estimates for the proportion of women either married or co-habiting (henceforth "in union") and the MNLC for women in union to calculate the maternal orphans from women in union. It is then assumed that the orphans from 30%, 19%, and 14% of unions in Guinea, Liberia, and Sierra Leone also lose a father, as in Table A5. This suggests that 643 of the total orphan count is accounted for by orphans who have lost both parents, or double orphans. This reduces the total orphan count from 10,483to 9,840.

7. Adjust for child mortality from EVD

Tragically, some proportion of these children who lose parents will have been among the dying themselves. As Table 1 shows, a relatively small proportion of children die from EVD, particularly given their high share in the population. No data from the current epidemic are available on the likelihood that a child contracts EVD, conditional on a parent contracting EVD. Returning to estimates from the 1995 outbreak, it is estimated that household members under 18 had a 4% chance of contracting EVD, conditional on an adult in the household contracting it. [15] Thus, if a parent dies in Guinea, the probability of a child dying is about 2.6% (4% chance of child infection * 66% chance of fatality).

If both of a child's parents die in Guinea, the probability of the child dying is higher, estimated at 5.2% [100%-(100%-2.6%)^2]. Unconditionally, the probability of a child dying of EVD is extremely low, ranging from 0·007% in Guinea to 0·043% in Liberia (i.e., even in Liberia, the probability is only 4 children in 10,000). Applying the country-specific probabilities of death among single and double orphans in this way would leave 9,655 surviving orphans (Table A6).

8. Resulting estimate of the total number of orphans

Thus, the total number of maternal, paternal, and double orphans is estimated as 4,112, 4,925, and 618, in Guinea, Liberia, and Sierra Leone, respectively, summing to 9,655 total orphans under the age of 15, as shown in Table A6 and Figure 2.

Table A5: Number of Paternal Orphans Explained by Spousal Contagion

	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
Guinea								
Proportion women who are in union	33.2%	67.5%	84.3%	92.2%	92.7%	92.5%	93.7%	
Women in union: Deaths	44.71	77.35	80.47	72.30	59.28	49.22	74.25	
Women in union: Mean number of living children	0.7	1.6	2.6	3.7	4.4	4.7	5.1	
Women in union: Maternal orphans <15 years old	32.6	123.0	206.0	243.5	220.2	190.3	308.7	
Number of spousal male deaths	13.2	22.8	23.7	21.3	17.5	14.5	21.9	135.0
Percentage of male deaths (15-59) explained by Ebola								18.8%
Number of paternal orphans created through spousal contagion								255.0
Liberia								
Proportion women who are in union	14.3%	52.4%	72.6%	79.8%	78.4%	76.2%	77.9%	
Women in union: Deaths	34.1	111.2	135.5	124.8	100.7	80.4	98.5	
Women in union: Mean number of living children	0.8	1.6	2.5	3.5	4.1	4.9	5.2	
Women in union: Maternal orphans <15 years old	27.3	175.6	338.8	412.6	363.2	331.4	429.6	
Number of spousal male deaths	6.6	21.5	26.3	24.2	19.5	15.6	19.1	132.8
Percentage of male deaths (15-59) explained by Ebola								9.5%
Number of paternal orphans created through spousal contagion								238.4
Sierra Leone								
Proportion women who are in union	18.8%	58.5%	81.7%	88.9%	87.3%	85.9%	82.0%	
Women in union: Deaths	38.5	107.4	134.2	124.1	99.0	76.8	97.6	
Women in union: Mean number of living children	0.7	1.5	2.4	3.3	4.0	4.5	4.8	
Women in union: Maternal orphans <15 years old	27.3	162.1	326.2	383.6	337.2	278.9	382.7	
Number of spousal male deaths	5.3	14.8	18.5	17.1	13.6	10.6	13.4	93.2
Percentage of male deaths (15-59) explained by Ebola								8.3%
Number of paternal orphans created through spousal contagion								149.6
Total paternal orphans explained by maternal mortality								643.0

Table A6: Orphan Count for Guinea, Liberia, and Sierra Leone

	Guinea	Liberia	Sierra Leone	Total
Maternal orphans (gross)	1,089	2,039	1,698	4,826
Paternal orphans (gross)	1,354	2,504	1,798	5,656
Total (gross)	2,443	4,543	3,497	10,483
Double orphans	255	238	150	643
Maternal orphans (adjusted for spousal contagion)	834	1,801	1,549	4,183
Paternal orphans (adjusted for spousal contagion)	1,099	2,265	1,649	5,013
Total	2,188	4,304	3,347	9,840
Double orphans (adjusted for child mortality)	242	230	146	618
Maternal orphans (adjusted for child mortality)	812	1,770	1,530	4,112
Paternal orphans (adjusted for child mortality)	1,071	2,226	1,629	4,925
Surviving orphans	2,125	4,226	3,304	9,655
Percentage of total children	0.05%	0.25%	0.14%	0.11%