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The Impact of the HIV/AIDS Epidemic on Kinship Resources for Orphans in Zimbabwe

EMILIO ZAGHENI

THE HIV/AIDS epidemic has led to unprecedented excess mortality in the populations of sub-Saharan Africa. The impact of the epidemic, however, is not limited to the people who contract the disease. The epidemic's physical, emotional, and economic consequences are felt by family members, including members of the extended family, and by the community at large (e.g., Palloni and Lee 1992; Bor and Elford 1998; Wachter, Knodel, and VanLandingham 2002).

Although there has been some progress in the containment of the epidemic worldwide, orphanhood resulting from HIV/AIDS mortality remains a pressing problem, especially in sub-Saharan Africa.[1] Even under the optimistic scenario of a fairly rapid reduction in new HIV cases over the next decade, the number of orphans will continue to grow. There are two main reasons for this: first, there is a lag between the peak in adult HIV prevalence and the peak in AIDS-related orphanhood prevalence; second, the transition to orphanhood is a cumulative process with age.

The negative indirect consequences of the epidemic are likely to become increasingly harsh for children and the elderly. Traditionally in sub-Saharan Africa, child fostering and other social practices based on mutual support among members of the same kin have mitigated the impact of orphanhood. The extended family remains an essential safety net. With the rising levels of widowhood and orphanhood associated with the HIV/AIDS epidemic, however, the material basis of traditional kin relations may weaken to the point where new forms of social relations may emerge (e.g., Palloni and Lee 1992; Merli and Palloni 2006). Estimates and projections of orphanhood prevalence and kinship resources available to orphans are important in evaluating both alternative strategies and the resources needed to address the lack of care. They are also relevant for the debate on whether new forms of social relations may replace traditional ones based on kin relations.

I use microsimulation to estimate and project probabilities of orphanhood and the evolution of the kinship structure in Zimbabwe for the period between

1980 and 2050. This study is the first attempt to evaluate in quantitative terms kinship resources available to orphans in the context of sub-Saharan Africa. Zimbabwe is one of the countries hardest hit by the HIV/AIDS epidemic. Against a background of poverty, economic failure, and international political isolation, the adult HIV prevalence rate as of 2007 is estimated to be about 15 percent (UNAIDS/WHO 2008). After reaching a peak of almost 30 percent at the end of the 1990s, the country's adult HIV prevalence rate has been decreasing, but is still extremely high. According to estimates by UNICEF (2006), 21 percent of children 0–17 years old in Zimbabwe were orphans in 2005. The country's level of orphanhood is likely to remain substantial for decades. Throughout the article, "orphan" refers to a child with a least one deceased parent. "Double orphan" is used when both parents are deceased.

The first section of this article provides some background on the impact of the HIV/AIDS epidemic on children in sub-Saharan Africa. It reviews the literature on the effects of orphanhood on economic, education, and health outcomes. The second section discusses the role of the extended family and traditional forms of social relations, such as child fostering. The third gives some context for the setting of Zimbabwe. The fourth section describes the microsimulation approach that I propose and the data sources that I use to inform the model. The fifth section provides the main results of the study, which I then discuss in the concluding section.

The impact of HIV/AIDS on children in sub-Saharan Africa

The HIV/AIDS epidemic has a negative effect on multiple aspects of children's lives. Children may be affected only indirectly, at a community level, or they may experience the burden of the disease directly: they, or a household member, may become infected. Some children may have to drop out of school to help with household work or to care for ill parents. These children may suffer both emotional distress and material hardship following the death of a parent.

The degree to which children are affected by the HIV/AIDS epidemic depends on several interrelated factors. For instance, some important elements that may mitigate or worsen the impact of the disease are the overall level of HIV incidence, the economic status of the community and the households affected by the disease, the sex and age of children when a household member becomes infected, and the efficiency of safety nets.

Economic impact

Children experience material hardship before they become orphans. When a parent develops HIV-related symptoms, children may have to care for other

members of the household, including sick parents and young siblings. They may have to devote their time to activities such as cooking, cleaning, carrying water, and caregiving. Girls are more frequently caregivers for female relatives and assume greater responsibility for domestic work (Robson 2000). Boys are more involved in agricultural and income-generating activities that help with medical expenses and compensate for their parents' reduced workload. When children become orphans, their workload is likely to increase, either because their household has been impoverished by the death of a parent or because the orphans move to the household of a relative, where their workload may be greater than that of non-orphans living in the same household (Foster et al. 1997).

Orphaned children may be at risk of losing their family's property. For instance, in the case of Zimbabwe, only a very small proportion of families write a will prior to death. In some cases, property is inherited by paternal relatives, and instances of "property-grabbing" by relatives vary from region to region. A survey in Zimbabwe indicated that property is usually inherited by children, with 15 percent of respondents reporting "property-grabbing" (Drew, Foster, and Chitima 1996).

The poorer people in a community, especially women, usually care for orphans in sub-Saharan Africa (Foster and Williamson 2000). This is often because orphans tend to live in larger households in which the caregiver is much older than the child (Monasch and Boerma 2004). Families that are better off, on the other hand, tend to find their economic reserves depleted since they are frequently asked to provide economic resources to relatives affected by AIDS (Foster and Williamson 2000).

Biological relatedness is a relevant predictor of the quality of care offered (Bishai et al. 2003). Expenditures on child-related goods are lower when the child's birth mother is absent (Case, Lin, and McLanahan 2000). In addition, maternal orphans are more likely to be "virtual" double orphans—that is, children who lose the care of both parents when one parent dies (Case, Paxson and Ableidinger 2004).

Impact on education

When a parent becomes sick, his or her children's education is often disrupted. With the financial strain of the disease and the reduced resources available for the household, insufficient funds may be available for children to attend school, or their caregivers may have less interest in the children's welfare. Children might therefore have to perform domestic work or income-generating activities rather than attend school (UNICEF 2006).

Although there are substantial variations across countries, several studies provide evidence that school enrollment rates for orphans are significantly lower than those of non-orphans. For instance, a study in eastern Africa

shows that double orphans between ages 6 and 10 years are half as likely to be at the appropriate educational level compared to non-orphaned children of the same age (Bicego, Rutstein, and Johnson 2003). Overall, the effect of orphanhood on schooling is larger for double orphans than for maternal or paternal orphans (Case, Paxson, and Ableidinger 2004). The negative effect of maternal death on schooling is larger than that of paternal death (Gertler, Levine, and Martinez 2003; Evans and Miguel 2007).

Under some circumstances, young girls may be more likely to be denied education than boys. It is not clear, however, whether the gender gap in education is more prominent in orphans than in non-orphans (UNICEF 2006). In some studies, probabilities of enrollment appear to be negatively correlated with certain characteristics of the children, such as being a female orphan, an AIDS-related orphan, living in a rural or poor household, or in a household headed by a man (World Bank 1997; Foster and Williamson 2000).

One key factor in the explanation of educational outcomes for orphans is the relationship between the child and the head of household. Regardless of the poverty level, the closer the biological tie, the more likely the child is to go to school consistently. The closest relatives tend to make substantial commitments to ensure that children under their care attend school (UNICEF 2006). This is consistent with arguments from evolutionary biology (e.g., Hamilton 1964). Much of the gap in schooling is related to the tendency of orphans to live with distant relatives or unrelated caregivers. Parker and Short (2009) show that, in Lesotho, children living with grandmothers are just as likely to attend school as children living with mothers, net of other factors. Their results emphasize the importance of grandparents and family structure on child outcomes in southern Africa.

Impact on health

The HIV/AIDS epidemic has a clear impact on child mortality beyond the direct effect of HIV transmission from the mother. For the youngest age group (between 0 and 3 years old), the loss of a parent is significantly associated with their survival probabilities.[2] Children who become orphans are also more vulnerable than non-orphans. They are more likely to become street children or sex workers and, as a result, to be infected with HIV (Richter and Swart-Kruger 1995).

Although the evidence of a general increase in morbidity and mortality among orphans is weak, it is expected that the health of orphans, particularly those being cared for by adolescents and elderly caregivers, is worse than that of other children (Foster 1998). For instance, orphans may be more malnourished than non-orphans, because of reduced household resources or because parental illness or death disrupts normal childrearing.

Orphanhood has consequences for psychological health as well as physical well-being. The stress and trauma of parental illness and death are

amplified by stigmatization, dropping out of school, changes in friendships, increased workload, discrimination, and social isolation (Foster and William-son 2000). Sengendo and Nambi (1997) found that most orphans in Uganda were depressed, with lower expectations about the future than non-orphans, especially those who relocated from urban to rural areas. They also noted that depression was more likely in children living with a widowed father than in those living with a widowed mother.

Coping mechanisms and the extended family

A generalized HIV/AIDS epidemic has a considerable impact on rates of mor-tality and fertility, with consequences for population age structure, sex ratio, and the probability of orphanhood. The epidemic also affects household struc-ture, movements in and out of the household, and the availability of kinship resources, both for young children and for the elderly (e.g., Wachter, Knodel, and VanLandingham 2002, 2003; Heuveline 2004). The principal safety net in sub-Saharan Africa is provided by the extended family. Some nurturing roles are delegated to non-biological parents through child fostering. Social protec-tion provided by governments is very limited or nonexistent in most settings. When some form of social protection exists, indirect assistance to foster fami-lies or to a parent whose partner has died may benefit only a small fraction of the population—namely, members of the middle class who are employed in the formal sector. Typically, especially for the poor, work is home-based and in the informal sector, without social protection provided by the state. In a crisis, external help may come from religious groups or nongovernmental donors, often funded by international organizations. More often, the primary source of assistance is the kin network.

　　A major challenge is whether traditional fostering practices can adapt to the increasing demands that the HIV/AIDS epidemic imposes on them. The coping mechanisms for orphans in sub-Saharan Africa vary across countries and social settings. Nevertheless, a common element that distinguishes sub-Saharan Africa from Western societies is that children are fostered rather than adopted. Child fostering consists of culturally sanctioned arrangements whereby children are reared by adults other than biological parents. These arrangements are based on agreements between biological parents and other adults, often relatives. They strengthen ties across the community and provide mutual benefits to both natal and fostering families. Although institutional care exists, mostly in post-conflict countries, orphanages generally are not culturally and socially acceptable, and are considered too expensive.

　　Fostering practices in sub-Saharan Africa can be categorized into "pur-posive" and " crisis" fostering. There are several reasons to foster a child under voluntary circumstances. Isiugo-Abanihe (1985) reviews the motivations for purposive child fostering in West Africa. Most fostering there takes place within the kinship network and is largely motivated by the need to real-

locate resources within the extended family or clan, in order to maximize the survival probabilities of the kinship unit and to strengthen kinship ties. Fostering practices are strongly related to factors such as kinship obligations, apprenticeship/training, alliance building, domestic labor, and education. Purposive fostering relies on reciprocal advantages, responsibilities, and rights. Social rules determine the age structure of the exchange, which is intended to bring reciprocal advantages. Crisis fostering, on the other hand, is related to specific obligations. Goody (1982) pointed out that kin members who have the right to a child in voluntary fostering are also obligated to foster the child in a period of crisis.

Before the onset of the HIV/AIDS epidemic in sub-Saharan Africa, the combination of fostering practices and the relative abundance of kinship re-sources alleviated the problems associated with orphanhood (e.g., Ntozi and Nakayiwa 1999). The epidemic has increased both the number of orphans and the proportion of those who are double orphans as a result of HIV transmis-sion between spouses. The larger number of double orphans, coupled with the increased mortality rate among adults, reduces the number of adult kin available for childrearing and increases the burden on grandparents. This situ-ation raises the question whether the practice of fostering, which allowed for a sustainable distribution of obligations among kin in the past, may be under-mined by the rapid increase in AIDS-related deaths (Madhavan 2004).

Mathambo and Gibbs (2009) review how families in southern Africa respond to the HIV/AIDS epidemic. They conclude that families remain a critical safety net, and that childcare responsibilities are changing in in-novative ways to include a wider network of kin and social relations. Lund and Agyei-Mensah (2008) show that the operations of the traditional safety net may depend largely on the services of community-based organizations, volunteers such as elderly women who are widowed or divorced, and other private caregivers.

Although orphans in Zimbabwe have traditionally been incorporated into the extended family, the very high number of adult deaths has shifted the burden to the elderly and adolescents (Drew, Makufa, and Foster 1998). As a result, households headed by grandparents or adolescents increased in the 1990s. In traditional Zimbabwean society, orphan children are cared for by members of the extended family. Foster (2000) describes how the caregiving functions of parents were usually assumed by paternal aunts and uncles. More recently, the safety net provided by the extended family has weakened. There are several reasons behind this process, such as changes in the economy and labor migration, and an increase in formal education (ibid.). With the rising number of orphaned children and the unavailability of traditional caregivers, grandparents are being recruited into childcare (e.g., Foster et al. 1996).[3]

The role played by members of the extended family in caring for orphans is closely related to cultural practices that vary across time and geographical

region. The onset of the HIV/AIDS epidemic has influenced such practices through changes in behavior—for instance, through stigmatization of households affected by HIV/AIDS. The epidemic has also altered the demographic structure of the population, reducing the kinship resources available to orphans and the elderly, and affecting household structure. In many countries in sub-Saharan Africa, especially where orphanhood rates are growing rapidly, the number of households comprised solely of older generations and children, the so-called skipped-generation households, has been rising (Samuels and Wells 2009; Zimmer 2009), and there has been a shift toward grandparents taking increased childcare responsibilities (Beegle et al. 2010). AIDS mortality is generally associated with a higher risk of union dissolution when the household head dies or when multiple deaths have occurred. Households with HIV-positive members adapt to the burden by exchanging household members within the kinship network or by borrowing cash or services (Heuveline 2008). Migration into and out of the household, in anticipation of or as a response to a death, is a key strategy to restore income sources (Madhavan, Schatz, and Clark 2009). The process of adaptation diffuses the impact of the epidemic over a considerable number of households.

The case of Zimbabwe

Zimbabwe, a landlocked country in southern Africa, has a population estimated by the UN at 12.6 million in 2010, with a life expectancy of around 50 years. About half the population is younger than age 18. The total fertility rate (TFR) is about 3.5, and the population growth rate is about 1.5 percent per year, but with a high degree of uncertainty. Fertility rates are expected to continue decreasing, following a trend that started a few decades ago. In the early 1980s, the TFR was around 6. According to UN estimates, it is expected to approach replacement level by around 2030. Marriage is nearly universal in Zimbabwe: the proportion of never-married women falls from about 76 percent in the age group 15–19 to 1 percent in the age group 45–49. Men tend to marry on average five years later than women (CSO and Macro International 2007).

The urban population accounts for nearly 40 percent of the country's total. Urban areas are characterized by a less traditional approach to social relationships. For example, the prevalence of polygamy, which is still accepted in rural areas, is very low among young urban men and women. According to Demographic and Health Survey data, the highest level of polygamy is in Central Mashonaland, where about 8 percent of men have two or more wives, compared with fewer than 1 percent of men in Bulawayo. The prevalence of polygamy is associated with age. Younger cohorts, and especially better-educated and affluent women, are less tolerant of polygamy.

Zimbabwe benefited earlier from a well-developed health care and financial system, but the country's economy and standard of living have de-

clined rapidly since the late 1990s. Its involvement in the war in the Democratic Republic of Congo, from 1998 to 2002, drained substantial resources from the country. In 2000, President Mugabe initiated a land reform that entailed a compulsory land redistribution to black Zimbabweans. One of its main consequences was a sharp decline in agricultural production and exports, which resulted in food shortages, high unemployment, and capital flight from the country. All sectors of the economy have been severely affected. To fund the budget deficits, the Reserve Bank of Zimbabwe routinely printed money, leading to hyperinflation and, ultimately, to the suspension of the Zimbabwean dollar in 2009. The country's HIV/AIDS epidemic contributed further to its economic decline and growing international isolation.

The two major ethnic groups in Zimbabwe are the Shona (about 82 percent of the population) and the Ndebele (about 14 percent).[4] These communities are built around a patrilineal kinship system. Members of the same patriline live together in multi-generational residential groups, have a strong sense of belonging to a large extended family, and provide mutual assistance and share resources. Traditionally, the concept of orphan did not exist in Zimbabwe, since biological orphans could rely on the care of members of the extended family—in particular, aunts and uncles. With recent demographic and economic change, however, the extended family has been weakened. For instance, the fact that new members of the community, such as maternal rather than paternal relatives, are becoming more prominent in providing care to orphans, especially in urban areas, is a sign of the breakdown of traditional practices (Foster, Drew, and Makufa 1995; Foster et al. 1997).

Data and methods

The SOCSIM microsimulation program

For the analysis of kinship dynamics over the course of the HIV/AIDS epidemic, I make use of SOCSIM, a stochastic microsimulation platform originally designed in the 1970s at the University of California, Berkeley (e.g., Hammel et al. 1976; Hammel, Mason, and Wachter 1990). SOCSIM has been used to model the dynamics of kinship structure in both historical and contemporary populations (e.g., Wachter, Hammel, and Laslett 1978; Wachter 1997; Wachter, Knodel, and VanLandingham 2002, 2003). The core microsimulation package is flexible and freely available to users who want to customize it.

Each individual in the simulation is an observation in a data file, with records of demographic characteristics for the referenced individual, and identification numbers for key kinship members.[5] The individual is the unit of analysis. Each person is subject to a set of rates, expressed as monthly probabilities of events, given certain demographic characteristics such as age, sex, and marital status. Every month, each individual is at risk for a number of

events including childbirth, death, marriage, and HIV infection. The selection of the event and the waiting time until the event occurs are determined stochastically, using a competing-risk model. Some other constraints are included in the simulation program, in order to draw events only for individuals who are eligible for them.

Each event for which the individual is at risk is modeled as a piecewise exponential distribution. The waiting time until each event occurs is randomly generated according to the associated demographic rates. The individual's next event is the one with the shortest waiting time. Marriage formation is somewhat more sophisticated: SOCSIM is a closed simulator, which means that all partners must be drawn from the existing population and cannot be externally generated. The computer program uses a two-stage process to pair eligible males and females from within the simulated population. When the next scheduled event for an individual is marriage, the person is placed in a pool of eligible members with whom to form a union. If a member of the opposite sex with appropriate demographic characteristics is available, then the two individuals are paired. Otherwise, the person stays in the pool until an appropriate mate is found.

At the end of the simulation, two main data files are created, the population file and the marriage file. These files contain a list of every person who has ever lived in the population and a list of every marriage that has ever occurred. These data sets can be analyzed to determine the main demographic characteristics of the population and to identify the entire kin network of any individual at any time.

Modeling the HIV/AIDS epidemic

Although SOCSIM was not specifically programmed to model the dynamics of a generalized HIV/AIDS epidemic and its demographic consequences, the microsimulator may be modified to address a wide range of research questions. I model key features of the HIV/AIDS epidemic by taking advantage of the flexible "group structures" in SOCSIM. Each individual in the simulation may belong to a series of mutually exclusive groups, which can be broadly defined. I use group structures to represent HIV status. Each individual can be either HIV-positive or HIV-negative at any given time, and is subject to mortality rates that are dependent on his or her HIV status. Adult agents in the microsimulation become HIV-positive according to age-specific rates of transmission. Their life expectancy at the time they become HIV-positive is modeled to be about 10 years. Newborns to HIV-positive mothers can become HIV-positive through perinatal transmission of the virus. This specific transmission mode is modeled through inheritance of group membership. If the mother is HIV-negative at the time she gives birth, her child is born HIV-negative. If the mother is HIV-positive at the time of birth, her child has a

probability of 0.35 of being HIV-positive at the age of one month. HIV-positive babies have a life expectancy of 7 years.

For a married individual, the probability of becoming HIV-positive is associated with the HIV status of the spouse. Sero-concordance in HIV status of partners increases the probability of double orphanhood, compared to a baseline scenario where couples are sero-discordant. In the version of SOC-SIM that I used, the baseline age-specific risk of transition from HIV-negative to HIV-positive status can be multiplied by a user-defined factor, when the individual's spouse is HIV-positive. The choice of the value for the multiplier is not obvious, since there is little empirical evidence on how the risk of becoming HIV-positive varies according to the HIV status of the partner. There is also considerable variability across countries and overall levels of adult HIV prevalence rates. Based on some results in the literature (e.g., Grassly, Phil, and Timaeus 2005; Todd et al. 2006), I chose a value of 9 as a risk factor for the simulation for Zimbabwe. This means that if an individual is HIV-positive, the spouse's risk of becoming HIV-positive is 9 times higher than the risk for an individual whose spouse is HIV-negative.

The microsimulation for Zimbabwe's population covers the period 1980 to 2050. A starting population that matches key demographic characteristics of the population of Zimbabwe in 1980 has been created by letting a small unmarried initial population evolve over 100 years. The initial simulated population for 1980 is composed of about 50,000 living individuals. The population size of living individuals at the end of the simulation, in 2050, is about 150,000.

The simulation is composed of 15 segments. For each segment, the computer program reads an input population file and demographic rates and produces an output population file.[6] For each five-year interval, new sets of demographic rates are used as input. These rates are estimated using data either from the United Nations or from the Demographic and Health Surveys for Zimbabwe. The basic set of age-specific and sex-specific rates needed for the simulation are fertility, marriage, and mortality rates. The baseline age-specific patterns of fertility are obtained from the 2006 Revision of the UN *World Population Prospects* (medium scenario). The baseline age-specific patterns of nuptiality come from the 2003 World Fertility and Marriage Database and the Demographic and Health Surveys. As for mortality rates, I distinguish between HIV-positive and HIV-negative individuals. For HIV-negative individuals, I estimated age-specific patterns of mortality based on cause-specific life tables derived from the 2006 Revision of *World Population Prospects*. For HIV-positive individuals, patterns of mortality reflect a remaining life expectancy at the time of infection of about 10 years for adults and 7 years for children (e.g., Stover 2004). Age-specific HIV infection rates are obtained using a back-calculation technique based on United Nations estimates and projections of numbers of AIDS-related deaths. (Appendix Table 1 summarizes

the main input parameters and demographic rates for the microsimulation and lists the respective data sources.) The approach to calibrate the input parameters reflects recent developments of Bayesian techniques in the area of statistical inference for simulation models (e.g., Ševčíková, Raftery, and Waddell 2007).[7]

Kinship resources for children and young orphans

The key estimates of interest are obtained by averaging summary statistics from the microsimulation over several runs with the same baseline parameters. The results are specific to Zimbabwe; however, to the extent that the pattern of AIDS mortality, prevalence of orphans, and availability of kinship are similar to those found elsewhere, the main insights from microsimulation are informative also for other contexts where a generalized HIV/AIDS epidemic is found.

The current peak of orphanhood prevalence in Zimbabwe

Figure 1 shows estimates and projected percentages of maternal and double orphans, by child's age, between 1980 and 2050 in Zimbabwe. The probability that both parents have died is fairly low at age 5, but increases rapidly thereafter. The probability of double orphanhood at age 10 reaches a peak at around 12 percent shortly after 2000. For children at age 15, the peak occurs at about 22 percent between 2005 and 2010. Probabilities of maternal orphanhood show a similar pattern with age, at a level that is clearly higher.

FIGURE 1 Estimated and projected percent of maternal and double orphans, by child's age, Zimbabwe 1980–2050
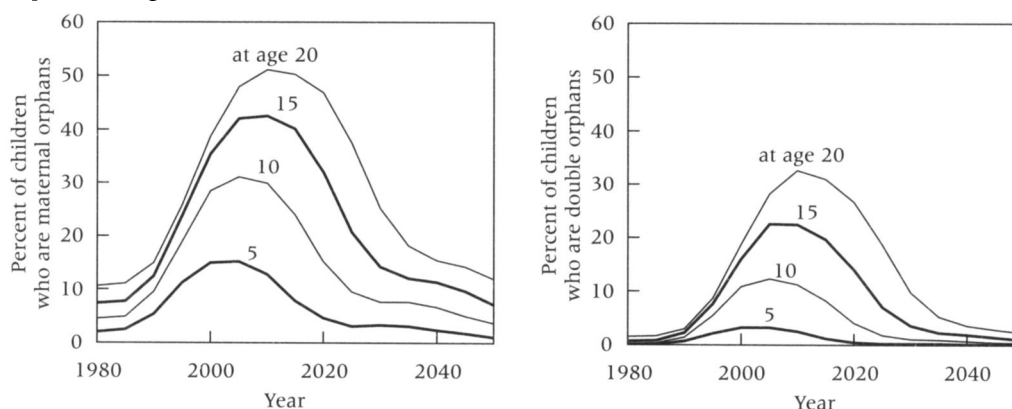
Orphanhood prevalence is highest between 2000 and 2010, depending on the age of the orphans, with younger ages reaching a peak earlier in time, since the process is cumulative.

The prevalence of maternal and double orphanhood is expected to decrease over the next two decades. For instance, the proportion of double orphans in the age group 0–17 is projected to decline from about 11 percent in 2010 to 6 percent in 2020 and 2 percent in 2030. These reductions are consistent with UNAIDS projections that adult HIV prevalence rates will continue to decrease steadily over time. My results are also consistent with estimates published by UNICEF (2006), which imply an orphanhood prevalence rate for the age group 0–17 of about 11 percent around 2005.

Whereas the youngest orphans are in greatest need of physical care and nurturing, adolescents may be more at risk of exposure to HIV and other sexually transmitted infections, of dropping out of school, and of being exploited. As seen in Figure 1, young children form the smallest group of orphans, but the peak in orphanhood probabilities occurs earlier in time for them. This means that the proportion of young orphans is relatively high in the initial stages of the AIDS epidemic. Thereafter, the proportion of adolescent orphans becomes increasingly large. In response, funding agencies should allocate sufficient resources to meet the needs of young children in the initial stages of the rise in orphanhood. In later stages, a relatively higher proportion of resources should be allocated to meet the needs of adolescent orphans.

The rising proportion of double orphans with no living grandparents

Although the proportion of orphans is projected to decrease during the next few decades, orphaned children will have fewer and fewer grandparental resources over that period. Figure 2 shows the percentage of children aged 0–17 who are double orphans and the percentage of these double orphans who have no living grandparents. There is a gap of more than a decade between the peak in orphanhood prevalence and the peak in scarcity of grandparents for double orphans. Between 2020 and 2030, about 35 percent of double orphans aged 0–17 will have no grandparents on whom to rely. By this time, the overall fraction of orphans will be relatively small, and they will no longer be in the youngest age group. However, the orphans who remain alive will lack an important component of their kinship network and thus will be especially vulnerable. My projections show that between 2020 and 2030, most double orphans will have only one living grandparent.

The lag between the peak in orphanhood prevalence and the peak in the scarcity of grandparents is related to the extended period of time over which the HIV/AIDS epidemic evolves. During the initial phase of the epidemic, the adult population is at the highest risk of infection. AIDS-related

FIGURE 2 Percent of children 0–17 years old who are double orphans (left scale), and percent of these double orphans who have no living grandparent (right scale)
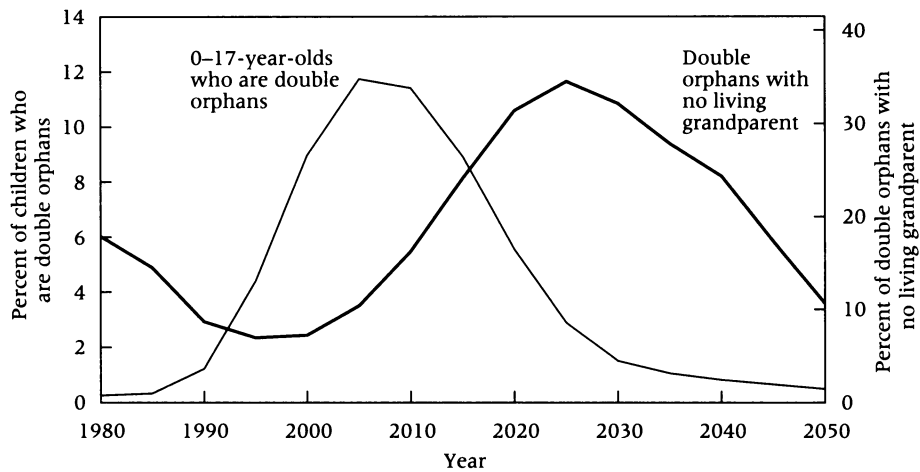
mortality starts to increase until it reaches a peak about 10 years after the peak in HIV prevalence. The incidence of orphanhood rises with the increase in adult mortality: as more adults in post-reproductive ages die, more children become orphans as a consequence. The grandparents of this first generation of orphans have gone through adulthood at a time when the epidemic was almost non-existent. As a result, the first generation of orphans has a high probability of having living grandparents during their childhood. However, the children of these orphans will face a different outlook, as their parents have a higher risk of dying of AIDS. This second generation of orphans will be smaller than the first, but it is more likely that they have lost not only their parents, but also their grandparents.

The most vulnerable children are double orphans with no living grandparents. In some cases, uncles and aunts may step in as caregivers. In other cases, other foster families, or international organizations, provide care. The balance between different caregivers depends on the extent to which traditional forms of social relationships are affected by the epidemic. That is related, in turn, to the degree to which kinship resources are eroded as a consequence of AIDS-related deaths.

## Availability of uncles, aunts, and siblings

In Zimbabwe, uncles and aunts, especially on the paternal side, play an essential role in raising children within the extended family, or in providing support to child-headed households (e.g., Foster et al. 1997). As a consequence of the HIV/AIDS epidemic and the declining rates of fertility, the number

of uncles and aunts available to children has decreased over time. Figure 3 shows estimates and projections of the average number of uncles and aunts for double orphans aged 0–17 years. In other words, the figure gives the ratio of the number of living uncles and aunts of double orphans to the number of double orphans. The estimated trend for the period 1980–2050 is U-shaped. Before the epidemic started, high fertility and the relatively low number of orphans resulted in an abundance of uncles and aunts for children who had lost both parents. As the severity of the epidemic increased, the availability of uncles and aunts fell to its lowest point in the early 2000s. I project that the availability of uncles and aunts will increase during the next few decades: although the pool of uncles and aunts will not grow, the number of double orphans will decline.

My results are consistent with the observations that traditional forms of social relationships are under stress and new members of the community are providing care to children. For instance, mutual help between members of the same patriline is less prevalent in urban areas, where it is becoming more common for maternal aunts and uncles to care for orphans. During the coming decades, the higher availability of uncles and aunts should partially compensate for the reduction in grandparental resources that I described earlier.

Orphans are often a heavy burden on relatives, who may refuse to care for them. Such refusal is indicative of the decline of traditional practices within the extended family. Foster et al. (1997) showed that the major factors that lead to the establishment of child-headed households are the death of both parents and the availability of relatives who may provide support to the children but refuse to accept them into their own households. In other

FIGURE 3   Estimates and projections of the average number of living uncles and aunts of double orphans 0–17 years old, Zimbabwe 1980–2050
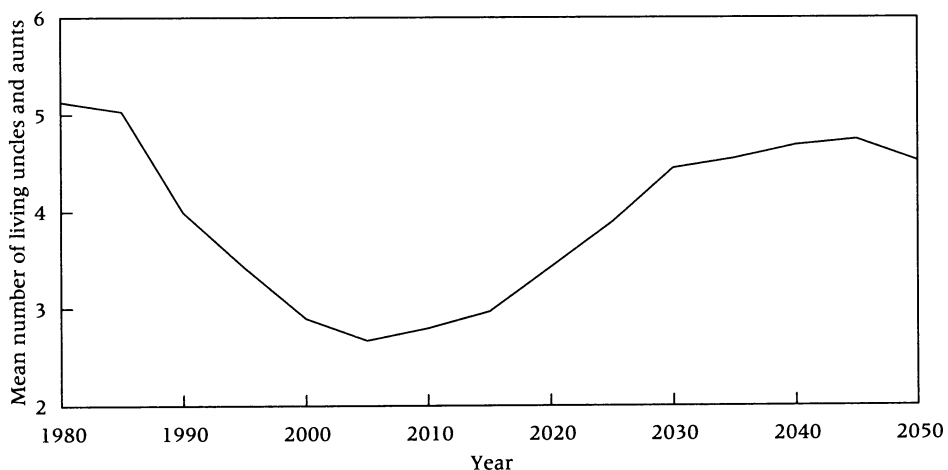
FIGURE 4   Estimates and projections of the percent of double orphans younger than 10 years who have at least one living sibling older than 15 years, Zimbabwe 1980–2050
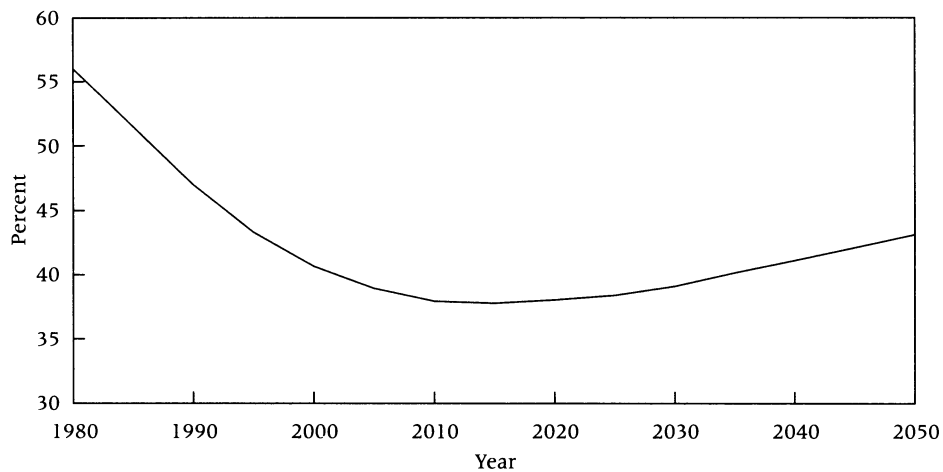
cases, relatives are non-existent, or they are distant, sick, or lack the material means to provide for additional children.

Households headed by adolescents represent an additional feature of the impact of HIV/AIDS on communities. It is thus informative to consider the availability of older siblings to support younger brothers and sisters. Figure 4 shows the estimated trend over time in the proportion of young double orphans (those under the age of 10) with at least one sibling who is older than 15 years. In the 1980s, before the HIV epidemic took off, about half of these double orphans fell into this category. By 2010, fewer than 40 percent of the youngest double orphans were estimated to have an older adolescent sibling. This percentage is projected to rebound gradually over the next few decades. Figure 4 shows that, at the time when the availability of uncles and aunts is at its lowest level, older siblings are also scarce. As a result, the formation of child-headed households as a strategy to cope with the epidemic may be seriously undermined by the age structure of siblings. This observation may explain the finding that the number of child-headed households has not been increasing in Zimbabwe in recent years, even as the number of orphans has continued to grow (Ciganda, Gagnon, and Tenkorang 2010).

A kinship transition for young children?

I examine the trend in overall kinship resources for young children by charting the evolution over time of an index of kinship availability. For children who are less than 10 years old, I estimate the average number of selected kinship members (parents, grandparents, uncles/aunts, older siblings). Each

kinship member is given a weight equal to his or her genetic relatedness to the child. Relatedness is measured by Hamilton's coefficient, defined as the percentage of genes that two individuals share by common descent.[8] The average number of living kinship members for children (in Hamilton's sense) is then weighted by the number of unique living kinship members for the period considered and normalized to the value of 100 for 1980. In other words, if the number of unique kinship members (who are also potential caregivers) decreases over time, all else being equal, then the index will decrease over time as well. Analogously, if the average number of weighted kinship members for children decreases over time, the index will also decrease.

Figure 5 shows the evolution of the index of kinship resources for children younger than 10 years old in Zimbabwe. It plots change from relatively high levels of kinship resources for children in the 1980s to relatively low levels from 2010 onward. The rapid decline in kinship resources results from the combination of higher adult mortality and lower fertility. When mortality conditions improve, the index can be expected to increase slightly. However, it will not return to pre-epidemic levels, as fertility rates are expected to be much lower in the future.

This transformation in kinship structure is largely a consequence of the demographic changes associated with the HIV/AIDS epidemic and the fertility transition. These structural changes can be seen as a "kinship transition." Before the HIV/AIDS epidemic, kin were abundant and played an important insurance role. Practices such as child fostering strengthened alliances and increased the chance that at least one member of the extended family would be able to help the rest of the family. The demographic shock caused by the HIV/AIDS epidemic accelerated a transition in kinship structure that was al-

FIGURE 5   Estimates and projections of an index of overall kinship resources for children younger than age 10, Zimbabwe 1980–2050
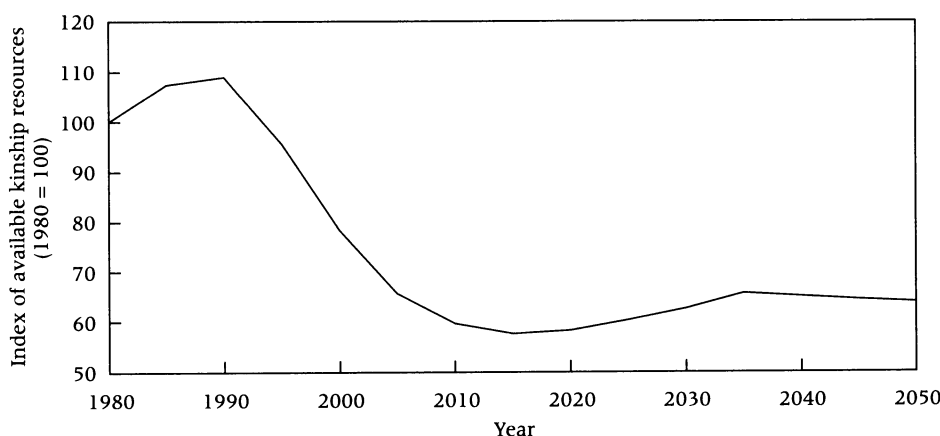
NOTE: For construction of index see text.

ready underway, and potentially undermined traditional social mechanisms on which the kinship organization relied. Some changes resulting from this transition may simply derive from changes in demographic rates of fertility and mortality. Other changes may be the result of the interaction between the transformation in the kinship network and social practices. These changes may lead to new forms of social cohesion supported by kinship structure.

Discussion

This study provides a quantitative assessment of the availability of kin for orphaned children in Zimbabwe. The proportion of double orphans with no living grandparent is expected to increase until about 2030, after which it will start to decrease. This phenomenon will result in a shift of responsibility for double orphans to uncles and aunts. On average, the number of uncles and aunts per double orphan decreased between 1980 and 2010, but it is expected to increase over the next two decades. On balance, between 1990 and 2010 Zimbabwe experienced a transition from fairly high to fairly low levels of kinship resources for young children.

Although microsimulation has been recognized as a leading approach for quantitative analyses of kinship structure, it has some limitations that need to be considered. If a correlation exists between demographic outcomes for individuals belonging to the same kin group, modeling kinship structure without taking this correlation into account may lead to biased results (Ruggles 1993). In this study, two types of correlations are accounted for: correlations in mortality rates between spouses and correlations between mothers and children, in both cases as a result of HIV transmission. These two types of correlations are the most relevant ones for the case under consideration, and the only ones for which data are available. Correlations are also likely in mortality rates between more distant kin members, such as between children and their uncles or aunts. These correlations are partially accounted for because a portion of the overall correlation is implicitly modeled. For instance, the mortality risks for siblings are not independent of each other: if their mother is HIV-positive, they are at risk of being infected through perinatal transmission. Analogously, aunts and uncles are siblings of the children's parents, and therefore the risks of mortality for children and their aunts or uncles are not independent and the correlations are partially accounted for in the simulation. Other factors that may affect the mortality risk of entire kin groups, such as socioeconomic status or neighborhood of residence, are not modeled in the simulation. To the extent that the correlation in mortality risk between members of the same kin is positive, kin groups with consistently high death rates will tend to have fewer living kin of any particular type, whereas kin groups with low mortality will tend to have higher numbers of kin (ibid.). This suggests that the distribution of living kin may be more homogeneous in

the microsimulation than in the real population. Consequently, the simulation may slightly underestimate the frequency of extreme cases, such as the proportion of people with no living kin or the proportion of people with large numbers of living kin. Modeling correlated heterogeneity is a general problem for microsimulations; however, for the model presented in this article, the relative size of the underestimation should be small, since some of the most relevant correlations are implicitly taken into account.

Although migration potentially affects demographic rates and may thus have an effect on kinship structure, it is not explicitly modeled in the microsimulation. There are two main reasons for this. First, migration data for Zimbabwe are sparse, hence modeling migration would substantially increase the uncertainty about the simulation outcomes. Second, at the time when the HIV/AIDS epidemic escalated, between 1990 and 2010, Zimbabwe experienced positive out-migration rates. As a consequence, it was mainly the geographic distribution of kin that was affected. It is not clear, however, whether having a kin network that extends beyond Zimbabwe is disadvantageous. On the one hand, certain types of care require physical proximity. On the other hand, remittances, especially in foreign currency, were extremely important at a time of hyperinflation and food shortages. The microsimulation makes no distinction between kinship members who stayed in Zimbabwe and those who left the country.

Although the study focuses on Zimbabwe, the results may apply to other geographic settings where patterns of AIDS mortality, prevalence of orphans, and availability of kin are similar to those found in Zimbabwe. Certain consequences of the epidemic in Zimbabwe, such as the lag between the peak in orphanhood and the peak in scarcity of grandparents, should be expected whenever the epidemic extends over a long period of time. Nonetheless, the severity of the consequences for children is particularly pronounced in Zimbabwe. This population has suffered both from the HIV/AIDS epidemic and from domestic policies that led to food shortages and high unemployment. Mugabe's land redistribution, for instance, resulted in a sudden drop in agricultural production that weakened all sectors of the economy. In addition, children in Zimbabwe are affected by the deterioration of antenatal services, child delivery health care, and childhood immunizations. This deterioration of services is more pronounced in African countries most severely affected by HIV/AIDS (Case and Paxson 2011).

The HIV/AIDS epidemic in sub-Saharan Africa has exerted increasing demographic pressure on social forms of support based on reciprocal obligations among members of the same kin group. Two broad questions deserve particular consideration. First, what level of kinship resources will be available to the most vulnerable members of the society, in particular young orphans? Second, what does the future hold for traditional social practices, such as

child fostering, that are mainly based on mutual support among members of the same kin group?

Answering the first question is an important step in addressing the lack of care for orphans and identifying the kinship networks that could be potential targets for interventions. Given the critical role of the extended family for coping with the epidemic, and the importance of close biological kin for children's school and health outcomes, it is crucial for planning purposes to estimate and forecast kinship resources available to orphans. Estimates and projections of kinship availability are neither generated nor published by international agencies. These estimates would complement currently available statistics on the number of orphans and the prevalence of orphanhood.

The second question has broad implications for sociological research. Will traditional forms of social relationships survive the impact of the HIV/AIDS epidemic? Demographic pressure may become strong enough to make some traditional practices, such as "purposive" fostering, unfeasible. An extended period of "crisis" fostering practices, together with a reduction in the average size of kinship groups, may undermine the basis for traditional forms of social obligations based on reciprocal advantages. New forms of social relationships and living arrangements may emerge to spread risks across kinship groups. During the next few decades, demographic pressure on traditional forms of social relationships will be strong, and the sustainability of practices such as child fostering will continue to be challenged.

APPENDIX TABLE 1   Description of the main input parameters and demographic rates for the microsimulation, and the respective data sources

Description	Data source
Age- and sex-specific mortality rates for each year in absence of HIV/AIDS	*UN World Population Prospects: The 2006 Revision* (1980–2050)
Age-specific fertility rates for each year	*UN World Population Prospects: The 2006 Revision* (1980–2050)
Age- and sex-specific marriage rates for each year	Demographic and Health Surveys (1988; 1994; 1999; 2005/06); World Fertility and Marriage Database 2003 (1982)
Age- and sex-specific transition rates from HIV-negative to HIV-positive status	Back-calculation based on data on AIDS-related deaths from *UN World Population Prospects: The 2006 Revision* (1980–2050)
Risk of mortality since HIV infection for adults	UNAIDS Spectrum Estimation and Projection Package (see Stover 2004)
Risk of mortality since HIV infection for children	UNAIDS Spectrum Estimation and Projection Package (see Stover 2004)
Probability of vertical transmission of HIV (mother-to-child)	UNAIDS Spectrum Estimation and Projection Package (see Stover 2004)
Risk factor for spouse-to-spouse HIV transmission	Chosen to be consistent with the results of Grassly et al. (2005) and Todd et al. (2006)

Notes

Figures in this article are available in color in the electronic edition of the journal.

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1 According to UNICEF figures, in sub-Saharan Africa in 2008, 22.4 million people were living with HIV, 1.9 million were newly infected with HIV, and 1.4 million died from AIDS. The HIV/AIDS epidemic has generated a severe orphanhood problem. UNICEF (2006) estimated that in 2005 there were some 48 million orphans (at least one parent dead) in sub-Saharan Africa in the age group 0–17 years. That corresponds to about 12 percent of all children 0–17 years old in the region.

2 Zaba et al. (2005) estimate, from cohort studies in Malawi, Tanzania, and Uganda, that the excess risk of mortality for children with an HIV-positive mother is 2.9 and lasts throughout childhood. The excess risk of mortality associated with maternal death is 3.9 in the two-year period centered around the mother's death.

3 Grandparents are often a last resort and agree to care for orphans because other relatives are not available or refuse, generating, in some cases, situations of mutual support, where frail grandparents become recipients of care from grandchildren (Foster 2000).

4 For several centuries until the nineteenth, the area of contemporary Zimbabwe was ruled by a succession of Shona kingdoms. In the 1830s, the Ndebele settled in what is now southern Zimbabwe. In the 1880s, Cecil

Rhodes's British South Africa Company took control of the area, which was then named Southern Rhodesia, until 1923, when it became a British colony. In 1965, the white minority government issued a unilateral declaration of independence which triggered a civil war that ended in 1980 with the granting of independence, and a general election won decisively by Robert Mugabe's ZANU party.

5 SOCSIM is written in the programming language C and exploits linked lists to keep track of kinship relationships and to store information. The simulator takes as input population files and demographic rates; it returns updated population files as output. For each segment of the simulation, the input populations are composed of two files, one with records for individuals and one with records for marriages. The demographic rates consist of fertility, mortality, marriage, and group transition. They can vary with the age, sex, marital status, and group affiliation of the individual. If the simulation has more than one segment, which is a typical situation when demographic rates change over time, the output population for one segment can be used as input for the next segment.

6 For instance, the initial simulated population for 1980, together with a set of average demographic rates for Zimbabwe for the pe-riod 1980–1984, is used as input for segment 2 of the simulation. The output for segment 2 is a simulated population file for Zimbabwe in 1985. Segment 3 of the simulation takes as input the simulated population file for 1985, together with a set of average demographic rates for Zimbabwe for the period 1985–1989, and returns a population file for 1990. The process is analogous for every segment of the simulation. With 15 segments, the last population file that is generated is for 2050.

7 The estimated input parameters and rates are used as a first approximation. To account for the uncertainty about the level of given demographic rates, I have introduced a set of rescaling factors. In particular, for each segment of the simulation, age-specific profiles of fertility, marriage, and HIV status transition rates have been rescaled to match key observed demographic rates for Zimbabwe over time. Details about the calibration of the microsimulation model are described in an appendix available on request (zagheni@ demogr.mpg.de).

8 A child inherits one half of his/her genome from a parent. The coefficient of relatedness for a child and his/her parents is 0.5, between a grandchild and his/her grandparents is 0.25, and between a nephew/niece and his/her uncles/aunts is 0.25.

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