

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

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## **Abstract**

The extended family has been recognized as a major safety net for orphans in sub-Saharan Africa. But the mortality crisis associated with the HIV/AIDS epidemic may drastically reduce the number of relatives available to orphans and thus undermine traditional forms of mutual support. In this paper, a microsimulation, whose core relies on SOCSIM, is used to estimate and project quantities such as the number of living uncles, aunts, siblings and grandparents available to double orphans. The model is calibrated to the Zimbabwean setting, using data from the Demographic and Health Surveys (DHS), and estimates and projections of demographic rates from the United Nations. The paper shows that there is a lag of more than ten years between the peak in orphanhood prevalence and the highest scarcity of grandparents for orphans. The results suggest that we may expect an extended impact of the HIV/AIDS epidemic on orphans. A first wave of rapid increase in the number of orphans will be followed by a second wave of impact characterized by a steady reduction in grandparental resources for orphans. This trend is likely to shift the burden of double orphans to uncles and aunts. The availability of living uncles and aunts per double orphan has been decreasing from 1980 to 2010, but it is expected to increase progressively during the next decades. This study raises questions on the social consequences of changes in kinship structure, and on the strategies needed to address the lack of care in the context of a generalized HIV/AIDS epidemic.

The HIV/AIDS epidemic has led to an unprecedented mortality crisis in the population of sub-Saharan Africa. Individuals infected with the HIV virus suffer from the direct consequences of the disease. The impact of the epidemic, however, is not limited to the people who contract the disease. The psycho-physical, emotional and economic consequences of the epidemic are felt by family members, as well as members of the extended family, and the community at large (e.g., Palloni and Lee 1992; Bor and Elford 1998; Wachter et al. 2002).

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

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. That is a consequence of the fact that the transition to the orphanhood state is a cumulative process with age, and that there is a lag between the peak in adult HIV prevalence and the one in AIDS-related orphanhood prevalence.

The negative indirect consequences of the HIV/AIDS epidemic are likely to become harsher and harsher on children and the elderly. Traditionally, in the setting of sub-Saharan Africa, child fosterage and other social practices based on mutual support among members of the same kin, have mitigated the impact of orphanhood. The extended family has been recognized as a very important safety net. However, it has also been noted that with the rising levels of widowhood and orphanhood, associated to the HIV/AIDS epidemic, the material basis of traditional kin relations may weaken to a point such that new forms of social relations may emerge (e.g., Palloni and Lee 1992; Merli and Palloni 2006).

How much pressure will be exerted on traditional forms of care and support? How much kinship resources will be available to children? How heavy will the burden on traditional caregivers be? This paper addresses these questions. Estimates and projections of orphanhood prevalence and kinship resources available to orphans are important to evaluate 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 1980-2050. This study is the first attempt to evaluate, in a quantitative and systematic way, overall kinship resources available to orphans in the context of sub-Saharan Africa. The geographic focus is Zimbabwe, one of the countries hit the hardest by the HIV/AIDS epidemic. On a background of poverty, economic crisis and international political isolation, the current adult HIV prevalence rate is estimated to be between 15% and 20% in Zimbabwe. After reaching a peak of almost 30% at the end of the 1990s, the adult HIV prevalence rate has been decreasing, but is still

extremely high. According to estimates produced by UNICEF (2006), 21% of children 0-17 years old in Zimbabwe were orphans in 2005. The orphanhood problem in Zimbabwe is likely to last for decades. A quantitative assessment of the extent of the crisis is vital to address adequately the lack of care, and to evaluate the potential consequences of the erosion of kinship resources available to children.

The paper is organized as follows. The first section provides some background on the impact of the HIV/AIDS epidemic on children in sub-Saharan Africa. It reviews the relevant literature on the effects of orphanhood on economic, education and health outcomes. The second section discusses the role as a safety net of the extended family and traditional forms of social relations, such as child fosterage. The third section gives some context for the geographical setting: Zimbabwe. The fourth section is an overview of the data sources that I used to inform my model. The fifth section describes the microsimulation approach that I propose. The sixth section provides the main results of the research, which are then discussed in the concluding section of the paper.

## **Background**

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

The HIV/AIDS epidemic has a pervasive negative effect on multiple spheres of children's lives. Children may be affected only indirectly, at a community level, or they may experience the burden of the disease directly in their households. Children may have to drop out of school to help with household work or to care for ill parents, and may suffer both psychosocial 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 incidence of the epidemic, the economic situation of the community and the households affected by the disease, the gender of the children and their age when a household member gets infected, the efficiency of safety nets, etc.

In this section, I review the main studies on the impact of the HIV/AIDS epidemic on children. I discuss the economic impact of the epidemic, as well as the effects of the epidemic on children's education and health.

#### **Economic impact**

Children start feeling material hardship before they become orphans. When a parent develops HIV-related symptoms, children may have to take care of the household and the ill parents or young siblings. They may have to dedicate their time to activities such as cooking, cleaning, carrying water, care giving, etc.

The division of workload among children is gender-specific. Girls are more frequently care-giving providers for female relatives and take more responsibilities for domestic work

(Robson 2000). Boys are more involved in agricultural and income generating activities that help with medical expenses and compensate the reduced amount of work of the parents.

When children become orphans, their workload may increase, either because their household has been impoverished by the death of a parent (e.g. due to the loss of a parent's income and the high costs of a funeral), or because the orphans move to the household of a relative, where their workload may be greater than the one of non-orphans living in the same household (Foster et al. 1997).

Children may risk to lose the properties of their family. For instance, in the case of Zimbabwe, only a very small proportion of families write a will prior to death (Drew et al. 1996). In some cases, properties are inherited by paternal relatives and there may be instances of "property-grabbing". The extent of these practices varies from region to region. The results of a survey study in Zimbabwe show that property is usually inherited by children, with 15% of respondents reporting "property-grabbing" (Drew et al. 1996).

The poorer people in a community, especially women, are the ones that usually take care of orphaned children in sub-Saharan Africa (Foster and Williamson 2000). This is related to the fact that orphans tend to live more frequently in larger households with a less favorable dependency ratio and where the caregiver is much older than the child (Monasch and Boerna 2004).

Better-off families, on the other hand, tend to find their economic reserves depleted since they are continuously asked to provide economic resources to relatives affected by AIDS (Foster and Williamson 2000). Beegle et al. (2010) use longitudinal data for a region of northwestern Tanzania to show that, in terms of consumption expenditure, there is a gap of 8.5% between maternal orphans and children whose mother survived until at least their 15th birthday.

## **Impact on education**

When a parent becomes sick, his/her children's education is often disrupted. With the financial strain of the disease and the reduced resources available for the household, there may not be enough funds for children to go to school, or the children's caregivers may have less interest in the children's welfare. Thus children might have to do either domestic work or income generating activities and miss opportunities in education in terms of lack of enrollment, interrupted schooling and poor performance while in school (UNICEF 2006).

Although there are significant variations across countries, several studies provide evidence that the enrollment rate for orphans is significantly lower than the one for non-orphans. For instance, a study based on data from eastern Africa shows that double orphans in the age group 6-10 are half as likely to be at the correct educational level, compared to non-orphan children of the same age (Bicego et al. 2003).

In some circumstances, young girls may be more at risk of being denied education than boys. However, it is not clear whether the gender gap is more prominent in orphans than in non-orphans (UNICEF 2006). In certain studies, probabilities of enrollment appear to be negatively correlated with certain characteristics of the children, such as being a girl 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 important factor in the determination of educational outcomes for orphans is the relationship between the child and the head of household. The closer the biological tie, the more likely the child is to go to school consistently, independently of the poverty level. As a matter of fact, the closest relatives tend to make substantial commitments to ensure that their children attend school (UNICEF 2006).

## **Impact on health**

The HIV/AIDS epidemic has had a strong impact on children's mortality. For the youngest age group (ages 0-3 years), the loss of a parent is significantly associated with the probability of survival. Zaba et al. (2005) estimate, from cohort studies in Uganda, Tanzania and Malawi, 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 to maternal death is 3.9 in the 2-year period centered around the mother's death.

Children who become orphans are more vulnerable than non-orphans. Some of them become street children or prostitutes and are more likely to get infected with HIV (Richter and Swart-Kruger 1995).

Although there is little evidence of a general increase of morbidity and mortality in orphans, it is expected that the health of orphans, particularly those in the care of adolescents and elderly caregivers, is worse than the one of other children (Foster 1998). Orphans may be more malnourished than non-orphans, possibly because of reduced household resources or because parental illness or death interfere with child rearing. This may affect the incidence of morbidity in orphans.

Orphanhood has important consequences on psychological health, in addition to physical health. The stress and trauma of parental illness and death is amplified by stigmatization, dropping out of school, changes in friendships, increased workload, discrimination and social isolation (Foster and Williamson 2000). Sengendo and Nambi (1997) conducted a study on children in Uganda and found that most orphans were depressed, with lower expectations about the future than non-orphans. They observed that orphans that relocated from urban areas to rural areas were more depressed, implying that the failure to adapt to social change leads to psychological problems. They also noticed that depression was more likely in children living with a widowed father than in those living with a widowed mother, suggesting that the loss of the mother is more distressing than the loss of the father.

Both children and adults feel grief for the death of their parents. But children, unlike adults, may not immediately understand the finality of death and thus may not go through the grieving process that is fundamental to recover from the loss (Brodzinsky et al. 1986). Children may not have reached a stage of intellectual and emotional development that enable them to positively control negative emotions. They are more at risk of growing up with unresolved negative emotions which are often expressed with anger and depression. The support and encouragement from adults to express emotions are crucial to the psychological health of the orphans. This support may not be present in the context of a generalized HIV/AIDS epidemic, where basic material needs may not be met.

Children's behavior changes during parental illness. They often become sad, worried and stop playing to be near the parents. They are more likely to become solitary, to appear miserable, distressed, fearful of new situations and to develop low self-esteem (Foster and Williamson 2000).

AIDS-related orphans who lack social, economic and psychological support tend to become more vulnerable to HIV infection through early onset of sexual activity, commercial sex and sexual abuse. The lack of support therefore affects the future physical health of children also indirectly.

## **Coping Mechanisms and the Extended Family**

To a first approximation, a generalized HIV/AIDS epidemic strongly affects mortality and fertility rates, with important consequences on population age structure, sex ratio and probability of orphanhood. To a second degree of approximation, the epidemic affects household structure, movements in and out of the household, and the availability of kinship resources, both for young children and for the elderly (e.g. Wachter et al. 2002, 2003; Heuveline 2004).

In the sub-Saharan setting, the extended family is the predominant caring unit for orphans in communities that are severely affected by the HIV/AIDS epidemic (Ankrah 1993). The main mechanism that prevents families from falling into destitution operates through community members and the extended family, who provide material relief and economic support.

In this section, I discuss the coping mechanisms that are in place in the context of sub-Saharan Africa to deal with the orphanhood crisis. The most important safety net is provided by the extended family. Some nurturing roles are delegated to non-biological parents, through fostering practices. Social protection provided by governments is very limited or inexistent in most settings. When some forms of social protection are in place, indirect assistance to foster families or parents whose partner had died, may benefit only a small proportion of the population, namely members of the middle-class who are employed in the formal sector. Typically, especially for poor people, work is home-based and in the informal sector, without particular protections from the government. In a crisis situation, external help may come from religious groups or NGOs, often funded by international organizations. More often, the primary source of assistance comes from the extended family.

A major issue is whether traditional fostering practices can adapt to the increasing stress imposed on them by the HIV/AIDS epidemic. It is important to identify who the care takers for orphans are and to what extent kinship members are involved in rearing orphans. I will discuss how the kinship role may change with the onset of the HIV/AIDS epidemic and I will conclude by pointing out the importance of a quantitative evaluation of the kinship resources available to orphans.

Who takes care of orphans? The question is of central importance. Providing an answer to it requires some discussion of fostering practices in sub-Saharan Africa. The coping mechanisms regarding orphans in sub-Saharan Africa are complex and vary across countries and social settings. However, a common element that distinguishes sub-Saharan Africa from western societies is that children are fostered, rather than 'adopted'. Child fostering consists

of a culturally sanctioned arrangement such that children are reared by adults other than the biological parents. These arrangements are agreed upon by biological parents and other adults, often relatives. They contribute to strengthen ties across the community and they provide mutual benefits for both natal and fostering families. Although institutional care exists, mostly in post-conflict countries, generally orphanages are not culturally and socially acceptable, in addition to being extremely expensive.

Fostering practices in sub-Saharan Africa can be categorized into two different classes: 'purposive' 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 in West Africa takes place within the kinship network and it is largely motivated by the need to reallocate resources within the extended family or clan, in order to maximize the survival probabilities of the kinship unit and to strengthen kinship ties. Altogether, fostering practices are strongly related to reasons such as kinship obligations, apprenticeship/training, alliance building, domestic labour and education. Purposive fostering relies on reciprocal advantages, responsibilities and rights. There are a set of social rules that determine the age structure of the exchange, which is intended to be symmetrical. Crisis fostering, on the other hand, involves some specific obligations. Esther Goody, in her classical book about fostering roles in West Africa (1982), pointed out that kin members who have the right to the child in voluntary fostering are also obligated to foster the child in a period of crisis.

Orphanhood is not a new problem in sub-Saharan Africa, a region where mortality rates have been relatively high since before the onset of the HIV/AIDS epidemic. In the past, the combination of fostering practices, the obligation of relatives to take care of orphans, and the relative abundance of kinship resources alleviated the problem (e.g., Ntozi and Nakayiwa 1999). In addition to kinship obligations, the choice of the foster parent depends on the reasons for fostering. If the objective is labour or simple companionship, grandmothers and childless couples tend to be an obvious destination (Goody 1982; Isiugo-Abanihe 1985).

With the increasing prevalence of HIV, how do foster practices for orphans change? First, with the onset of the HIV/AIDS epidemic, not only the overall number of orphans increases, but also the proportion of them who are double orphans increases, because of HIV transmission that occurs within couples. The increased number of double orphans, coupled with the higher mortality rate of adults, reduces the number of adult kin and increases the burden on grandparents. This situation raises questions on whether the logic of fostering, that enabled a sustainable distribution of obligations among kin in the past, may be overwhelmed by the rapid increase in AIDS-related deaths (Madhavan 2004).

Drew et al. (1998) observe that, although traditionally in Zimbabwe orphans have been incorporated into the extended family, the very high number of adult deaths has shifted the burden to elderly and adolescents. As a result, the phenomenon of grandparent-headed households and adolescent-headed households has been increasing. In the traditional Zimbabwean society, orphan children were cared for by members of the extended family. Geoff Foster (2000), in particular, describes how the caregiving functions of parents were usually taken on by paternal aunts and uncles. More recently, the safety net provided by the ex-



tended family has been weakened. According to Foster (2000), there are several reasons behind this process, such as changes in the economy, labor migration and formal education. Another important reason is the reduction in the number of available aunts and uncles, due to the HIV/AIDS epidemic, during a time when orphans have been increasing. With the increasing number of orphaned children and the unavailability of traditional caregivers, grandparents are recruited into childcare (e.g., Foster et al. 1996). Grandparents are often a last resort and agree to take 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).

Foster (2000) suggested measuring the strength of the extended family safety net by monitoring certain proxies. We may expect that where traditional values are maintained, such as in rural communities, the extended family safety net is better preserved. Analogously, the prevalence of purposive fostering within a community is an indicator of the strength of the extended family safety net. Where traditional widow inheritance is common, then orphan inheritance is likely to be prevalent too. The higher the frequency of regular contacts between relatives, the smaller the risk for orphans to be abandoned. Conversely, such risk is higher in situations where unions are established without the payment of a brideprice.

The role played by members of the extended family in providing care for orphans is strongly related to cultural practices that vary across time and geographical regions. The onset of the HIV/AIDS epidemic has influenced such practices through changes in behavior, for instance in terms of stigmatization of households affected by HIV/AIDS. The epidemic has also dramatically altered the demographic structure of the population, reducing the amount of kinship resources available to orphans and to the elderly. There have been several anthropological studies about the effect of the epidemic on the role of the extended family as a safety net in sub-Saharan Africa. Most of the quantitative research in this area has focused on a very specific set of kin members, that is 'parents'. There has not been a comprehensive quantitative evaluation of the effect of the epidemic on kinship structure in sub-Saharan Africa. My study fills this gap in the literature.

## **The Zimbabwean setting**

Zimbabwe is a landlocked country in southern Africa, mostly lying on a high plateau, with a higher central plateau and mountains in the eastern part of the country. The population size is between 11 and 12 millions, with a life expectancy of approximately 45 years. About half of the population is younger than 18 years. The total fertility rate (TFR) for 2009 is estimated to be 3.7, and it is associated to a population growth rate of about 1.5% per year. 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 get closer and closer to replacement level in the next couple of decades.

Marriage is nearly universal in Zimbabwe. The proportion of never married women falls from about 76% in the age group 15-19 to 1% in the age group 45-49. Men tend to get married later in their life course than women. More than 99% of men in the age group 15-19

never married. The percentage of never married men becomes 75% for those in the age group 20-24 and about 1% for those in the age group 45-49 (CSO and Macro International Inc. 2007).

The urban population accounts for slightly less than 40% of the total population. There are relevant demographic differences between urban and rural population. Urban areas are characterized by a less traditional approach to social relationship. Polygyny, which is still fairly accepted in rural areas, has a very low prevalence among young urban men and women. According to Demographic and Health Surveys data, the peak of polygyny prevalence is in the areas of Central Mashonaland, where about 8% of men have two or more wives. In Bulawayo, less than 1% of men have more than one wife. The prevalence of polygyny is associated to age. Younger cohorts, and especially more educated and wealthy women, are less and less acceptant of polygyny.

The two major ethnic groups in Zimbabwe are Shona (which accounts for about 82% of the population) and Ndebele (which accounts for about 14% of the population). For several centuries, until the 19th century, the area of contemporary Zimbabwe was ruled by a succession of Shona kingdoms. The system then collapsed due to internal and external pressure. In the 1830s, the Ndebele people settled in what is today's southern Zimbabwe, after migrating from south and generating upheaval in the region. In the 1880s, Cecil Rhodes' British South Africa Company took control of the area, that was then named 'Southern Rhodesia', until 1923, when it became a British colony. In 1965, the settlers issued a unilateral declaration of independence. This triggered a civil war between the white minority government and fighters for African independence, ending in 1980, with the granting of independence and the holding of a general election under British auspices, which was won decisively by Robert Mugabe's ZANU party.

Zimbabwe has benefited from a well developed infrastructure, health care and financial system. But the economy and the standards of living in the country have declined rapidly since the late 1990s. The involvement in the war in the Democratic Republic of Congo in 1998-2002 drained a large amount of resources from the economy. In 2000, President Mugabe started a land reform which entailed a compulsory land redistribution to blacks. One of the main consequences has been a sharp decline in agricultural production and export, which resulted in food shortages, high unemployment and capital flight from the country. All sectors of the economy have been severely affected. In order 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 HIV/AIDS epidemic contributed to an already dramatic situation of economic crisis and growing international isolation. Zimbabwe is one of the countries in the world hit the hardest by the HIV/AIDS epidemic. According to UNAIDS/WHO estimates (2008), the adult HIV prevalence rate reached a level of almost 30% towards the end of the 1990s. Since then, it has been decreasing to current levels of about 15-20%. The epidemic has had dramatic consequences on the country and has been challenging traditional forms of social relationships that are based on reciprocal obligations among members of the same kin.

Traditionally, the extended family has had the role of a safety net. Zimbabwean Shona

and Ndebele communities are built around a patrilineal kinship system. Members of the same patriline live together in multi-generational residential groups. In a traditional setting, people have a strong sense of belonging to a large extended family, help each other and share the resources. Traditionally, the concept of social orphan did not exist in Zimbabwe, since biological orphans could rely on the care of members of the extended family, and, in particular, on paternal 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 peri-urban areas, is an indication of the crisis of traditional extended family practices (Foster et al. 1995; Foster et al. 1997)

## Data

I used two main data sources to inform the microsimulation for Zimbabwe: United Nations (UN) population statistics and the Demographic and Health Surveys (DHS). The most relevant collection of demographic data from the United Nations is the *2006 Revision of the World Population Prospects*. These data come in the form of a CD-ROM which contains essential demographic data such as estimates and projections of total births, total deaths, population counts, mortality and fertility indicators by five-year age groups and sex for the period 1950-2050. A complementary data source from the United Nations Population Division is the World Fertility and Marriage Database 2003.

The Demographic and Health Surveys provide rich sample surveys collected in Zimbabwe in 1988, 1994, 1999 and 2005/2006. The 2005/2006 DHS for Zimbabwe includes a module on HIV seroprevalence based on HIV testing administered to the respondents.

### United Nations population statistics

The United Nations compile data for most countries of the world from civil registrations, population censuses and nationally representative sample surveys. The criterion for inclusion of potential data sources is their reliability. Two main collections of data, estimates and projections provide relevant information for my research.

The *2006 Revision of the World Population Prospects* was prepared by the United Nations Population Division, and offers a consistent set of population data, estimates and projections for the world's countries. It incorporates all the relevant data sources that were available as of 2005. The database consists of all the essential fertility, mortality and migration rates and counts, by five-year age groups and sex, for the period 1950-2050. The projections are based on a series of assumptions about future trends in fertility, mortality and international migration. A number of variants are presented: for instance, low, medium, high and constant fertility, constant-mortality, no-change, zero-migration, no-AIDS, high-AIDS, etc. The No-AIDS scenario applies the mortality rates to which non infected individuals are likely to be subject, to the whole population. The high-AIDS scenario assumes that the parameters of

the mathematical model for AIDS, that determine the path of the HIV/AIDS epidemic, stay constant at their 2005 level.

The *World Fertility and Marriage Data 2003* was compiled by the Population Division of the United Nations Department of Economic and Social Affairs. The collection contains data for 192 countries of the world. For each country, the available data are presented for two dates: an earlier date for the period between 1960 and 1985, and a later date for the most recently available data since 1986. The Fertility section of the database contains data on annual number of births, age-specific fertility rates, mean age at childbearing, etc. The Marriage section of the database contains data on total numbers of marriages, divorces, proportion of men and women ever married, and other synthetic measures, such as the singulate mean age at first marriage. For the specific case of Zimbabwe, the database provides valuable information on fertility and marriage rates, based on the census of 1982. These rates complement the data available through the 2006 United Nations World Population Prospects and the Demographic and Health Surveys.

## Demographic and Health Surveys

The Demographic and Health Surveys (DHS) are part of a project sponsored by the U.S. Agency for International Development (USAID) to provide data and analysis on the population, health, and nutrition of women and children in developing countries. The program started in 1984. Since then, DHS has provided technical assistance to 84 countries, for the implementation of more than 240 surveys, including HIV testing in more than 30 countries.

For Zimbabwe, surveys for four different time periods are available: 1988, 1994, 1999 and 2005/06. The Zimbabwe DHS are nationally representative surveys implemented by the Zimbabwean Central Statistical Office. The core of the surveys are household and individual questionnaires. The purpose of the household questionnaire is to collect information on characteristics of the household dwellings, to obtain basic data about the members of the household and the care and support available for them, and to identify members of the household who are eligible for an individual interview. Eligible respondents are then contacted and interviewed using an individual questionnaire that is different for women and men. Individual questionnaires include information on marriage, fertility, family planning, reproductive health, child health, and behavior towards HIV/AIDS. For special information, that are not contained in the core questionnaires, there are some optional questionnaire modules which are country-specific.

The first DHS in Zimbabwe was implemented in 1988. 4,789 households were selected and about 90% were successfully interviewed. At the individual level, only women were interviewed: among the eligible women, 4,201 were interviewed. The 1994 Zimbabwe DHS is a follow up to the 1988 DHS. It is a nationally representative survey of 6,128 women age 15-49 and 2,141 men age 15-54, implemented by the Central Statistical Office. The 1994 DHS, as the 1988 DHS, provides information on levels and trends in fertility, family planning knowledge and use, infant and child mortality, and maternal and child health. In addition to that, data have been collected on compliance with contraceptive pill use, knowledge and behaviors related to HIV/AIDS and other sexually transmitted diseases, and

maternal mortality. The 1999 DHS for Zimbabwe is similar in scope to the 1994 DHS. The target sample was approximately 6,208 women and 2,970 men. The 2005-06 Zimbabwe DHS is the fourth of the series of DHS in Zimbabwe and the first one to provide population-based estimates of prevalence of HIV. A representative probability sample of 10,800 households was selected. If a child in the household had a parent who was sick for more than three consecutive months in the 12 months preceding the survey or a parent who had died, additional questions related to support for orphans and vulnerable children were asked. Additionally, if an adult in the household was sick for more than three consecutive months in the 12 months preceding the survey or an adult in the household had died, questions were asked related to support for sick people or people who had died. For the individual questionnaires, 8,907 women and 7,175 men were successfully interviewed. The response rate across the four surveys is about 90%.

## Methods

### **The microsimulation program: SOCSIM**

The individual-based model that I have built to perform my analysis relies on SOCSIM, a stochastic microsimulation program whose core was designed in the 1970s at the University of California, Berkeley. The infrastructure of the first version of SOCSIM was developed by Eugene Hammel and Kenneth Wachter, at the Department of Demography, UC Berkeley (e.g., Hammel, Mason and Wachter 1990).

SOCSIM has been used very successfully to model the dynamics of kinship structure in historical and contemporary populations (e.g., Wachter, Hammel and Laslett 1978; Wachter 1997; Wachter, Knodel and VanLandingham 2002, 2003). The core microsimulation package is very flexible and freely available to users who would like to customize it. It has been designed to model very detailed sub-groups of a population, and to address a wide range of research questions.

Each individual in the simulation is an observation in a rectangular data file, with records of demographic characteristics for the individual, and identification numbers for key kinship members. SOCSIM is efficiently written in C and takes full advantage of arrays of 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. The supervisory file represents the interface between the user and the source code. The user provides information to the core simulator with regards to where input files are stored, where output files are to be placed, and where demographic rates are located. In addition to that, the supervisory file contains switches for specific features, such as fertility heterogeneity and birth spacing. For each segment of the simulation, the input populations are composed of two files, one that has records for individuals and one that has records for marriages. The demographic rates consist of fertility, mortality, marriage, and group transition rates. 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 a segment can be used as input for the next one.

The individual is the unit of analysis of the simulator. Each person is subject to a set of rates, expressed as monthly probabilities of events, given certain demographic characteristics such as age, sex, marital status, etc. Every month, each individual faces the risk of a number of events including childbirth, death, marriage and migration. 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 that are eligible for the events (e.g., to allow for a minimum interval of time between births from the same mother, to avoid social taboos such as incest, etc.).

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 a bit more sophisticated. SOCSIM is a closed simulator, in the sense that all partners must be drawn from within 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', then the person is placed in a pool of eligible members to form an union. If a member of the opposite sex with appropriate demographic characteristics is available in the pool, then the two individuals are paired. Otherwise, the person stays in the pool until an appropriate mate 'picks' him/her, based on a random process with probabilities dependent on demographic characteristics of the two potential spouses.

At the end of the simulation, two main files are created, the population file and the marriage file. These files contain a list of everyone who ever lived in the population and a list of every marriage that ever occurred. From these data, it is possible to determine the main demographic characteristics of the population and the entire kin network of any individual at any time.

For more details about SOCSIM, its history, computer routines and applications, see Hammel et al. (1976), Wachter et al. (1997) and the online documentation available at [www.demog.berkeley.edu](http://www.demog.berkeley.edu).

## **Modelling the HIV/AIDS epidemic with SOCSIM**

SOCSIM has not been specifically programmed to model the dynamics of a generalized HIV/AIDS epidemic and its demographic consequences. However, the microsimulator has been designed to be customized and modified to address a wide range of research questions. In this section, I discuss the simulation strategy that I pursued and the modifications to the original source code that have been made to model the HIV/AIDS epidemic.

I model some of the dynamics of the HIV/AIDS epidemic by taking advantage of the flexible 'group structures' in SOCSIM. Each individual in the simulation belongs to a specific group, where the meaning of group depends on the context and the purpose of the simulation. For instance, generally speaking, groups can represent ethnicities, geographical residence,

country of origin, allegiance to a soccer team or any other sort of membership. Groups are mutually exclusive: each individual can belong to only one group at a time. In the context of an HIV epidemic, I use group structures to represent HIV status. Each individual can be either HIV positive or HIV negative and is subject to mortality rates that are dependent on his/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 of the virus 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 she gives birth, her child is HIV positive with a probability of 0.35 at the age of one month. HIV positive children are expected to live, on average, 7 years.

For a married individual, the probability of becoming HIV positive may be associated to the HIV status of the spouse. Positive correlations in HIV status of partners increase the probability of double orphanhood, compared to a baseline scenario where the HIV status of spouses are uncorrelated. The original version of Socsim is not designed to model these correlations. The source code of the microsimulator was thus modified to allow for more flexibility in this regard. In the version of Socsim 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 not a lot of empirical evidence in the literature on how the risk of becoming HIV positive varies according to the HIV status of the partner. There is also quite a bit of variability across countries and 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 risk factor for the simulation for Zimbabwe. This means that if an individual is HIV positive, the hazard rate of becoming HIV positive for the spouse is 9 times higher than the hazard rate of becoming HIV positive for an individual whose spouse is HIV negative.

In summary, SOCSIM has not been originally designed to model an HIV/AIDS epidemic. However, careful use of group structures and minor modifications to the core source code make it possible to model key characteristics of the HIV/AIDS epidemic, which are relevant for the process of orphans generation.

## Parameterization

So far, I have discussed how the simulation program has been customized in order to model the dynamics of a population affected by the HIV/AIDS epidemic. Here I introduce some key aspects of the parameterization of the model.

The microsimulation for the population of Zimbabwe covers the period 1980-2050. A starting population that matches key demographic characteristics of the the actual population of Zimbabwe in 1980 has been created by letting a small unmarried initial population evolve over 100 years of time. The rates that were used for this first segment of the simulation were approximately the ones estimated for Zimbabwe in 1980, based on United Nations

data sources. 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 in as input a population file and demographic rates. It then produces as output a new population file. For instance, the initial simulated population for 1980, together with a set of average demographic rates for Zimbabwe for the period 1980-1984, are 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 the one for 2050.

For each time interval of five years, 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 that are 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 World Population Prospect (medium scenario). The baseline age-specific patterns of nuptiality come from the World Fertility and Marriage Database 2003, and the Demographic and Health Surveys. As for mortality rates, we need to distinguish between HIV positive and HIV negative individuals. For HIV negative individuals, I estimated age-specific patterns of mortality using a procedure based on cause-specific life tables derived from the 2006 Revision of the World Population Prospect. For HIV positive individuals, the pattern of mortality has been chosen to reflect a life expectancy at the time of infection of about 10 years for adults and 7 years for children. Age-specific HIV infection rates, or HIV incidence, are calculated using a back-calculation technique based on UN estimates and projections of numbers of AIDS-related deaths, and some assumptions on the progression rates from the first stage of HIV infection to AIDS and death.

The estimated rates, which are obtained from a variety of data sources, are used as a baseline. In order to provide more flexibility to the model, and to account for the fact that there is quite a bit of uncertainty about the level of certain demographic rates, I introduced a set of parameters that rescale age-specific profiles of fertility rates, marriage rates, and transition rates from HIV negative to HIV positive status. This means that, in the simulation model, there are three rescaling parameters per segment. Given that the whole simulation is composed of 15 segments overall, the total number of parameters is 45.

## **Calibration of the microsimulation model**

In principle, perfect knowledge of demographic rates should lead to an unbiased reconstruction of the kinship network through demographic microsimulation. The only uncertainty associated to the simulated kinship structure would be related to the stochasticity of the microsimulation (the use of different seeds for the microsimulator generates different random



realizations).

In practice, knowledge of vital rates is far from being perfect. Kinship reconstruction and forecasting demand a level of detail for demographic rates that is often missing in available data sets. For instance, transition rates from one marital status to another one are usually not readily available and estimates may not be very accurate. Fertility rates are usually not broken down by marital status or parity, especially in the developing world. In most cases, demographic rates that are used as input to the microsimulation need to be estimated from various data sources with different sampling errors. Even when reliable data sources exist to compute demographic rates broken down by the categories of interest, the heterogeneity of the population's rates within the tabulated categories constrains the accuracy of the microsimulation.

In this section, I discuss the method that I propose to calibrate the microsimulation. The general goal of the calibration process is to find a set of input rates which are associated to simulated populations whose key characteristics closely match the ones extracted from sample surveys or population censuses. The approach that I use inspired by the recent development of Bayesian techniques in the area of statistical inference for simulation models (e.g., Raftery et al. 1995; Poole and Raftery 2000; Sevcikova, Raftery and Waddell 2007; Alkema et al. 2007)

In the microsimulation that I ran, several sets of rates are used as input to the model (e.g., age-specific fertility rates, age-specific marriage rates, age-specific transit rates from HIV-negative status to HIV-positive status, HIV-status and age-specific mortality rates, etc.). The simulation is composed of 15 segments and covers the period 1980-2050. For each segment, which spans a period of time of five years, there is an associated set of input rates and an output population file. The input rates are estimated using data from the Demographic and Health Surveys and United Nations estimates and projections.

We do not know the demographic rates with accuracy. I assumed that the shape of the estimated age-specific rates is fairly accurate and thus most of the uncertainty is associated to the scale or level of the parameters. Based on this premise, I chose a set of three parameters for each segment that rescales age-specific fertility rates, marriage rates and transit rates from HIV negative to HIV positive status. I refer to the triplet of parameters for segment  $i$  as  $\theta_i$ , with  $\{i = 1, \dots, 15\}$ .

For each  $\theta_i$ , I express my uncertainty by providing a prior distribution. The main purpose of the prior, for my application, is to define upper and lower bounds that are consistent with UN and DHS data sources. I chose the the prior on the rescaling parameters to be uniform, typically between 0.1 and 3.

For the first set of rescaling parameters,  $\theta_1$ , the likelihood for a specific combination of three rescaling parameters is computed as follows:

1. Run SOCSIM  $n$  times, with the same set of chosen parameters, but different seeds, and store the outputs.
2. From the  $n$  simulation outputs, compute the mean vector  $\mu$  and the variance-covariance matrix  $\Sigma$  for a set of five key summary quantities: total fertility rate, proportion of

population younger than 25, proportion of males younger than 25 who are married, proportion of women younger than 25 who are married, HIV prevalence rate.

3. Based on a normal approximation, the probability of observing the UN estimates (medium scenario) for the key summary quantities,  $x$ , given the chosen set of parameters is:

$$f_X(x) = \frac{1}{(2\pi)^{5/2} |\Sigma|^{1/2}} \exp\left(-\frac{1}{2}(x - \mu)' \Sigma^{-1} (x - \mu)\right) \quad (1)$$

This is the likelihood of the specific set of parameters, that is the probability of observing the data (UN or DHS), given the chosen parameters.

Figure 1 shows a schematic representation of the approach that I used. For the set of rescaling parameters other than the first one, the approach is analogous, with the only difference being that SOCSIM is run with mean posterior estimates of the rescaling parameters for the segments that come before the segment of interest.

Given a prior distribution and a parameterization to compute the likelihood, the posterior distribution for the rescaling parameters is obtained using the SIR algorithm (Rubin 1987, 1988):

1. Sample with replacement a number  $m$  of parameter vectors from the prior distribution.
2. For each sampled vector, compute the sampling importance weight, which is proportional to the likelihood for the sampled vector.
3. Sample with replacement from the  $m$  parameter vectors with probabilities proportional to the weights to approximate the posterior distribution.

An obvious choice for the final rescaling parameters is the mean of the posterior distribution. In practice, some further minor adjustments are needed in order to smooth the key summary statistics for the simulated population over time.

## Kinship resources for young orphans

### Orphanhood probabilities

In this section, I show some estimates and projections of probabilities of maternal and double orphanhood in Zimbabwe for the period 1980-2050. Orphanhood prevalence by age and time is obtained from the analysis of the output population generated with the microsimulation program that I previously described.

Figure 2 shows estimates and projections of maternal orphanhood prevalence by age, and over time. The estimated pattern is consistent with survey data and results obtained from a macrodemographic model. The peak in orphanhood probabilities is between 2000 and 2010, depending on age, with younger ages reaching a peak earlier in time. Maternal orphanhood prevalence decreases to pre-epidemic levels within a couple of decades from the peak. It

is relevant to observe that around 40% of children at age 15 are estimated to be maternal orphans in 2010, and that in 2030 such percentage is still about 30%.

Figure 3 shows the evolution of probabilities of double orphanhood over time. The probability of having both parents dead is fairly low at age 5, but it rapidly increases with age. The probability of double orphanhood at age 10 reaches a peak at a level of around 15%. For teenagers of age 15, the peak is at about 20%. Figure 4 shows the estimated prevalence of double orphanhood over time for children in the age group 0-17 years old. We can observe a rapid increase in the probabilities of double orphanhood in the 1990s, with a peak around 2010 at a level of about 11%. Given the UNAIDS projections that the adult HIV prevalence rates will continue to decrease over time, the prevalence of double orphanhood will also decrease. I project the prevalence of double orphanhood to be about 6% in 2020 and 2% in 2030. Double orphanhood prevalence for 2005 is consistent with the estimates published by UNICEF (2006) which imply a prevalence in the age group 0-17 of about 11%. Projection of prevalence of double orphanhood for the future is a challenging task. As far as the author knows, the results of the microsimulation are the first set of projections which go beyond a 5-year horizon for Zimbabwe. These projections are novel and informative to address the lack of care.

The trend in prevalence of double orphans in Zimbabwe is of great concern. The double orphanhood condition has relevant negative consequences on the health, education and general well-being of the children who have lost their parents. The impact of double orphanhood is much more dramatic than the one of maternal or paternal orphanhood alone. A caregiver who is not a biological parent is needed for double orphans. In most cases, the caregiver who fosters the child is a member of the kinship group, either a grandparent or an uncle or aunt. The HIV epidemic has a strong impact on adult mortality and reduces the pool of kinship resources available to children, at a time when the number of orphans is very high. A quantitative evaluation of kinship resources available to orphans is missing in the literature. In the next sections, I will address this important problem.

## Grandparents

In this section, I assess the evolution over time of grandparental resources available to orphans. The young population age structure of Zimbabwe, together with the relevant demographic impact of the HIV/AIDS epidemic, generate a strong imbalance between number of orphans and availability of grandparents as potential caregivers.

Figure 5 shows the estimated evolution over time of the ratio of number of double orphans in the age group 0-17 years old, and number of elderly who are at least 60 years old. The ratio is very small in the early 1980s, but it then rapidly increases in the 1990s. In 2005, the number of double orphans is about equal to the number of elderly, meaning that the burden on the elderly is very high. The ratio then slowly declines to pre-epidemic rates, as a consequence of population aging and the reduction in adult AIDS-related deaths.

The microsimulation output allows for a more detailed analysis than the one based on macrodemographic measures similar to dependency ratios. For instance, we can look at the average number of grandparents available specifically to double orphans. Figure 6 shows the

evolution over time of this quantity for double orphans in the age group 0-17 years old. It is interesting to note that the lowest level of grandpaternal resources has yet to be reached. Based on the microsimulation results, I expect that the minimum value will be between 2020 and 2030. During that decade, double orphans will have, on average, only about one living grandparent to count on. Some of them will not have any grandparent at all. There will be less double orphans, but these orphans will have less grandparental resources. Figure 7 shows the proportion of double orphans whose grandparents are all dead. Between 2020 and 2030, we expect that about 35% of double orphans in the age group 0-17 years will not have any grandparent to rely on. These children will be particularly vulnerable. The problem of lack of care is very dramatic and needs to be addressed, especially in those situations where traditional kinship resources may not be enough. These results are therefore particularly informative for international organizations whose mission is to protect children.

A pattern analogous to the one that I have described so far emerges also from the analysis of probabilities of living grandparents by age of the orphan. Figure 8 shows the estimated fraction of living maternal grandmothers for maternal orphans, by age, for the period 1980-2050 in Zimbabwe. I chose to show maternal orphans and maternal grandmothers because losing the mother has more adverse consequences on children's health and well-being than losing the father. Maternal grandmothers have an important role as caregiver when the mother of the child dies. We observe that the probabilities of having a living maternal grandmother are at their lowest levels in the decade 2020-2030. Younger orphans tend to have a slightly higher probability of having a living grandmother than older ones, since their grandmothers are younger, on average.

This section shows the relevant impact of the HIV/AIDS epidemic on grandpaternal resources available to orphans. The most vulnerable children are double orphans with no or very little grandpaternal resources. In some cases, uncles and aunts may step in as caregivers. In other cases, other foster families, international organizations or churches may be needed. The balance between these actors depends on how traditional forms of social relationships will be affected by the epidemic. That is related to the amount of kinship resources that will be eroded as a consequence of AIDS-related deaths. In the next section, I will present a quantitative evaluation of the availability of uncles, aunts and siblings for orphans.

## Uncles, aunts and siblings

The extended family is the traditional safety net for orphans in Zimbabwe. In this section, I discuss the quantitative availability of uncles, aunts and siblings for orphans. In the patrilineal system of Zimbabwean communities, paternal uncles and aunts have an important role in raising children within the extended family, or in providing support to child-headed households (e.g., Foster et al. 1997).

Figure 9 shows the estimated average number of living paternal uncles and aunts for a maternal orphan, by age, for the period 1980-2050 in Zimbabwe. Maternal orphans are more vulnerable than paternal orphans. I decided to show paternal uncles/aunts, because of their important role as caregivers in the patrilineal system of Zimbabwe. Figure 9 shows a progressive decline of available aunts and uncles for orphans over time. There are some

differences in the number of living aunts and uncles by age of the orphan: younger children tend to have younger uncles and aunts, who are subject to a different mortality risk than older individuals. The trend over time is similar, though. It is consistent with the observation that traditional forms of social relationships are under stress, and new members of the community are providing care to children. For instance, the mechanism of 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 take care of orphans.

Figure 9 shows one side of the story: over time, children have a smaller number of uncles and aunts to rely on. The second important aspect of the problem is the burden on each of the uncles and aunts, which is related to the number of orphans that are in need of care. I will focus on double orphans, who are the children who need a caregiver the most. Figure 10 shows the ratio of number of living uncles/aunts and number of double orphans in the age group 0-17 years old, over time. The ratio has been computed by extracting the number of unique people who are uncles/aunts to double orphans in the simulated population. Figure 10 shows that the burden on uncles and aunts is currently at its highest levels. In the next few decades, although orphans will continue on counting on approximately the same number of uncles/aunts, the overall number of orphans (and, more generally, children) will decrease and thus the per-capita burden on uncles and aunts will be alleviated.

Orphans are often a heavy burden on relatives, who may refuse to take care of them. Such refusal is a sign of the decline of traditional extended family practices. Foster et al. (1997) show that leading factors to the establishment of child-headed households are the death of the parents and the availability of relatives who provide support to the children, but do not accept them into their households. In other cases, relatives are nonexistent, or they are distant, sick or do not have the material means to provide for additional children. Households headed by adolescents are an additional coping mechanism in response to the impact of HIV/AIDS on communities. It is thus relevant to consider the availability of elder siblings to support their younger brothers and sisters. Figure 12 shows the trend over time of the fraction of double orphans younger than 10 years old who have at least one elder sibling who is older than 15 years old. There is some stochasticity after 2040, mostly related to the smaller number of expected double orphans at that time. However, the trend is fairly clear. In the 1980s, before the HIV epidemic took off, half of the youngest double orphans (less than 10 years old) were expected to have at least one adolescent sibling older than 15 years old. By 2020, only about a third of the youngest orphans are expected to have a living adolescent sibling. Then the ratio is expected to increase over the course of the next decades. This result shows that, at the time when the availability of grandparents, uncles and aunts is at its lowest levels, the resources provided by elder siblings are also thin and the additional coping mechanism provided by child-headed households may be seriously undermined by the age structure of siblings.

## **An index of kinship resources for young children**

In the previous sections, I analyzed the effect of the HIV/AIDS epidemic on the generation of orphans and the availability of grandparents, uncles, aunts and siblings. In this section, I

provide an index of overall kinship resources for young children.

I quantify the amount of kinship resources by weighting the availability of members of the same kinship group by their relatedness to the child considered. The weights are obtained using the Hamilton's coefficient of relatedness, which is defined as the percentage of genes that two individuals share by common descent. A child inherits  $\frac{1}{2}$  of his/her genome from a parent. The coefficient of relatedness for a child and one of his/her parents is thus  $\frac{1}{2}$ . The coefficient for a child and one of his/her grandparents is  $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ . The coefficient of relatedness for a child and one of his/her uncles/aunts is  $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$ , and so on.

Figure 12 shows two indexes of kinship resources for children younger than 10 years old in Zimbabwe, over time. The indexes are normalized so that the initial value in 1980 is equal to 100. The dashed line is the normalized average amount of kinship resources for a child less than 10 years old. For the calculation of the index, the kinship members considered are elder siblings, parents, grandparents, uncles and aunts. The members of the kinship group are weighted by their coefficient of relatedness with the child. The solid line is constructed in an analogous way, with the exception that the amount of kinship resources are also weighted by the number of unique individuals in the population that are potential caregivers. In other words, the index represented with a dashed line is multiplied by the number of unique members of the population who take up the role of siblings, parents, grandparents, uncles and aunts, to get the solid line index. The bigger the number of unique individuals, the less the average burden on each of them to take care of the children in the society.

The indexes in figure 12 show a transition from relatively high levels of kinship resources for children, to relatively low levels of kinship resources. The index corrected for the number of unique members of the potential caregivers group (solid line) shows a more rapid decline in kinship resources in the 1990s. Both indexes show a very slow increase in kinship resources for children after 2020.

These results open important questions on the future of traditional forms of social support based on reciprocal obligations. The demographic change associated to the HIV/AIDS epidemic, and the demographic transition, may reduce the amount of kinship resources available to children to a point that undermines the traditional role of the extended family as a safety net, and the existence of certain social mechanisms such as child fosterage.

## Conclusion

This study provides a quantitative assessment of the material basis of traditional kin relations in Zimbabwe. I used data obtained from the Zimbabwe Demographic and Health Surveys, and United Nations estimates and forecasts of demographic rates, to inform a microsimulation model. The population outputs of the simulation are used to estimate quantities for which analytical expressions are not manageable. For example, the microsimulation is useful to evaluate the trend in kinship resources for double orphans. The proportion of double orphans without any living grandparent is expected to increase until about 2030. Then it will decrease. This trend is likely to shift the responsibility for double orphans to uncles and aunts. On average, the number of uncles and aunts per double orphan has been decreasing

from 1980 to 2010, but it is expected to increase progressively during the next decades. Overall, I estimate a transition, between 1990 and 2010, from fairly high to fairly low levels of kinship resources for young children in Zimbabwe.

The extended family has been recognized as an important safety net in sub-Saharan Africa. With the onset of the HIV/AIDS epidemic, there has been an increasingly stronger demographic pressure on social forms of relationships based on reciprocal obligations among members of the same kin group. Two broad questions arise. First, how much kinship resources will be available to the most vulnerable members of the society, in particular young orphans? Second, what is the future for traditional social practices, such as purposive child fosterage, which are mainly based on mutual support among members of the same kin group?

Answering the first question is important to address the lack of care for orphans. Given the relevance of the extended family for coping mechanisms, it is crucial to estimate kinship resources available to orphans for planning purposes. Estimates and projections of kinship structure are not generated and published by international agencies. Such quantities would complement statistics on number of orphans and prevalence of orphanhood. This research highlights the importance of kinship resources to cope with the dramatic impact of the HIV/AIDS epidemic in Zimbabwe. The study is a call for the development of kinship forecasting for sub-Saharan Africa. Forecasts of kinship resources available to orphans would be useful for policy makers when they plan interventions to mitigate the impact of HIV/AIDS on children.

The second question has broad implications for sociological research. Will traditional forms of social relationships survive the impact of the HIV/AIDS epidemic? My hypothesis is that demographic pressure may become strong enough to make some traditional practices, such as purposive fosterage, unfeasible. An extended period of 'emergency' fosterage practices, together with a reduction in the average size of kinship groups, may undermine the basis for the existence of traditional forms of social obligations based on reciprocal advantages. New forms of social relationships and living arrangements may emerge in order to spread risks across kinship groups. I showed that during the next couple of decades demographic pressure on traditional forms of social relationships may continue to be strong. The next couple of decades will thus be crucial for the sustainability of practices such as fosterage.

The paper raises important questions that should be addressed with further research. The geographic focus of the study is on Zimbabwe. I believe that it would be relevant to produce generalizations, in the spirit of model life tables, that go beyond a single country. Different patterns of mortality typical of societies affected by the HIV/AIDS epidemic can be used as input for microsimulations. As output, we would have a series of measures of kinship resources associated to different levels of adult HIV prevalence, or life expectancy. This general model would allow us to evaluate the average effect of a change of one percentage point in HIV prevalence, or one year of life expectancy, on an index of kinship resources.

In addition to generalizations, it may also be relevant to evaluate the spatial heterogeneity within a country. For instance, in those cases where detailed information is available at a

fine geographical level, it would be interesting to disaggregate the analysis by areas within the country. Behaviors, attitudes and social practices of urban areas may be very different from the ones of rural areas. Kinship structure strongly interacts with the socio-economic context. Obligations and economic resources of uncles and aunts may depend on the region of the country. Churches and non-governmental organizations may have a stronger role in mitigating the adverse effects of the epidemic in urban areas than in rural villages, etc. I see some potential for linking the results of a microsimulation model with statistical analyses of sample surveys such as the Demographic and Health Surveys.



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## Figures

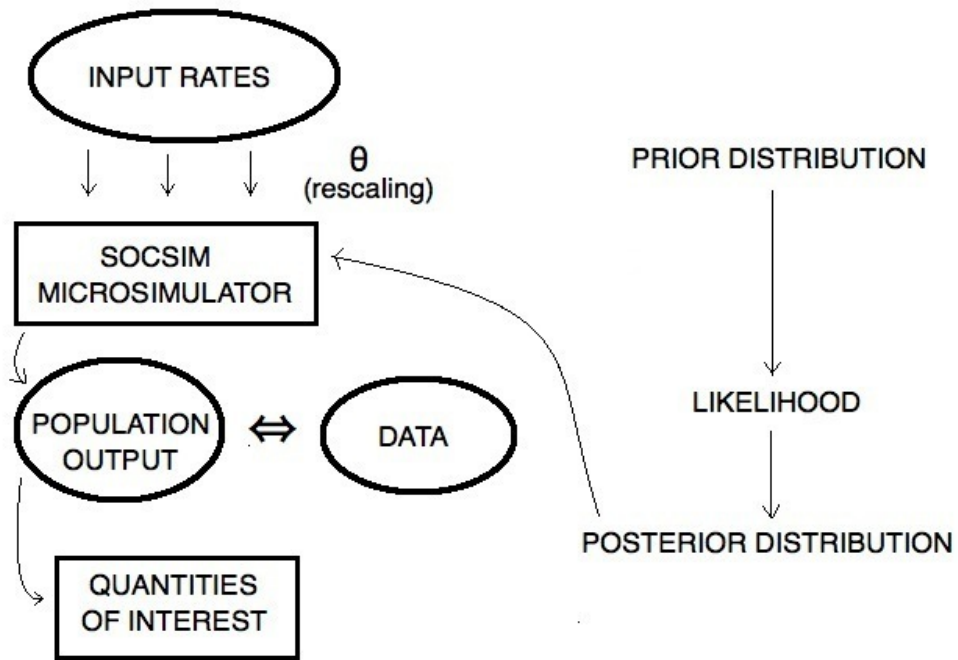


Figure 1: A schematic representation of the approach that I used to calibrate the microsimulation model for the evaluation of the effect of the HIV/AIDS epidemic on kinship structure in Zimbabwe.

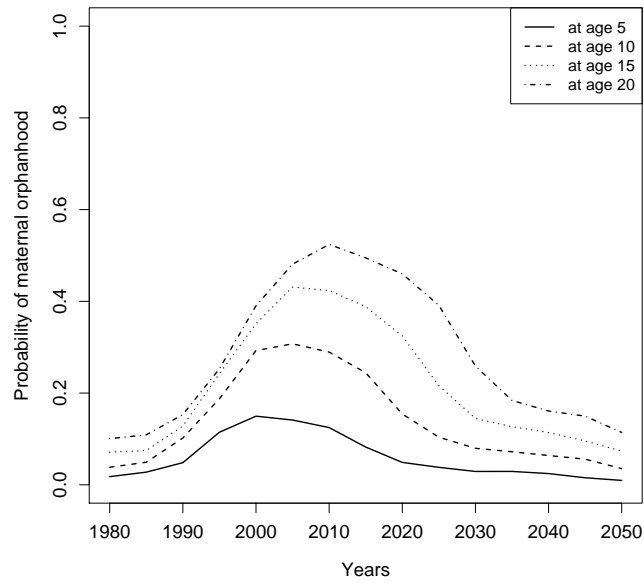


Figure 2: Estimated fractions of maternal orphans, by age, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

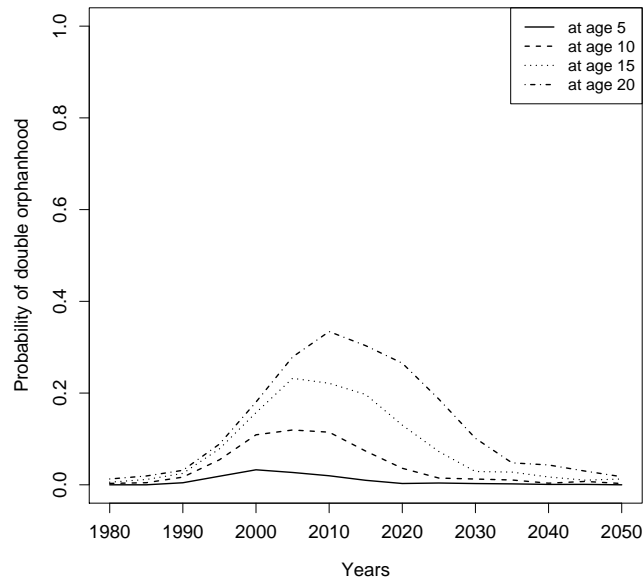


Figure 3: Estimated fractions of double orphans, by age, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

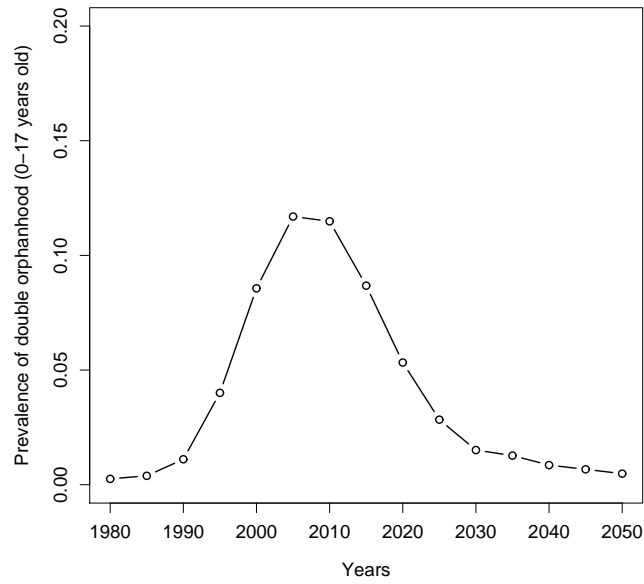


Figure 4: Estimated prevalence of double orphanhood in Zimbabwe for children in the age group 0-17 years old, for the period 1980-2050. Results are based on the output population file of the microsimulation.



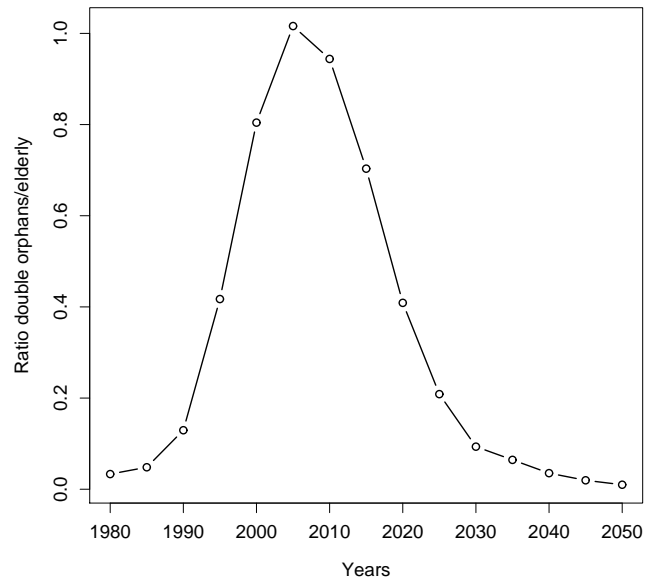


Figure 5: Estimated ratio of the number of double orphans in the age group 0-17 years old, and the number of elderly who are at least 60 years old, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

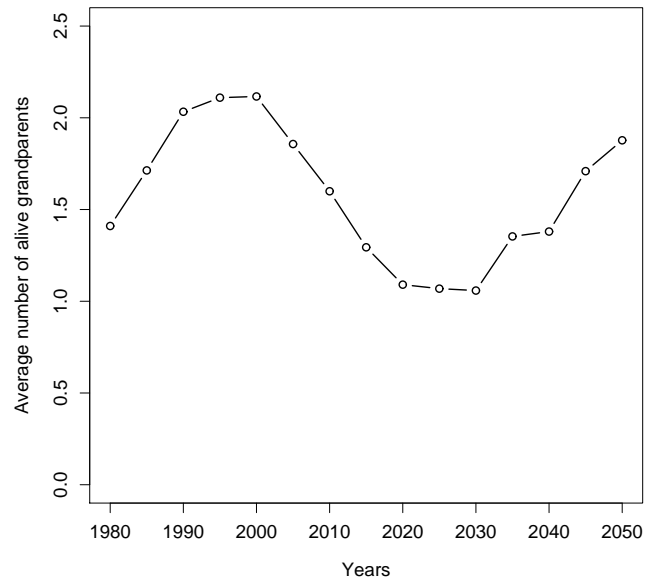


Figure 6: Average number of alive grandparents of double orphans 0-17 years old, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

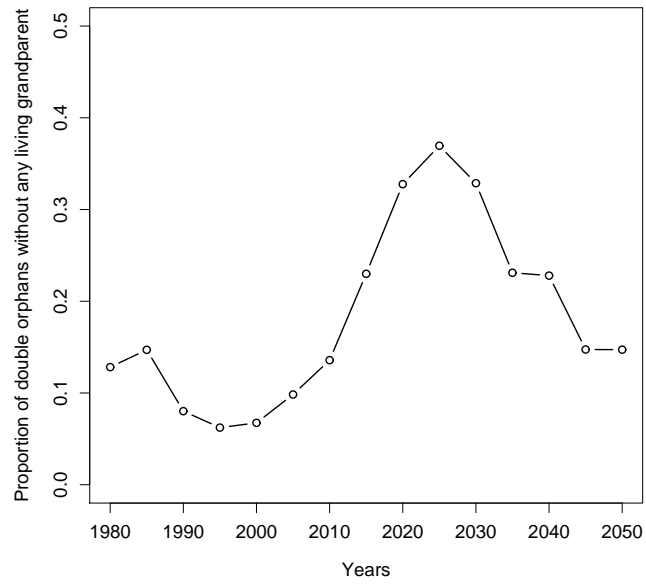


Figure 7: Estimated fraction of double orphans 0-17 years old whose grandparents are all dead, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

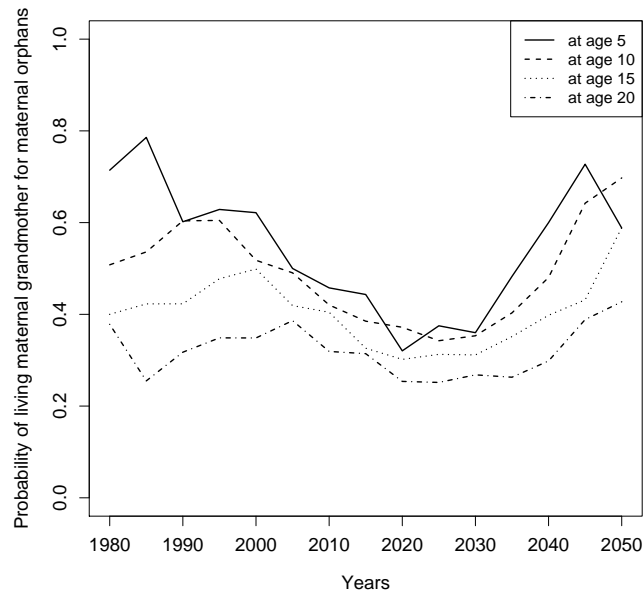


Figure 8: Estimated fraction of living maternal grandmothers for maternal orphans, by age, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

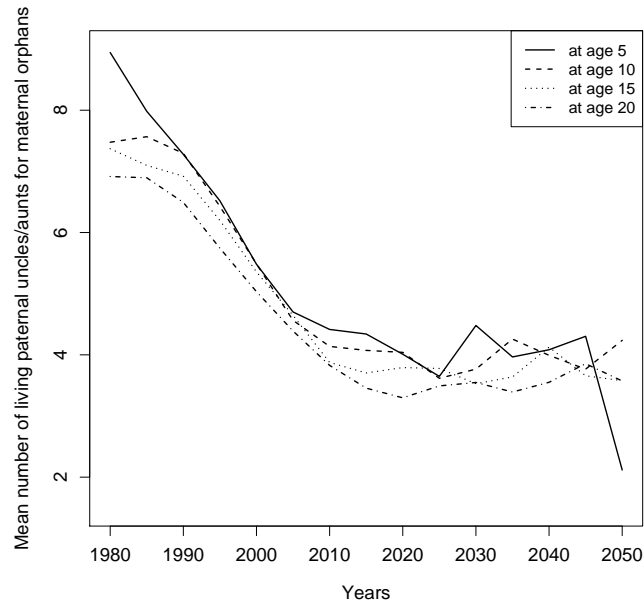


Figure 9: Estimated average number of living paternal uncles and aunts for a maternal orphan, by age, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

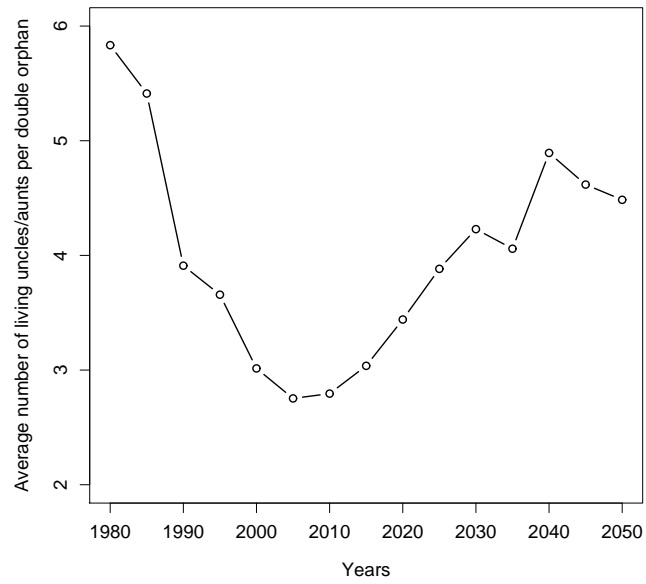


Figure 10: Estimated ratio of number of living uncles/aunts and number of double orphans (age group 0-17 years old) for the period 1980-2050, in Zimbabwe. Results are based on the output population file of the microsimulation.

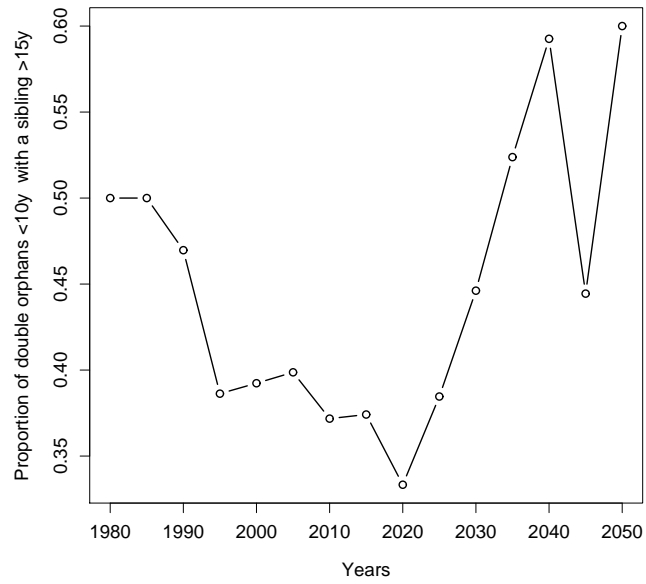


Figure 11: Estimated fraction of double orphans younger than 10 years old who have at least one elder sibling who is older than 15 years old, for the period 1980-2050 in Zimbabwe. Results are based on the output population file of the microsimulation.

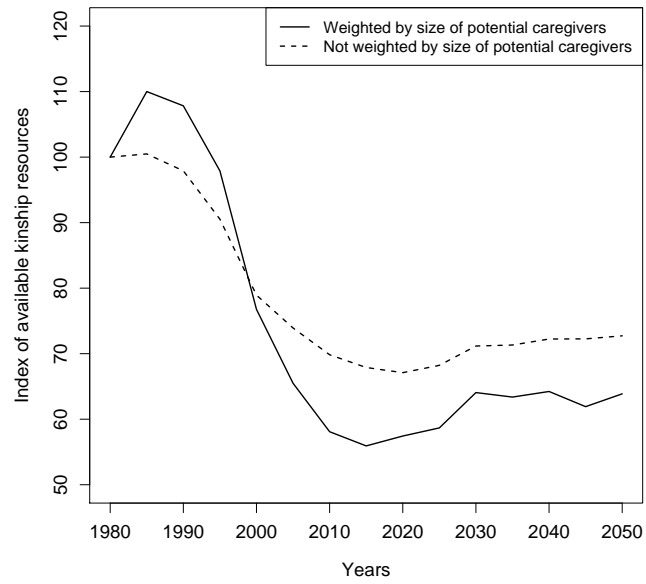


Figure 12: Two indexes of availability of kinship resources for children younger than 10 years old, for the period 1980-2050 in Zimbabwe. See main text for details on the indexes. Results are based on the output population file of the microsimulation.