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The Impact of AIDS on Orphanhood in South Africa: A Quantitative Analysis

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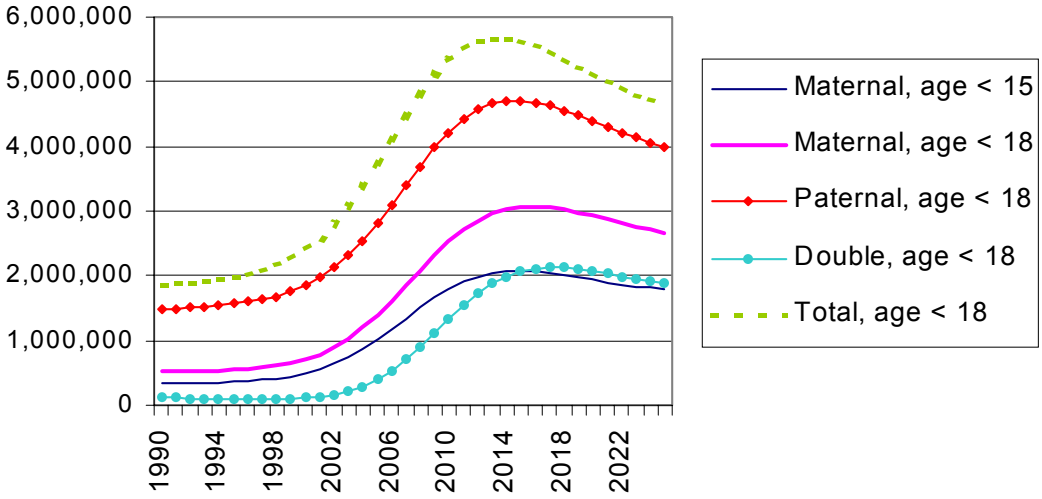
Synopsis

The purpose of this report is to present an analysis of the impacts of the HIV/AIDS epidemic on the number of orphans in South Africa. Most South African AIDS literature makes cursory reference to the impact AIDS will have on numbers of orphans, but little attempt has been made to present a detailed analysis of the size and demographic profile of this group. The primary focus of this report is on the quantification of the orphan population, and the ASSA2000 Orphans model is presented as a tool for projecting the size and demographic profile of this population. Numbers of orphans are projected under various scenarios, and the capacity of the South African system to deal with the growth in orphan numbers is briefly assessed.

The model used to produce the estimated number of orphans is the ASSA2000 Orphans model. This model operates in parallel with the ASSA2000 AIDS and Demographic model, a model developed by the Actuarial Society of South Africa to project the impact of the AIDS epidemic at national and provincial levels. Three versions of the Orphans model have been developed: one to estimate numbers of maternal orphans, one to estimate numbers of paternal orphans, and one to estimate numbers of "double orphans". The maternal orphans model calculates numbers of orphans by taking female deaths in each year, and back-projecting the maternal fertility rates in previous years, taking into account the mother's age and duration since infection (if HIV positive) at death. This yields estimates of children born in previous years, and the survival of these children is then taken into account up to the time at which the number of orphans is being assessed. In extending the method to calculate numbers of double orphans, it is assumed that the paternal mortality is a function of the mother's age and level of risk behaviour at the birth of the child. The paternal orphans model is a simple extension of the double orphans model.

The graph below shows the projected numbers of orphans using different definitions of orphanhood. Regardless of the definition used, the number of orphans is likely to peak around 2015 – at roughly 2 million in the case of maternal orphans under the age of 15, and at roughly 3 million in the case of maternal orphans under the age of 18. The number of paternal orphans under the age of 18 is expected to peak at 4.7 million in 2015, and the total number of children having lost one or both parents will be at its highest around 2014, at a level of 5.7 million. The growth in the proportion of the orphan population consisting of double orphans is largely attributable to the dependency between paternal and maternal mortality that is introduced by AIDS. It should be noted, however, that the number of paternal and double orphans estimated here may well under-estimate the true number of children without paternal care, as no allowance has been made in these projections for fathers who are alive but absent.



A more detailed analysis of the demographic profile of the orphan population shows that:

- Rates of maternal orphanhood are higher among older children than among younger children, with rates ranging from close to 0 among children at young ages, to well over 30% for children between ages 15 and 17.
- Relatively few orphaned children are likely to be HIV positive, as most HIV positive orphans do not survive for long enough to constitute a significant proportion of the orphan population.
- Rates of orphanhood are likely to be highest in the black African population group and among poor socio-economic groups.

Comparing the estimates from the ASSA2000 Orphans model with estimates from other AIDS models shows that the ASSA2000 estimates of orphan numbers are relatively low, in spite of the ASSA2000 model predicting higher levels of AIDS mortality than any of the other AIDS models. This discrepancy can be explained in terms of differences between the models in the treatment of fertility, and it would seem that the ASSA2000 Orphans model is the most realistic of the models examined in terms of the treatment of fertility. Demographic and Health Survey (DHS) data from 1998 roughly confirm the reasonableness of the model outputs. However these estimates also suggest that in South Africa absent fathers could be contributing to some extent to the problem.

The effects of various interventions were also analysed in terms of numbers of orphans. It was estimated that implementing mother-to-child transmission prevention programmes would ultimately lead to a rise of roughly 250 000 in the number of maternal orphans under the age of 15. Programmes to distribute more condoms and improve STD treatment are unlikely to reduce the number of orphans significantly in the next decade, but may well have a positive impact in the longer term. However, making antiretroviral drugs freely available would probably reduce significantly the number of orphaned children by extending the lives of HIV positive parents.

South Africa's capacity to deal with the increased number of orphaned children is currently limited. Although foster care grants can ease the burden on foster parents significantly, they are difficult to access, and there is a lack of awareness among those

in need, of these and other forms of assistance. The Child Care Act has also been criticized as being limited in the placement options it sets out for orphaned children. Institutional care is being provided, but in order to contain costs, policy makers are shifting their focus towards models of community-based care. It is encouraging that the communities likely to be worst hit by the orphan burden tend to regard orphaned children as the responsibility of the community rather than the responsibility of government.

South Africa faces the prospect of several long-term social costs if the situation is not managed effectively: increased rates of juvenile crime, reduced levels of literacy, and increased economic burdens on the state. However, many of these long-term costs can be reduced if action is taken now. Most importantly, models of community-based care need to be further developed, and forms of state assistance to those caring for orphaned children need to become more extensive and more efficient.

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1. Introduction

1.1 Background and Motivation

Globally the AIDS epidemic has had a dramatic effect on populations. In the twenty years since the disease was first identified, AIDS has killed millions and significantly affected many countries socially and economically. One of the most tragic consequences of the epidemic is the large number of children that are orphaned as a result of parents dying from AIDS. Many of these children are HIV positive themselves, having been infected by their mothers either perinatally or through breast milk. UNICEF (2001) estimate that at the end of 1999 there were 14.6 million children worldwide under the age of 15, whose mothers had died of AIDS – of these, roughly 1.4 million were living with HIV/AIDS.

In South Africa the number of orphans has been increasing slowly, and as a result has attracted relatively little public attention. In years to come, however, the number of orphans is likely to rise rapidly as AIDS mortality increases. Whether because of the lack of immediacy associated with the problems of caring for them, or the complexities in quantifying the situation, there has been relatively little research into the quantification of the current and future levels of orphanhood in South Africa. Most South African AIDS literature makes cursory reference to the impacts of AIDS on numbers of orphans, but little attempt has been made to present a detailed analysis of the size and demographic profile of this group. It is imperative that this be understood if strategies to provide care for these children are to be developed successfully.

1.2 Objectives and Overview

The objective of this study is to describe the methods of estimating the number of orphans using the ASSA2000 AIDS and Demographic model, and to present results of projecting the size and demographic profile of the orphan population. These results are compared with other estimates and empirical data. The monograph also includes a brief discussion of the sociological and policy implications of the expected growth in orphan numbers.

1.3 Acknowledgements

The authors would like to thank Stephen Kramer of Metropolitan Life for providing information about the Doyle model, and Gerard Callaghan for producing estimates of the number of orphans in South Africa based on the Spectrum model and Epimodel. Special thanks are also due to Ian Timæus (London School of Hygiene and Tropical Medicine), Debbie Budlender (Community Agency for Social Enquiry) and Debbie Bradshaw (Medical Research Council) for their valuable comments and suggestions. This work was partially funded by the Secure the Future project, sponsored by Bristol Myers-Squibb.

2. Methodology

The focus of this study is primarily on maternal orphans (i.e. children whose mothers have died), and to a lesser extent on "double orphans" or "dual orphans" (children that have lost both parents). Estimates of numbers of paternal orphans have also been included to allow for estimation of the number of children compromised through the loss of one or both parents.

2.1 Maternal Orphans

The model used to estimate the number of maternal orphans operates in parallel with the ASSA2000 AIDS and Demographic model[*]. The latter is a spreadsheet model used to estimate the impact of AIDS on the South African population, both nationally and provincially (Dorrington, 2000). The model is based on the division of the population into four "risk groups", each defined in terms of an assumed level of sexual activity. Two versions of the model exist: a "lite" version which ignores racial differences, and a "full" version which projects the course of the epidemic separately for each of South Africa's four population groups. "Lite" and "full" versions of the maternal orphans model have been developed to work in parallel with the corresponding versions of the ASSA2000 model.

The method used to estimate the number of maternal orphans can be explained briefly as follows. Firstly, female deaths by age at death in each year are estimated from the ASSA2000 model. The past fertility of these women is then back-projected from the time of death, taking into account the duration since HIV infection at death in cases where the woman died HIV positive. This is used to estimate the number of children women at each age leave behind when they die, as well as the dates of birth of these children. Knowing the HIV status of the mothers at birth also makes it possible to determine approximately the number of children infected perinatally as well as the number infected by breast-feeding. A separate spreadsheet is then used to project the mortality of children (taking into account differences in mortality of children that are infected perinatally, children that are infected through breast-milk and children that remain uninfected). This yields estimates of the numbers of orphans for each year since the start of the epidemic. A more detailed algebraic description of the method is given in Appendix A.

2.2 Double Orphans

Timæus and Grassly (2001) identify two methods of estimating the number of double orphans. The first is to estimate the number of maternal orphans and then to calculate the proportion of maternal orphans whose father would have died in each year. The second is to make use of a regression model fitted to Demographic and Health Survey (DHS) data on the numbers of maternal and paternal orphans from various sub-Saharan African countries. Timæus and Grassly favour the latter approach on the

[*] This model is publicly available and can be downloaded free of charge from www.assa.org.za/committees/aids/aids.htm

grounds that the first is likely to require empirical data that would often not be available. They acknowledge, however, that there are problems in using DHS data (these problems are discussed in more detail in section 5.3).

The first approach described by Timæus and Grassly has been adopted in this paper. The principle challenge is to estimate the proportion of maternal orphans with fathers dying at different times. Crucially, the modeller needs to take into account the dependency between maternal and paternal mortality – if the mother has died from AIDS, there is a good chance that the father has also died, or will soon die, from AIDS. The method used makes implicit allowance for this dependency by linking the risk group of the mother to the risk group of her partner at the time of birth, using the assumptions in the ASSA2000 model regarding sexual interactions between the risk groups. Future mortality rates are then projected for each male risk group, so that the distribution of paternal deaths with respect to calendar year can be determined. A more detailed algebraic description of the method is given in Appendix A.

Because of the significant computational problems involved in developing and running such a model of dual orphans, work, at this stage, has been confined to developing only the version that uses the "lite" version of the ASSA2000 model.

2.3 Paternal orphans

The method used to estimate the number of paternal orphans is similar to that used to estimate the number of dual orphans. Male mortality is projected into the future for all births, taking into account the age and the risk group of the mother at birth.

2.4 Shortcomings of the Methodology

The following are the most important of the shortcomings associated with the method described above.

- The ASSA2000 model, for simplicity, assumes that the proportion of male partners in each age group, for women of a certain age, is the same for all women, irrespective of their risk group. It is also assumed that the age distribution of male partners remains stable over the course of the epidemic, and that the patterns of sexual interaction between the risk groups also remain stable over time. None of these assumptions is very realistic. These, however, are limitations of the underlying ASSA2000 model rather than the Orphans model itself.
- The age distribution of male partners of women of a given age has been estimated from South Africa's 1998 Demographic and Health Survey. In this survey women were asked the age of their "husband/partner". This age is assumed in the Orphans model to be the same as the age of the father of any child the women is currently pregnant with. This is not an unreasonable assumption, and it is unlikely that it would result in the paternal or double orphan estimates being significantly biased.
- Timæus and Grassly (2001) observe that most models assume orphaned children are subject to the same mortality as that of children that have not been orphaned. However, it is more likely that orphaned children (whether infected by their mother or not) experience higher mortality than children that have not

been orphaned. While the model as used for this study allows for the differences in mortality between uninfected and infected children, it does not make allowance for differences between uninfected orphans and uninfected non-orphans. Although the model can be adapted to allow for these differences, changes have not yet been made due to a lack of data regarding these differences. The effect would be to reduce the number of orphans slightly.

- HIV infection is known to produce a reduction in fertility, particularly in women at older ages (Zaba and Gregson, 1998). While the model developed here makes allowance for this effect, it must be emphasized that there is little data regarding the achieved fertility of women that go on to die from AIDS (Timæus and Grassly, 2001), and that the projected numbers of maternal orphans are quite sensitive to changes in this assumption.
- The further into the future that the model is used to project, the greater is the uncertainty surrounding the estimates produced. This is a particular problem with projections of numbers of orphans, as the rise in orphan numbers is the most long-term consequence of the AIDS epidemic.

Currently the ASSA2000 Orphans model can only be used to assess the impact of AIDS on orphan numbers in South Africa. However, a version will in due course be developed to operate in parallel with the ASSA2000 Urban-Rural model, the model currently being used to project the impacts of AIDS in other African countries (Dorrington and Schneider, 2001). The results in the sections that follow will then be available for other African countries. Once the ASSA2000 model has been fitted to each of South Africa's provinces, it will also be possible to present similar projections for each province in South Africa.

3. Base Projections

The most commonly used definition of the term "orphan" is children under the age of 15 whose mothers have died. This definition is applied in sections 3.1 to 3.5 in order to assess the projected number of orphans and the demographic profile of the orphan population. All results are based on the "full" version of the ASSA2000 model (though the numbers using the "lite" version of the model are very similar).

All projections in this section are based on the assumption that there is no change in sexual behaviour and no significant health interventions in future.

3.1 Orphans in the context of the AIDS epidemic

Dramatic increases in the number of orphaned children are the most long-term of the consequences of the AIDS epidemic. South Africa's AIDS epidemic is still in its early stages, relative to other African countries, and South Africa has yet to experience the levels of orphanhood that have been observed elsewhere in Africa. However, currently there are more people infected with HIV in South Africa than in any other African country, and it is therefore quite possible that the country will ultimately have more AIDS orphans than any other country on the African continent.

To appreciate exactly how long-term the impacts on orphan numbers are, it is useful to consider the epidemic in terms of a series of "waves", as depicted in Figure 1. The first of these waves, the wave of new HIV infections, peaked in about 1998, at about 930 000 infections a year. It is being followed by the wave of total HIV infections, which is projected to peak in about 2006 at about 7.7 million infections. The wave of AIDS deaths is expected to peak soon after that, in about 2010, at about 800 000 deaths per annum, and will in turn be followed by the wave of AIDS orphans (defined here as children under the age of 15 whose mothers have died from AIDS). This wave is expected to peak at around 1.85 million around 2015. It is clear, therefore, that the rise in the number of orphans is the most long-term of the consequences of the epidemic.

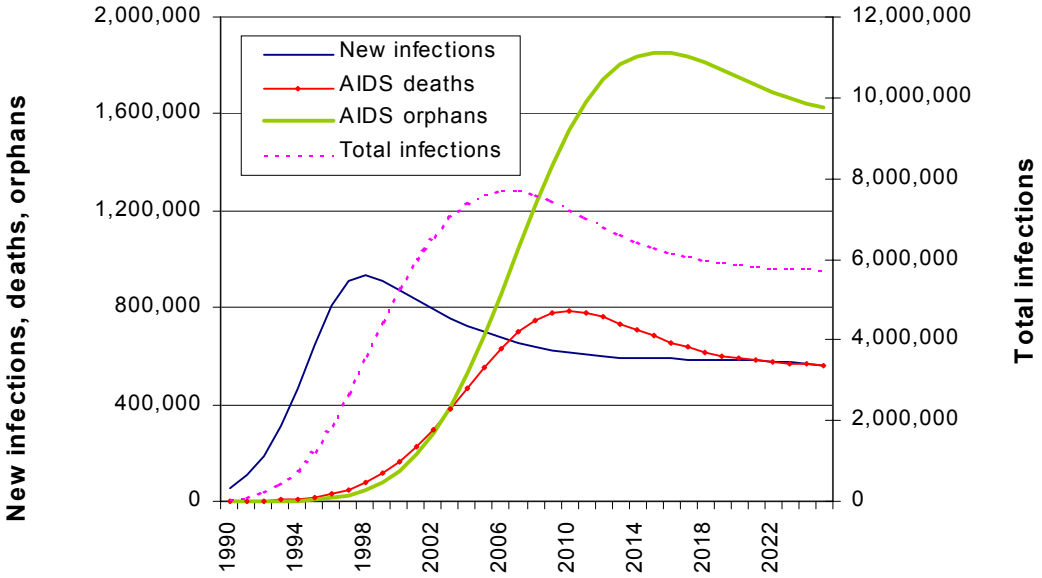

Figure 1: Waves of the AIDS epidemic

3.2 Aggregate Results

Figure 2 shows the projected total number of orphans in South Africa between 1990 and 2025. The figure shows that the number is likely to rise dramatically during the next decade, and ultimately peak at about 2.07 million orphans in 2015. The gradual decline in the total number of orphans after 2015 is largely attributable to the decline in AIDS deaths.

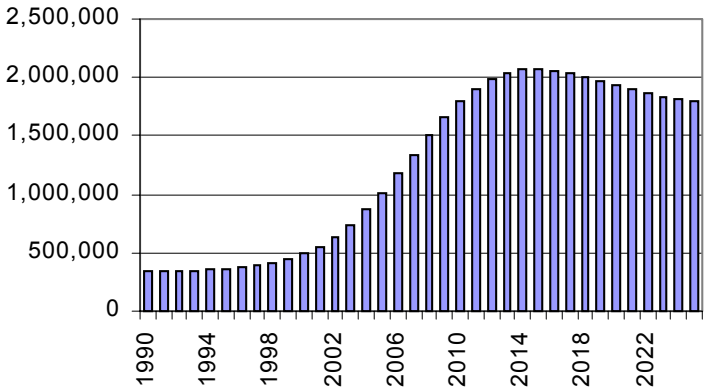

Figure 2: Total maternal orphans under the age of 15

As the population may change over time it is perhaps more useful to think in terms of the *percentage* of children that are orphaned. The model predicts that in the absence of AIDS mortality, roughly 2.6% of children under the age of 15 are maternally orphaned at any point in time. With AIDS mortality, however, we can expect to see

this percentage rising to a peak of nearly 15% in 2016. This is demonstrated in Figure 3.

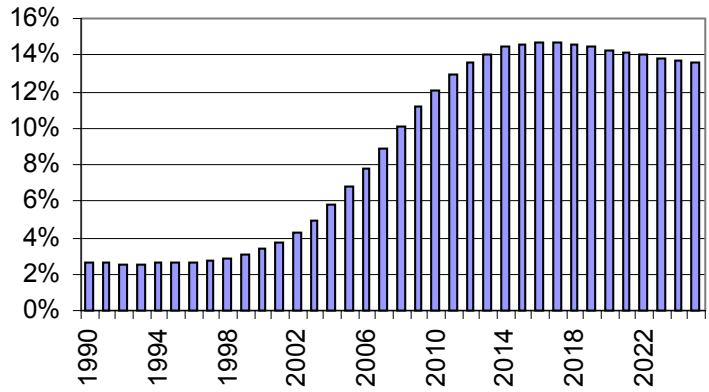

Figure 3: Percentage of children aged < 15 that are maternally orphaned

3.3 Understanding the Different "types" of Orphans

It is possible to distinguish three types of orphans for the purpose of this analysis:

(i) Orphans that are HIV positive as a result of having being infected by their mothers.

(ii) Orphans that are not infected with HIV, but whose mothers died either from AIDS or while HIV positive.

(iii) Orphans that are not infected, and whose mothers were HIV negative when they died.

It is important to distinguish between uninfected orphans of *uninfected* mothers and uninfected orphans of *infected* mothers; this enables one to estimate the extent to which the orphan numbers are attributable to AIDS. It is also important to distinguish between orphans that are HIV positive and orphans that are clear of infection, since the mortality rate of the former will generally be considerably higher, and this mortality differential needs to be taken into account when projecting the numbers of orphans surviving to future times.

HIV positive orphans usually become infected with HIV in one of two ways. Firstly, a certain proportion of the children of HIV positive mothers will be infected perinatally (i.e. at the time of birth). Estimates of this proportion vary: Saba (1999) estimates a rate of 17%, Nduati *et al* (2000) estimate a rate of 20.5%, and a rate of 25% has been estimated from work done by Spira *et al* (1999). The ASSA2000 model assumes the latter rate of 25%. If children are not infected perinatally, it is also possible for them to become infected through being breast-fed by a mother who is HIV positive. The proportion of children infected in this way depends very much on the amount of breast-feeding the child receives. Miotti *et al* (1999) and Spira *et al* (1999) estimate that roughly 10% of children that are breast-fed by HIV positive mothers will become HIV positive as a result of breast-feeding, if they are not already infected perinatally – which is in line with what ASSA2000 assumes. (Nduati *et al* (2000), however, estimate the percentage to be closer to 16%). Most models do not distinguish

between the two modes of transmission, but it is commonly assumed that the overall rate of transmission from mother to child is roughly 35%, which is not inconsistent with the rates of transmission assumed in the ASSA2000 model.

It is important to emphasize the differences between perinatal and mother's milk infections because there is evidence to suggest that those children infected through breast milk tend to survive for significantly longer than those that are infected perinatally (Spira *et al*, 1999). The ASSA2000 model assumes that the median survival from birth for perinatal infections is two years, and that the median survival from the point of infection with mother's milk (on average six months after birth) is six years. Thus, although HIV transmission through breast milk is less common than perinatal transmission, the longer survival of children infected by breast milk means that they make up a greater proportion of the total orphans at a given point in time, as Figure 4 shows.

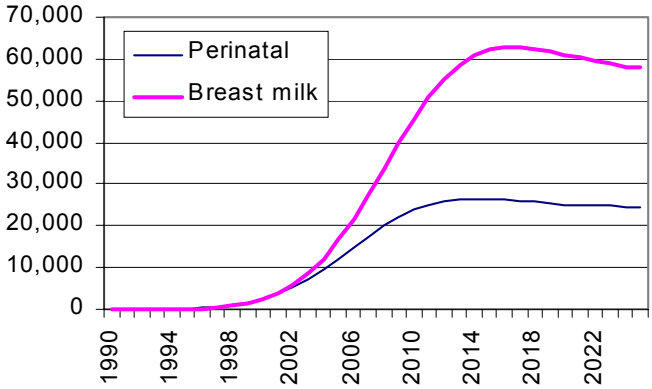

Figure 4: Numbers of infected orphans by mode of transmission

It should be noted that the above numbers are relatively small, and when the numbers of HIV positive orphans are compared with the total numbers of orphans (see Figure 5), it is apparent that they constitute a relatively minor proportion of the total orphan population. This is because roughly two thirds of babies born to HIV positive women will not be infected and because most infected orphans usually do not survive for long enough to make up a sizeable group of children.

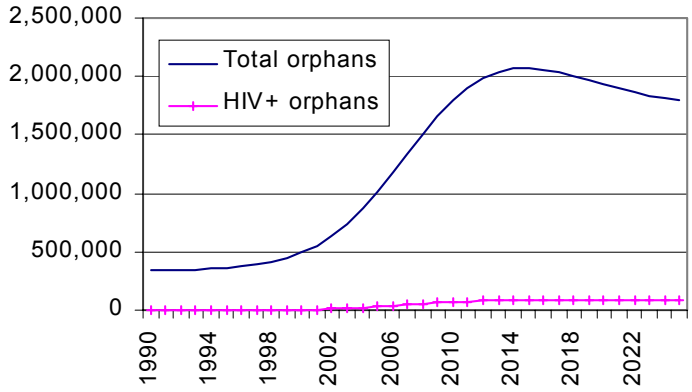

Figure 5: Number of HIV positive orphans relative to total orphans

The term "AIDS orphans" is conventionally used to refer to children that have lost a parent due to AIDS, but for the purpose of modelling convenience, the term is applied slightly more broadly in this paper to include also children whose parents died while HIV positive (even if not necessarily from AIDS). Similarly, we use the term "non-AIDS orphans" to refer to children that have been orphaned while their parents were HIV negative. Figure 6 shows the numbers of children in these two categories over time. The projections suggest that the number of non-AIDS orphans will gradually decline. This is largely the result of declining trends in fertility (which result in women having had fewer children at the time of death, as time progresses), but partly also a consequence of there being fewer mothers dying from causes other than AIDS. The number of AIDS orphans, on the other hand, rises enormously over the next decade, and peaks at about 1.85 million in 2015.

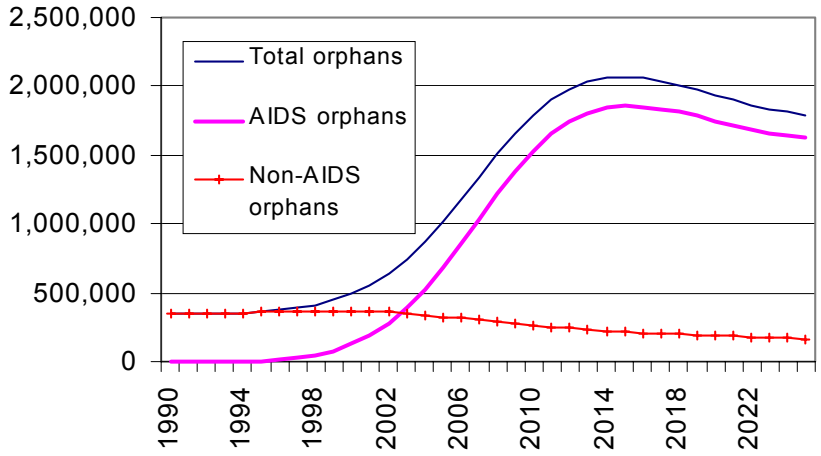

Figure 6: Numbers of AIDS orphans and non-AIDS orphans

3.4 The Age Profile of the Orphan Population

By 2015, without significant changes in sexual behaviour or interventions, roughly 15% of all children under the age of 15 are expected to be orphaned. It is important to

realize, however, that the percentage of children that are orphaned varies significantly with respect to age. As Figure 7 shows, the percentage rises almost linearly, from close to zero for children born in the last 12 months, to well over 30% for children over the age of 15. The near linearity with respect to age is to be expected; the older a child is, the greater is the chance that their mother has died during the time that they have been alive.

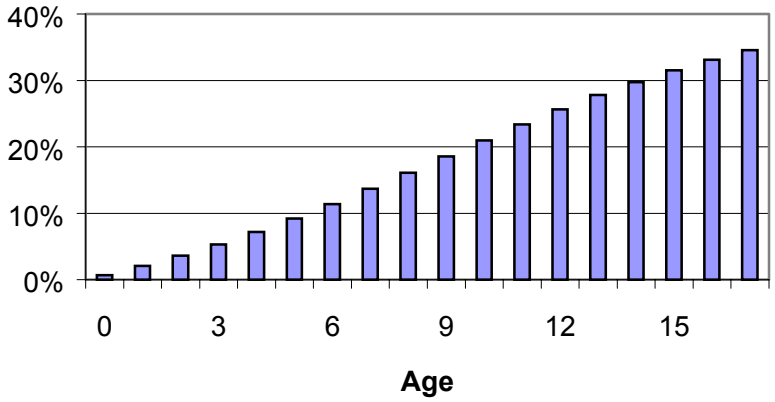

Figure 7: Percentage of children maternally orphaned in 2015

It is fortunate that there will be relatively few orphans at the younger ages, when children are at their most vulnerable. However, it is alarming that more than 30% of all children between the ages of 15 and 17 will have lost their mothers. The development of such an "orphan generation" is likely to have profound implications for society.

The age distribution of children *at the time that they are orphaned* differs from that in Figure 7. Figure 8 shows the number of children with mothers dying in 2015, by age at the end of 2015. (The unusually low number of orphans at age 0 arises because these are births that have occurred during the last year, and the mother is known to survive at least to the point of birth). The number of children orphaned rises with age to a peak at age 11 to 12. This is probably because most women become infected within years of first giving birth and will not survive much beyond 10 years after that.

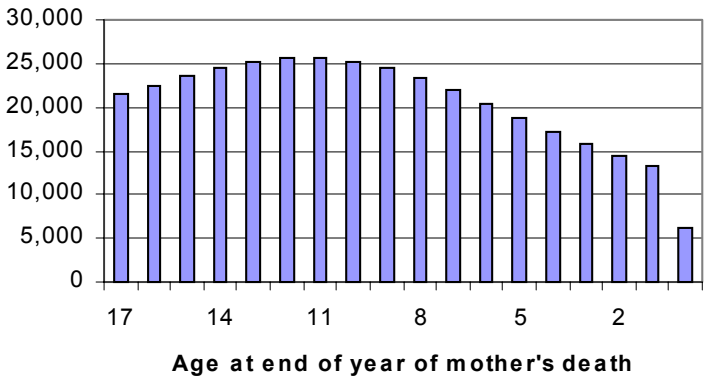

Figure 8: Children with mothers dying in 2015, by age at end of 2015

3.5 The Profile of the Orphan Population by Race

It is useful to assess the profile of the orphan population by race for two reasons. The first is that race is still very highly correlated with income, and the racial profile of the orphan population can therefore give a rough sense of the socio-economic profile of the orphan population. This is important from the point of view of assessing the extent to which orphaned children will be provided for financially after their parent's death. The second reason for examining the racial profile is that there may exist cultural differences that affect the ways in which orphaned children are cared for, and these have a bearing on the extent and form of the government assistance that is necessary.

Figure 9 shows that currently the vast majority of orphans are black African, and this pattern is likely to continue in future. The proportion of orphans that is black African is clearly in excess of the roughly three quarters of the total population that is black African, and this is largely because of the higher levels of non-AIDS and AIDS mortality in the black African population (which are to a large extent attributable to low incomes in the this population). However, the large proportion of the orphan population that is black African is also attributable to the higher levels of fertility in this population group relative to the other population groups.

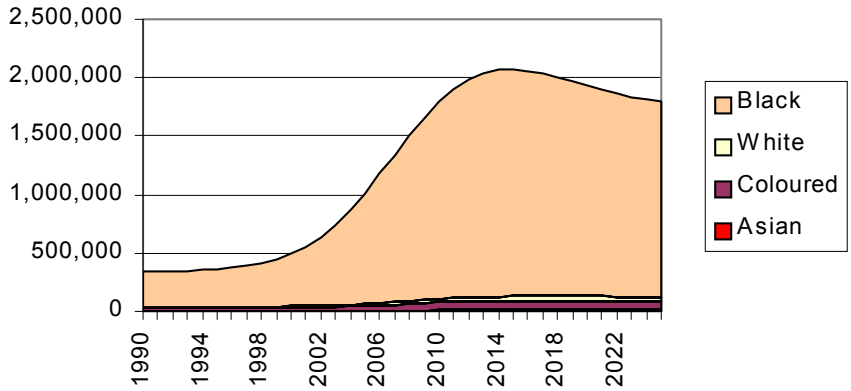

Figure 9: Composition of orphan population by race

It is also useful to look at the percentages of children under the age of 15 that are maternally orphaned separately for the different race groups. This is shown in Figure 10. Clearly, rates of orphanhood are highest in the black African population, peaking at about 16.8% in 2016. The rates of orphanhood are substantially lower in the coloured population (with a peak of 6.8% in 2017) and even lower in the white and Asian populations.

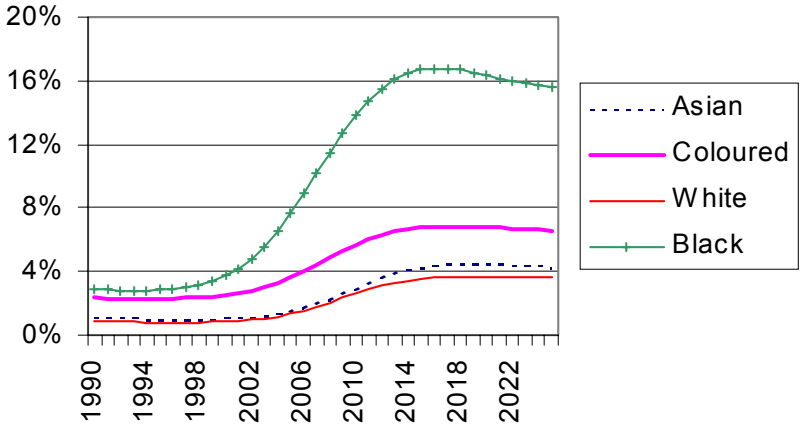

Figure 10: Percentage of children maternally orphaned, by race

It is clear, therefore, that levels of orphanhood will be high in the relatively poor population groups.

4. Examining Alternative Definitions of Orphanhood

A wide variety of definitions of orphanhood are possible. The most commonly used definition, examined in detail in section 3, is children under the age of 15 whose mothers have died. As Whiteside and Sunter (2000) argue, however, orphans do not cease to have needs on reaching age 15. Nor is it obvious that the plight of maternal orphans is more desperate than that of paternal orphans. It is therefore necessary to examine different definitions of orphanhood, and to compare the associated projections with the projections from section 3.

4.1 Alternative Age Definitions

AIDS modellers and demographers typically use age definitions corresponding to cut-off ages of 14, 15, 18 or 21 (Foster, 1997). Figure 11 shows projected numbers of orphans using age definitions of 12, 15 and 18 (even though the first of these definitions is relatively rare), and demonstrates quite clearly that using age 18 as the cut off results in a considerably higher estimate. The number of maternal orphans under the age of 18 is likely to peak at roughly 3.07 million in 2015. Arguably this is a more important measure of levels of orphanhood, since the Constitution defines children to be persons under the age of 18, and most policy makers would agree that children under this age should not be expected to be self-supporting.

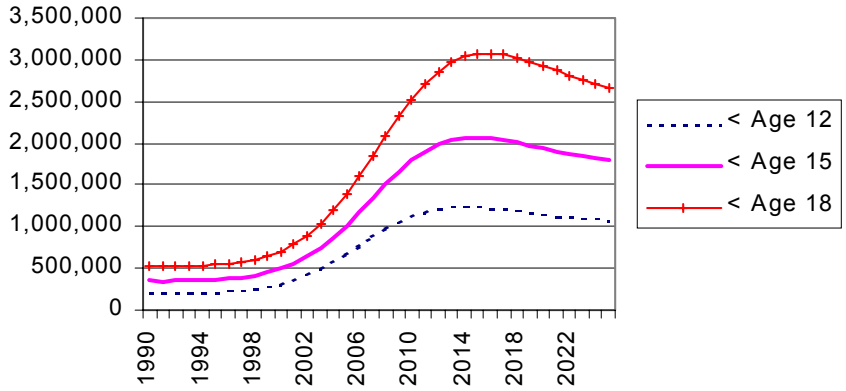

Figure 11: Numbers by alternative age definitions for maternal orphans

4.2 Allowing for Paternal Mortality

The numbers of maternal orphans are relatively easy to calculate, and hence are the most commonly used basis for projections of numbers of orphans. However, Monk (2000) argues that because traditional views of the family are based on "patrilineal structures", and because fathers tend to be breadwinners, it is often the death of the father, rather than the death of the mother, that will have the most material impact on

a child. It has also been observed that widowers find it easier to remarry than widows do (Webb, 1995).

It is therefore necessary to project numbers of paternal orphans in addition to numbers of maternal orphans. Figure 12 shows the total number of children under the age of 18 that have lost one or both parents. The graph also shows how this number is composed of maternal orphans, paternal orphans and double orphans. (It should be noted in passing that the terms "maternal orphans" and "paternal orphans" are used here to *include* double orphans). The number of paternal orphans is well in excess of the number of maternal orphans, and this is due to high rates of non-AIDS male mortality relative to non-AIDS female mortality. AIDS has the effect of bringing male and female mortality rates closer together in relative terms, and thus maternal orphans become a greater proportion of the total orphans as the epidemic matures. Double orphans also become a substantially larger proportion of the total orphan population, rising from roughly 5% of all orphans in the mid-1990s to over 40% of all orphans by 2020. This is largely due to maternal and paternal mortality being more strongly correlated in the presence of an AIDS epidemic than they would be in the absence of an AIDS epidemic. The number of double orphans is projected to peak at about 2.13 million in 2017 and the number of paternal orphans is projected to peak at about 4.71 million in 2015. The total number of orphans under the age of 18 is expected to reach its highest level in 2014, at 5.67 million (all of these projections are from the "lite" version of the Orphans model).

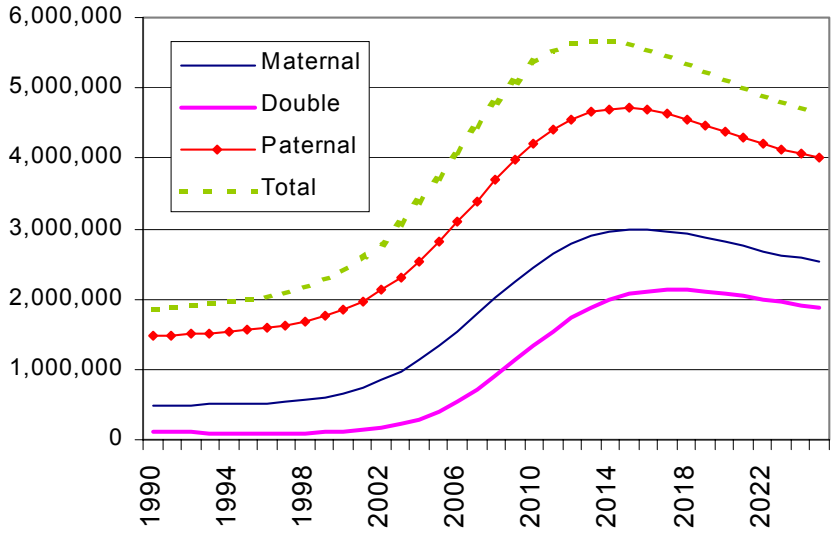

Figure 12: Maternal, paternal and double orphans under the age of 18

These numbers can also be expressed as percentages of all children under the age of 18 without one or both parents. In Figure 13 it is shown that in 2015 18% of all children under the age of 18 will have lost their mother, 28% will have lost their father, and 12% will have lost both parents. Roughly 33% of all children under the age of 18 will have lost one or both parents if no change in sexual behaviour patterns occurs and if no significant health interventions are introduced.

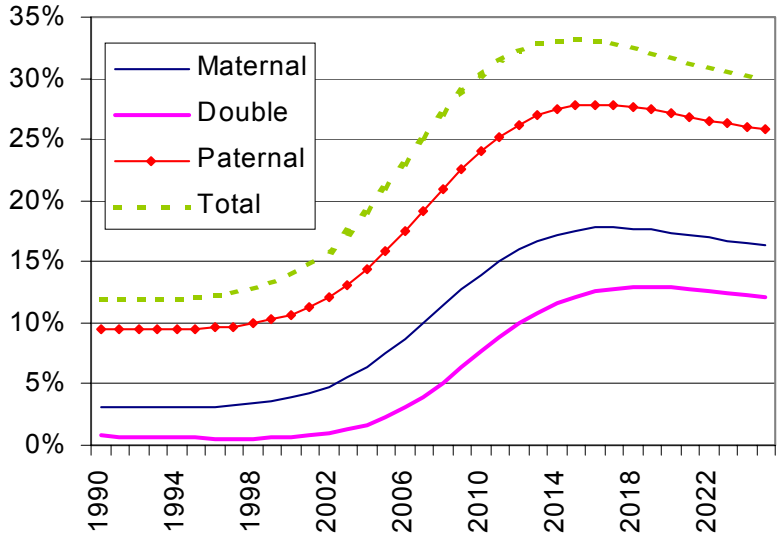

Figure 13: Percentage of children under the age of 18 orphaned

While it is debatable whether maternal or paternal orphans are worse off in terms of material and emotional support, it is clear that double orphans are the most vulnerable of all, and it is also clear that these double orphans will comprise an increasingly significant component of the total orphan population as the epidemic matures.

4.3 Allowing for Absent Fathers

Paternal orphans are usually defined as children whose fathers have died. However, in many cases children are without fathers not because their fathers have died, but because they have lost contact with them. Orphan enumeration studies (Webb, 1995) and demographic and health surveys (Timæus and Grassly, 2001) from a variety of African countries show that the number of paternal orphans is typically more than double the number of maternal orphans. While this may be due in part to higher male mortality, it is likely that a substantial proportion of paternal orphans are effectively orphaned because they were brought up without a father or because their parents have separated. (Although these surveys usually ask care givers of orphaned children if the child's father is dead (as opposed to being merely absent), respondents may be inclined to answer "dead" even if the father is only absent or missing, for various reasons). This suggests that it may not be possible to explain these observed differences in levels of orphanhood in terms of male-female mortality differentials alone. Anecdotal evidence also indicates that when women disclose their HIV status to their partners, their partners often abandon them, leaving them to look after their children by themselves (Giese, 2001).

One therefore needs to bear in mind that the estimates of numbers of double orphans reflected in Figure 12 may understate the number of children who are effectively without parental care.

5. Comparison with Other Models and Empirical Evidence

In order to get a sense of the reasonableness of the estimates produced by the model, the numbers are compared with those from a number of other models and against empirical findings.

5.1 Projections from Other HIV/AIDS Models

Our estimates are compared here with those from three other AIDS models: the Metropolitan-Doyle model (a South African AIDS model developed by Peter Doyle of Metropolitan Life), the Spectrum AIDS model and Epimodel (the latter two models are both international AIDS models, which were set up to produce estimates for South Africa by Callaghan (2001)). Comparisons are also made with estimates from the US Census Bureau (Hunter and Williamson, 2000). An unfortunate limitation on this comparison is that the method used to calculate the number of orphans in the case of Epimodel and the US Census Bureau model does not appear to have been documented.

Figure 14 shows the numbers of maternal AIDS orphans under the age of 15 projected by three of the four models, and by the US Census Bureau. Clearly, ASSA2000 produces the lowest estimates of the numbers of orphans; its estimate of the number of orphans in 2010 is 1.53 million, which compares with the US Census Bureau estimate of 1.82 million, the Doyle model estimate of 1.94 million and the Spectrum estimate of 2.21 million.

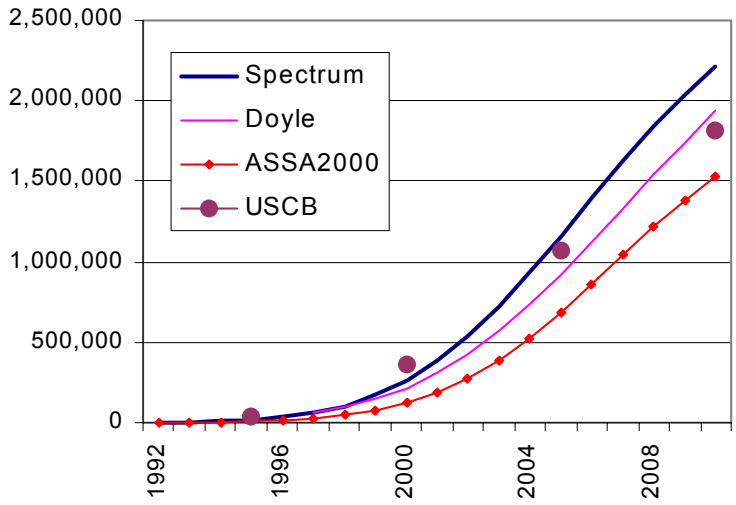

Figure 14: Maternal AIDS orphans under the age of 15
Source: Callaghan (2001), Whiteside & Sunter (2000), Hunter & Williamson (2000)

Epimodel does not produce a "total number of orphans" as such, but it does estimate the number of children newly orphaned by AIDS each year. The numbers estimated

are compared with the corresponding estimates from the ASSA2000 Orphans model in Figure 15 (using the "maternal orphan under the age of 15" definition). Again, the ASSA2000 estimates are low relative to this model.

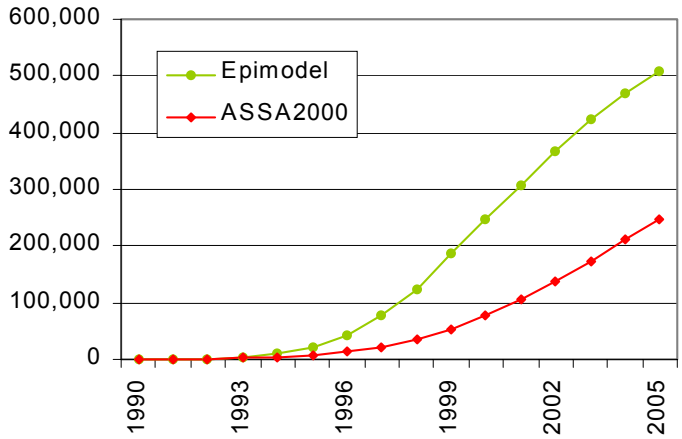

Figure 15: Children newly orphaned to AIDS
Source: Callaghan (2001)

In comparing the numbers produced by the different models, it is important to bear in mind that the estimates of the numbers of AIDS orphans are strongly influenced by two factors: the assumed rate of fertility of women infected with the virus, and the assumed rate of AIDS mortality.

The fertility of women with HIV/AIDS differs from that of uninfected women. HIV infection is known to be associated with a reduction in fertility (Zaba and Gregson, 1998), and this effect can be expected to increase with time since infection (Heuveline, 2001). This will have a significant effect on the number of children a woman leaves behind when she dies of AIDS. While the ASSA2000 model (and hence the Orphans model) makes an allowance for this reduction in fertility, the Spectrum model (Callaghan, 2001) and the Doyle model do not do so in estimating the number of orphans. It would also appear that the Spectrum and Doyle models do not allow for declines in fertility rates over time in their calculations of number of orphans. Another difference in terms of the modelling of fertility is that the ASSA2000 model assumes that fertility rates are higher among women who are in stable relationships and who are less at risk of infection, than among women that engage in riskier sexual behaviour. The Doyle and Spectrum models, on the other hand, assume for the purpose of estimating numbers of orphans that the rate of fertility is uniform across all women of the same age. These factors to a large extent explain why the ASSA2000 Orphans model produces lower estimates of maternal AIDS orphans than the Spectrum and Doyle models.

The second key determinant of the number of AIDS orphans is the level of AIDS mortality. In general, one would expect models that predict high levels of AIDS mortality also to predict high numbers of AIDS orphans. However, as Figure 16 shows, it is ASSA2000 that predicts the highest level of AIDS mortality. This would appear to be inconsistent with the relatively low levels of orphans predicted using the

ASSA2000 Orphans model. However, it must be emphasized that the methods used in the Spectrum and Doyle models to estimate the number of orphans involve several simplifying assumptions, and much of the discrepancy can be explained in terms of the lack of allowance for the impact of HIV on fertility in the Spectrum and Doyle models. In addition, it would appear that the Doyle model understates the rate of mortality among children that are born HIV positive, and this may also partially explain why the Doyle model produces higher estimates of numbers of surviving orphans than ASSA2000.

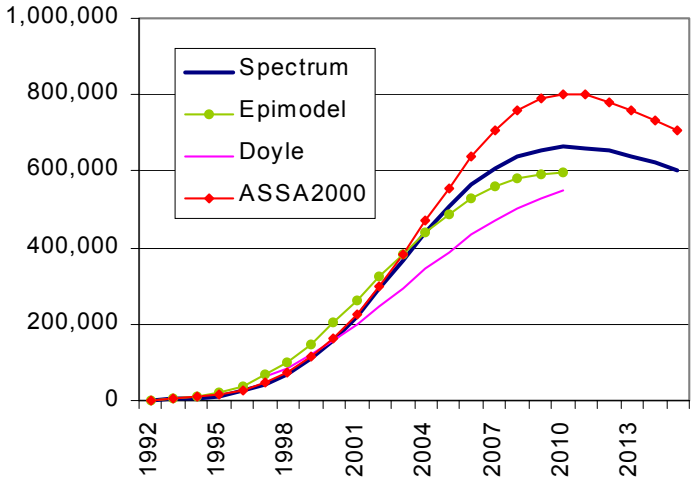

Figure 16: Projected AIDS deaths
Source: Callaghan (2001)

5.2 Antenatal Clinic Data

As emphasized in 5.1, estimates of numbers of orphans are sensitive to assumptions about fertility. Information on levels of gravidity*, collected from antenatal clinic data (supplied by the Department of Health), can provide a rough sense of the relationship between HIV status and fertility. The problem with antenatal clinic data, however, is that there is a host of confounding factors that need to be controlled for when studying relationships between different variables. A logistic regression was therefore performed on the national antenatal clinic data for 1998 and 1999, using GENSTAT 4.1. HIV prevalence was regressed on province, age, gender, education, year and gravidity. The odds ratios for the probability of HIV infection for women with different levels of gravidity are given in Table 1 below.

* Gravidity is defined as the number of children a women has given birth to, and includes any child(ren) that she is currently pregnant with.

Table 1: Odds ratios for HIV prevalence at different gravidity levels

Gravidity	Odds ratio	p value
1	1	-
2	1.135	0.002
3	0.946	0.29
4 or more	0.722	0.001

It is clear from these odds ratios that HIV prevalence is significantly higher among women that are in their first or second pregnancy than among women that are in their third or subsequent pregnancy, even when age and other differences are controlled for. This suggests that HIV positive women are indeed less fertile than uninfected women, and that models that ignore this difference are therefore likely to overstate the number of orphans. (It is also plausible, however, that there are certain temporal factors mediating the relationship between gravidity and HIV prevalence, and data from other years may be needed before firm conclusions can be drawn).

5.3 Demographic and Health Survey Data

Timæus and Grassly (2001) present Demograhic and Health Survey (DHS) data on levels of orphanhood collected from a number of African countries during the 1990s. We analyse here only the data collected from those countries on or below the equator (see full details in Appendix B), since the epidemic in West Africa is characterized by mostly HIV-2 infection, and levels of infection are much lower than elsewhere in sub-Saharan Africa. For each DHS estimates were obtained of the proportion of children that were maternal orphans, the proportion of children that were paternal orphans, and the proportion of children that were double orphans.

Before proceeding to a detailed analysis of this data, it is important to stress some of the problems associated with DHS data. Timæus and Grassly (2001) describe three major problems, all of which will lead to the DHS underestimating the true number or proportion of children that have been orphaned:

1. DHS data do not provide information on children living outside of household environments – in particular, they do not count children in institutional care or children living on the streets. Many of these children will be orphaned.
2. In some cases the DHS did not succeed in contacting child-headed households. This also leads to the estimated proportion of children that are orphaned being understated.
3. In some cases orphaned children are reported as having living parents, either because the respondent assumes the term “parent” to refer equally to step-parents or foster-parents, or else because the interviewer assumes the care-giver to be the biological parent and therefore does not ask whether the child is orphaned.

Despite these problems, DHS data is useful in identifying patterns in levels of orphanhood. A number of insights can be gained from a study of this data.

Firstly, it is worth looking at the DHS data from South Africa in isolation from the data from other African countries. South Africa's first – and so far only – Demographic and Health Survey was conducted in 1998. In this it was found that 2.1% of children under the age of 15 had lost their mothers, 8.7% had lost their fathers, and 0.7% had lost both their mothers and fathers. In comparison, the ASSA2000 Orphans model estimates that in 1998 2.9% of children under the age of 15 had lost their mothers, 8.2% had lost their fathers and 0.4% had lost both their parents. Although these differences could in part be due to sampling error, the difference between the 2.1% and the 2.9% could probably be explained largely by the abovementioned biases in the DHS. The difference between the 8.7% and the 8.2%, as well as the difference between the 0.7% and the 0.4%, could probably be explained in terms of absent fathers*. The DHS estimates are thus roughly consistent with the estimates of the ASSA2000 Orphans model, although the exact extent of the bias in the DHS estimates is unknown.

It is also important to note that the percentage of children that are paternally orphaned in South Africa is extremely high. As Figure 17 shows, the ratio of paternal orphans to maternal orphans (as estimated in the DHS) is over 4 in South Africa – higher than in any other African country. Although this can be explained largely in terms of the abnormally high non-AIDS mortality rates among South African men, it may also reflect a higher level of absent fathers in South Africa, due probably in no small part to the entrenchment of the system of migrant labour and the breakdown of the traditional family unit during the apartheid era.

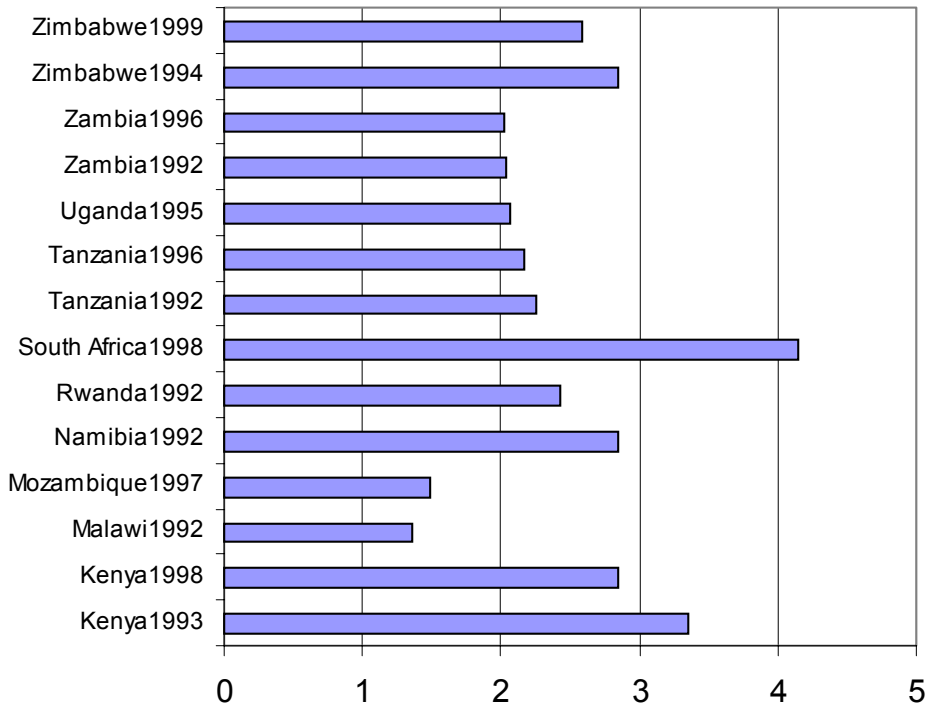

Figure 17: Ratio of maternal to paternal orphans

* The proportion of children with absent fathers would be greater than the difference between these number to the extent that the DHS fails to capture all orphans.

It is also possible that South Africa's ratio is high because the DHS was conducted in 1998, when South Africa was still in the relatively early stages of its epidemic. The ratio would be expected to fall over the course of the epidemic, because the level of AIDS mortality tends to be higher among females than among males initially, and the effect of AIDS mortality becomes more significant as the epidemic progresses, swamping the sex differences in non-AIDS mortality. Indeed, the data from Kenya, Tanzania and Zimbabwe do suggest that such declines are being observed. It has been suggested, though, that the ratio may start to climb again in the later stages of the epidemic as male AIDS mortality starts to increase relative to female AIDS mortality (Hunter and Williamson, 2000).

As suggested in 4.2, the percentage of maternal orphans that are also paternal orphans is likely to increase considerably over the course of the epidemic, from under 15% in the early stages of the epidemic, to roughly 70% as the epidemic matures. This is shown by successive DHS results in Kenya, Tanzania, Zambia and Zimbabwe (see Appendix B for more detail).

6. The Impact of Interventions and Changes in Behaviour

The projections presented thus far are based on the assumption that there are no changes in sexual behaviour patterns over the course of the epidemic. It has also been assumed that there are no nation-wide programmes to prevent mother-to-child transmission of the HI virus or to improve access to sexually transmitted disease (STD) treatment. Neither of these assumptions is realistic, and the purpose of the discussion that follows it to examine the implications of possible future changes in sexual behaviour, and the likely effects of possible government intervention programmes.

6.1 The Impact of Mother-to-child Transmission Prevention Programmes

As mentioned in section 3.3, children can be infected by their mothers in one of two ways: perinatally, or through breast milk. It has been found in developed countries that the probability of perinatal transmission can be reduced to low levels through the provision of long-course antiretroviral treatment to women during their pregnancy and through Caesarean sections. In resource-poor settings, studies have shown the use of short-course antiretroviral treatment to mothers prior to birth (and to babies after birth) also to be effective in reducing the probability of transmission. Estimates of the percentage reduction in the probability of transmission, from short-course antiretroviral treatment, lie between 35% and 50% (McIntyre and Gray, 2000), but the biases inherent in these estimates suggest a true reduction that is closer to 50%. Infection through breast milk can be prevented through the substitution of formula feeding for breast-feeding, although evidence suggests that combining breast- and bottle-feeding may in fact lead to a higher risk of transmission than breast-feeding alone (Coutsoudis *et al*, 1999).

In South Africa there has been much pressure on the government to make short-course antiretroviral treatment available to all HIV positive pregnant women. Currently the government is making nevirapine freely available to pregnant HIV positive women in at least two health facilities in all nine provinces, and formula milk is being offered to women that have access to running water (HST, 2001). The treatment, however, is not easily accessible for most women. A further problem is that at many of the pilot sites the proportion of women that agree to be HIV tested is low, and hence many women do not receive the treatment and are not aware that they need it, even though they are eligible to receive it.

In modelling the effect of introducing a mother-to-child-transmission prevention (MTCTP) programme, it must be recognized that (a) the programme is already in its early phases of implementation, and (b) even when the programme is fully implemented, it is unlikely that all women eligible for treatment will receive treatment. It has therefore been assumed that the percentage of pregnant HIV positive women with access to nevirapine is 0 in 2000, 40% in 2001, 60% in 2002, 70% in 2003, 80% in 2004, and 90% in all subsequent years. A similar phasing in of access to formula milk has been assumed. It has been further assumed that the percentage

reduction in the probability of perinatal transmission from nevirapine is 50% and that the percentage reduction in breast-milk transmission from formula feeding is 50% (this makes implicit allowance for the fact that not all of the women who have access to formula feeding have access to running water, and some women may combine breast- and bottle-feeding).

Figure 18 shows the projected number of maternal orphans under the age of 15, on the assumption that the MTCTP programme described above is implemented, compared with the numbers of orphans in the absence of any MTCTP programme. It is clear that such a phasing in of the MTCTP programme is likely to increase significantly the number of orphans. This occurs because fewer children are infected by their HIV positive mothers, and hence children survive for longer on average. By 2015 the number of maternal orphans under the age of 15 is likely to be roughly 2.26 million, 200 000 more than would be expected in the absence of any MTCTP programme. By 2020 the difference is likely to be more than 250 000.

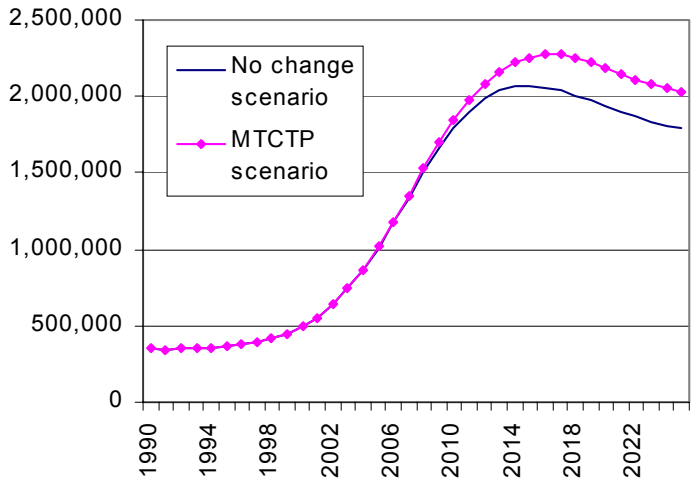

Figure 18: Numbers of orphans, with and without an MTCTP programme

While it is evident that providing MTCTP is likely to increase the number of orphans, it is also evident that a great number of lives can be saved through the implementation of an MTCTP programme.

6.2 The Impact of Changes in Sexual Behaviour

It is important to recognize that as the epidemic progresses and as its effects become increasingly visible, individuals are likely to adopt more cautious sexual behaviour patterns. Unfortunately, though, there is very little hard data to suggest the nature and extent of these changes, and patterns may differ from one society to another. The following scenario is therefore not intended to be a realistic picture of what is likely to happen, but rather an illustration of what may be expected to occur *if* certain behaviours change.

It is assumed that three changes occur:

1. The rate of condom usage doubles between 2001 and 2005.
2. The number of new sexual partners people have every year falls by 15% between 2001 and 2005.
3. Treatment of sexually transmitted diseases (STDs) improves, to the extent that there is a 15% reduction in the probability of transmission per sexual contact between individuals in the STD or PRO risk groups, and a 7.5% reduction in the probability of transmission per sexual contact between individuals in the STD and RSK risk groups.

All of these changes are phased in linearly between 2001 and 2005.

Figure 19 shows the impact of these changes on the number of maternal orphans under the age of 15. Clearly the changes have very little effect in the short term, with the number of maternal orphans peaking in 2013 at 1.95 million. However, in the longer term the reduction in the number of orphans does become appreciable.

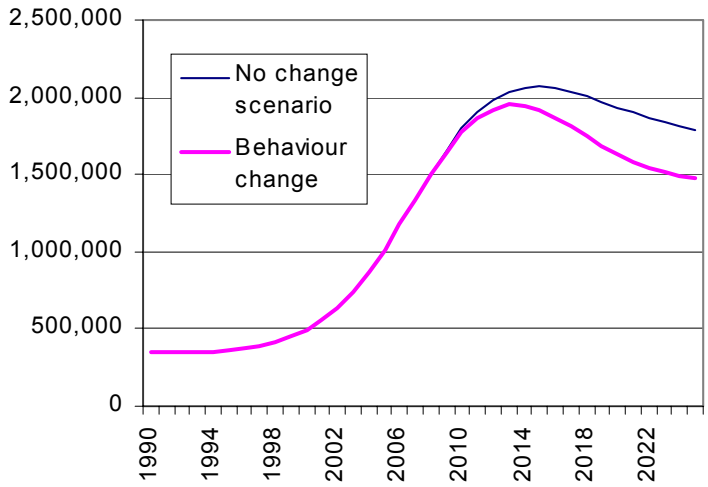

Figure 19: Numbers of orphans, with and without behaviour change

It would appear that the expected number of orphans is – in the short term at least – relatively insensitive to changes in sexual behaviour patterns. Increased expenditure on condom distribution programmes, AIDS awareness programmes and STD treatment programmes are unlikely to change the fact that the country will have close to two million orphans on its hands 12 years from now (though these programmes may well reduce the total number of orphans substantially in the longer term). It is therefore vital that policy makers direct their attention toward creating capacity for communities and the state to care for orphaned children.

That said, it should also be emphasized that a significant reduction in the number of orphaned children can be achieved through antiretroviral treatment programmes to all HIV positive individuals – both in the immediate future and in the longer term. As demonstrated below, such programmes may lessen the need for increased capacity.

6.3 The Impact of Antiretroviral Treatment Programmes

Antiretroviral treatment can reduce significantly morbidity and mortality rates in HIV positive individuals. It is possible, therefore, that programmes aimed at making antiretroviral treatment generally available may succeed in extending the lives of a large number of parents to the stage where their children are self-supporting. This suggests that the implementation of antiretroviral treatment programmes may dramatically reduce the number of orphans.

The improvement in survival prospects on initiating antiretroviral treatment is largely dependent on (a) the type of treatment being initiated, (b) the stage of disease in which treatment is initiated, and (c) the rate of adherence to the drug regimen. In the analysis that follows it is assumed that treatment consists of two nucleoside reverse transcriptase inhibitors and a non-nucleoside reverse transcriptase inhibitor (i.e. "triple therapy"), and that all of those initiating treatment start after becoming diagnosed as sick with AIDS. The rates of adherence are a source of uncertainty, although there is evidence to suggest that high rates of adherence are possible even in resource-poor settings (Orrell *et al*, 2001). For simplicity, it has been assumed that individuals initiating antiretroviral treatment experience a median survival (from HIV infection to death) 50% higher than that among individuals not initiating treatment. Although this may be regarded as conservative in the light of long-term antiretroviral studies (such as conducted by Palella *et al* (2001) and Barba Martin *et al* (2000)), there is some allowance in this for the possibly lower levels of adherence in indigent populations, and for the possibly lower levels of efficacy of "triple therapy" relative to treatment combinations containing protease inhibitors.

It has been further assumed that individuals receiving antiretroviral treatment have 80% less unsafe sex, and that women receiving antiretroviral treatment experience a rate of fertility 50% lower than they would have experienced had they not been on treatment. Although there is little empirical evidence to support these assumptions, it is reasonable to assume that women who are aware of their HIV status are less likely to have children out of fear of infecting them perinatally or leaving them as orphans, and that individuals aware of their HIV status are less likely to engage in unsafe sex. It is also assumed that if an antiretroviral treatment programme were introduced in 2002, it would be accessed by 40% of people with AIDS in 2002, by 60% in 2003, by 70% in 2004, by 80% in 2005 and by 90% in all subsequent years.

Figure 20 shows the numbers of maternal orphans under the age of 15 with and without the antiretroviral treatment programme (both projections were obtained using the "lite" version of the Orphans model). By 2015, the number of maternally orphaned children is 1.05 million, roughly a half of the number that would be expected without any antiretroviral intervention. The number of maternal orphans under the age of 15 peaks in 2020 at 1.15 million. This later peak can be explained in terms of the roughly five-year increase in median survival that is assumed to result from antiretroviral treatment.

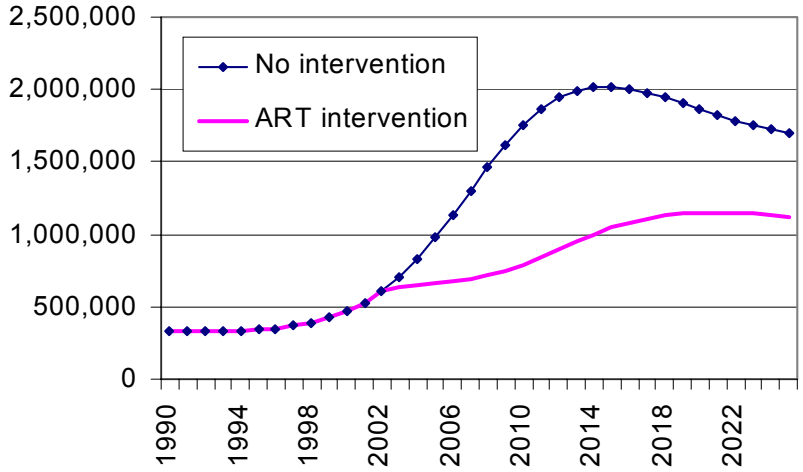

Figure 20: Numbers of orphans, with and without antiretroviral interventions

It remains to be confirmed that the assumed changes in sexual behaviour and fertility under antiretroviral treatment are reasonable. However, sensitivity tests show that changes in these assumptions do not have a material impact on the numbers of orphans before 2015. It can therefore be stated fairly conclusively that an antiretroviral treatment programme could reduce significantly the number of orphans in the next 15 years.

7. Planning for the Impact of AIDS on Orphans

7.1 The Plight of the Orphan

For many children, orphanhood begins prior to the death of their parent. When the parent becomes sick with AIDS the household is often without income, and the parent is no longer able to support the child. This, as well as the trauma of having to witness their parent slowly dying, is the first of the stresses that the orphaned child has to face.

Once the parent has died, the orphaned child is often taken care of by the deceased's extended family – the traditional provider of care in African culture. Much has been made of the capacity of traditional coping mechanisms to handle the increased burden of care, and indeed there is encouraging evidence of community-based responses in other African countries (Foster, 1997). However, there remain two serious concerns regarding the ability of the community to deal with the expected increase in orphan numbers. The first is that South Africa's extended family structures are weak relative to those in other African countries, as a result of the country's history of displacement and migrant labour (KFF, 2001). The second is that the unprecedented number of orphans, resulting from AIDS mortality, may place more strain on extended families than they would otherwise have been able to deal with. In many cases extended families do not provide care, and it is not uncommon for relatives to take away the property and livestock of the deceased, or to "sell" orphaned daughters into marriage at a young age (Foster et al, 1997).

In cases where orphans are cared for by the extended family, they are often exploited. Many are forced to drop out of school and are made to work to supplement the household income (Barrett *et al*, 1999). Often they are treated differently from the caregiver's own children and are given an excessive burden of household chores, or are abused physically and sexually.

The poor education prospects of orphaned children are a particular concern. Studies from Zambia show very low rates of school enrolment among orphans when compared with non-orphans (Webb, 1995), and it is predicted that South African school enrolment levels will fall dramatically in the areas worst hit by the epidemic (Badcock-Walters, 2001). Although children in foster care are exempt from paying school fees, in practice schools discriminate against them because they receive no compensation from the Department of Education in respect of these children (Giese, 2000). Orphans therefore tend to grow up poor and uneducated, in circumstances that make them vulnerable to HIV infection.

Most serious of all are the psychological impacts of orphanhood on children. A variety of studies show that children orphaned as a result of AIDS have low self-esteem and tend to display more aggression, anxiety and depression than other children (Foster, 1997). Children who are alienated from or abandoned by their extended families are more likely to become street children and engage in antisocial behaviour or prostitution.

The growth in orphan numbers therefore creates three significant burdens for society at large:

1. State hospitals are likely to be inundated by children sick with AIDS, many of whom will already have lost their mothers or fathers. Evidence suggests that already a large proportion of cases in paediatric wards of public hospitals are HIV-related (Giese, 2001).
2. Increasingly, households will find themselves caring for orphans of deceased relatives. A 1993 national survey in Zambia found that the proportion of households caring for orphans was 42% in urban areas and 33% in rural areas (Webb, 1995). This has obvious implications for spending and savings patterns.
3. There is likely to be a significant rise in juvenile crime if adequate care is not provided for orphaned children.

7.2 The Capacity of the Current System to Deal with the Anticipated Increase in Orphan Numbers

In assessing the capacity of the current system to deal with the expected rise in orphan numbers, it is useful to think of the system as being made up of formal and informal structures. The formal framework incorporates the legislation regarding orphaned children and the government provisions for orphans and care givers. The informal framework is made up of the attitudes and customs determining the ways in which communities and extended families respond to orphaned children.

The formal framework is reviewed extensively by van den Heever (2001). It comprises the following elements:

- The Child Care Act No. 74 of 1983: This specifies that orphaned children may be placed in foster care, placed in residential care (eg. children's homes), or adopted. The Act is currently in the process of being rewritten.
- Foster care grants: Any child that has been legally placed in the care of foster parent(s) is eligible for a benefit of R410 / month, payable to the foster parent (Giese, 2001). While this can potentially ease the load on foster parents, a major problem is that to qualify, the child has to be placed in the care of its foster parents in the Children's Court, which is a lengthy process (Giese, 2000).
- Care dependency grant: This is payable to parents / guardians of children between the ages of 1 and 18, who receive and require permanent home care due to severe mental or physical disability. Currently the benefit is not payable in respect of children with chronic illnesses such as HIV/AIDS (Guthrie, 2000).
- Institutional care: Unlike most African countries, South Africa does have a framework for providing institutional care. However, the costs of maintaining these institutions are significant, and many provinces are therefore currently exploring alternative models of community care (KFF, 2001).

Barrett *et al* (1999) argue that the current system is limited in terms of placement options, and that it is being hampered by lengthy procedures as well as by a lack of awareness among those in need of support, of the various placement options. While there is clearly a framework in place, its capacity to deal with the anticipated growth

in orphan numbers is hindered by an excess of bureaucracy and a lack of allowance for alternative placement options.

Assessing the capacity of the informal system to deal with the rise in orphan numbers is more problematic. A study conducted among a number of South African communities (Webb, 1994) attempted to assess how sympathetic individuals were to the idea that communities, rather than government, should be responsible for caring for orphans. The key findings were that:

- People who knew others that were sick with AIDS or that had died from AIDS tended to be more sympathetic to the idea than others.
- Poor households and affluent households tended to be sympathetic to the view, while middle-income households were relatively unsympathetic.
- It tended to be the households with the most dependants that were most sympathetic. This may be viewed as a paradox; it may alternatively be explained in terms of larger families having a stronger sense of community.
- In urban areas such as Soweto, individuals were largely unsympathetic, while in rural areas individuals were considerably more receptive to the idea.

While it is encouraging that positive attitudes are demonstrated to community-based responses in the communities that are likely to be most affected by the epidemic, it is a concern that the households in these communities are for the most part very poor and already have large numbers of dependants. They are therefore the households that are materially least able to provide care for children of deceased relatives.

7.3 Possible Policy Responses

A number of writers have proposed methods of tackling the problems associated with the expected increase in orphan numbers. It is unlikely that any single intervention will provide an adequate solution to all aspects of the problem, and it is therefore necessary that a range of both institutional and community-based responses be developed.

As far as institutional responses are concerned, it is necessary that all forms of institutional care be expanded. Van den Heever (2001) argues that the Child Care Act should be modified to allow for alternative placement options for children in need of care and support. He also argues that the Care Dependency Grant should be extended to parents / guardians having to look after children suffering from chronic conditions such as AIDS, and the basis for eligibility should be a “needs test” rather than a strict application of the medical definition of disability. Making antiretroviral treatment freely available will result in a reduction in the cost of foster care grants, but whether or not this reduction is likely to exceed the costs associated with the antiretroviral treatment itself needs to be further investigated.

Community-based responses also need to form a core component of any intervention programme. Four main models of community-based care have been identified in South Africa (Schneider and Russell, 2000). The first – and currently most prevalent - of these involves placing orphaned children with a member of the extended family. It has been suggested that a second possible model may be to allow the formation of child-headed households, where the oldest sibling is 15 years or older, and where social services can provide regular support to the household. Van den Heever (2001),

however, argues that this should not be encouraged except as a temporary measure for children awaiting placement. Placing adults (usually older women) in the homes of orphaned children is a third possible model. Closely related to this is the fourth model: "Create a Family" or "Cluster Foster Care" programmes. These involve identifying surrogate mothers and hiring them to look after a number of orphans in the community. Each surrogate mother is provided with a home in which she lives with the orphans under her care, and she is assisted in obtaining foster care grants in respect of these children. Such programmes are already operating in Durban.

In attempting to help communities to deal with the increased burden of care, external organizations and government agencies need to be wary of undermining traditional coping mechanisms (Foster, 2000). It also needs to be recognized that children are in need of support well before their parents die; interventions therefore need to be directed at households where children are having to care for sick parents and are in need of emotional and material support (Thorne, 1997).

It is clear that a number of potential solutions exist. It is also clear, however, that any attempt to manage the situation in an effective and comprehensive manner is likely to come at a considerable cost to the state. It is vital, though, that these programmes be put in place now. Avoiding the short term costs will simply result in an escalation of the long-term costs to society, in terms of reduced levels of literacy, increased levels of crime, and increased economic strain on affected households.

8. Conclusion

South Africa can expect to see an alarming growth in the number of orphaned children over the next 15 years. The majority of these children will be teenagers, and will come from poor socio-economic backgrounds. If their needs are not met, many of them will grow up as disaffected and alienated members of society. South Africa's capacity to provide care for these orphaned children will therefore determine the long-term social stability of the country. Little can be done to reduce the number of orphaned children in the short term, short of introducing a national antiretroviral treatment programme.

The projections presented in this paper are based on sophisticated demographic models. Although the estimates are lower than those produced by most other AIDS models, they are based on more realistic assumptions, and make full allowance for the relationship between fertility and HIV infection. The results are also roughly confirmed by data from South Africa's 1998 Demographic and Health Survey.

Although further work is needed to address the shortcomings in the underlying ASSA2000 model and (to a lesser extent) Orphans model, it is not expected that improvements made will alter significantly the projections presented in this paper. Work is also needed to develop a version of the Orphan model that will operate in parallel with the ASSA2000 Urban-Rural model (Dorrington and Schneider, 2001). This will make it possible to produce similar results for other African countries. Work on the fitting of the ASSA2000 model to each of South Africa's provinces will also make it possible to produce similar projections for each province in South Africa.

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HST	Health Systems Trust
KFF	Kaiser Family Foundation

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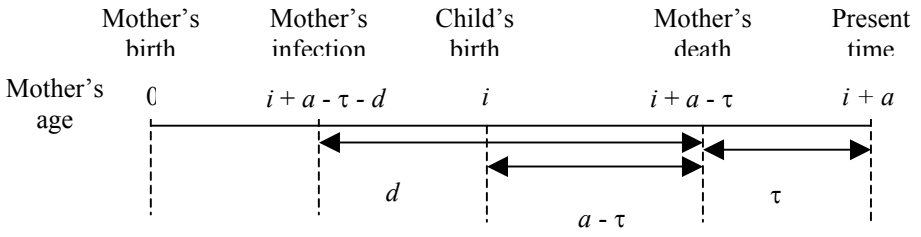
Appendix A: Algebraic development

The method used to calculate the number of maternal orphans is similar to that used by Timæus and Grassly (2001), and we have borrowed heavily from their work in setting out the algebraic development of the model. The method employed in this paper is, however, slightly more complex than that used by Timæus and Grassly, and the notation used does therefore not correspond exactly with that used in their paper.

The following diagram may assist in the interpretation of the symbols defined below:



Note that it is possible for the mother to be infected after the child's birth (so that $d < (a - \tau)$), or for the mother not to be infected at all.

Define the following symbols:

$\Omega_t(a,\tau)$ = number of maternal orphans of age a at time t whose mothers died τ years ago

Ω_t = number of maternal orphans at time t

$$\Omega_t = \sum_{a=0}^{14} \sum_{\tau=0}^{a} \Omega_t(a,\tau) \qquad (1)$$

(This assumes we are defining maternal orphans to be under the age of 15 – the upper limit on the first summation can be changed to reflect other age definitions).

$\mu'_{t-\tau}(d,r,i+a-\tau)$ = number of deaths among women in risk group *r*, that were HIV+, with duration *d* years since infection at death, aged $(i + a - \tau)$, who died in year $(t - \tau)$

$\mu_{t-\tau}(r,i+a-\tau)$ = number of deaths among women in risk group *r*, that were uninfected at the time of death, aged $(i + a - \tau)$, who died in year $(t - \tau)$

$m'_{t-a}(i,d,r)$ = fertility rate of woman in risk group *r*, aged *i*, duration *d* since infection, at time $(t – a)$

$m_{t-a}(i,r)$ = fertility rate of woman in risk group *r*, aged *i*, uninfected, at time $(t – a)$

ξ_p = probability of perinatal transmission from HIV positive mother to her child

ξ_m = probability of HIV positive mother infecting her child through breast-milk

$p_{t-a}(a)$ = probability of uninfected child born at time $(t – a)$ surviving to age *a*

$p'_{t-a}(a)$ = probability of perinatally infected child, born at time $(t – a)$, surviving to age *a*

$p''_{t-a}(a)$ = probability of child infected by breast milk, born at time $(t – a)$, surviving to age *a*

It follows that the number of maternal orphans of age *a* at time *t*, whose mothers died uninfected, τ years ago, is

$$\sum_{r=1}^{4}\sum_{i=15}^{49}\mu_{t-\tau}(r,i+a-\tau).m_{t-a}(i,r).p_{t-a}(a) \qquad (2)$$

The number of maternal orphans of age *a* at time *t*, whose mothers died HIV positive, τ years ago, but became positive after giving birth, is

$$\sum_{r=1}^{4}\sum_{i=15}^{49}\sum_{d=0}^{a-\tau-1}\mu'_{t-\tau}(d,r,i+a-\tau).m_{t-a}(i,r).p_{t-a}(a) \qquad (3)$$

The number of maternal orphans of age *a* at time *t*, whose mothers died HIV positive, τ years ago, and became positive before giving birth, is

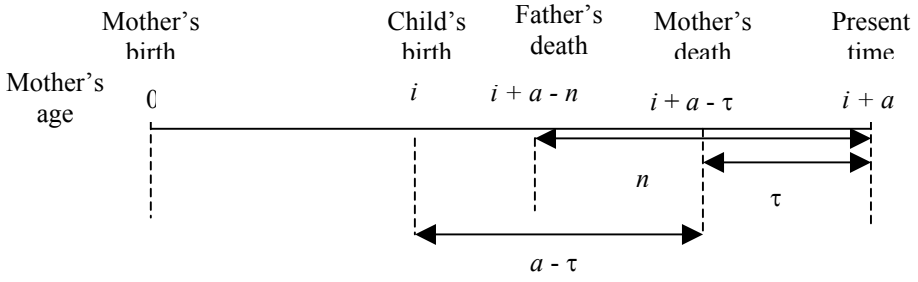
$$\sum_{r=1}^{4}\sum_{i=15}^{49}\sum_{d=a-\tau}^{29}\mu'_{t-\tau}(d,r,i+a-\tau).m'_{t-a}(i,d-a+\tau,r).$$
$$\left[\ \xi_p.p'_{t-a}(a)+(1-\xi_p)\xi_m.p''_{t-a}(a)+(1-\xi_p)(1-\xi_p)p_{t-a}(a)\ \right] \qquad (4)$$

It then follows that

$\Omega_t(a,\tau)$ = sum of (2), (3) and (4)

By substitution into equation (1), the total number of maternal orphans at time *t* can then be estimated.

Arriving at an estimate of the number of double orphans is slightly more complicated. The following diagram, similar to that set out previously, will assist in the interpretation of the algebraic developments that follow.



Naturally, *n* could be smaller than τ (if the father died after the mother).

Define the following symbols:

$\Omega'_t(a,\tau,n)$ = number of double orphans of age *a* at time *t* whose mothers died τ years ago and fathers died *n* years ago

$l_t(v,y)$ = number of men of age *y* in risk group *v*, alive at time *t*

$P_{t-a}(i,r,i+a-n)$ = probability of survival of the partner of a woman in risk group *r*, aged *i* at birth of child, to (*i* + *a* – *n*) years after birth, given that the birth occurred at time *t* - *a*

$x(v \mid r)$ = proportion of partners in risk group *v* for women that are in risk group *r*

$f(y \mid i)$ proportion of partners that are aged *y*, for women that are aged *i*

Then it follows that

$$P_{t-a}(i,r,i+a-n) = \sum_{v=1}^{4} x(v \mid r) \sum_{y=15}^{72} f(y \mid i).\frac{l_{t-n}(v,y+a-n)}{l_{t-a}(v,y)}$$

It should be obvious from the previous developments for maternal orphans that $\Omega_t(a,\tau)$ can be expressed in the form

$$\Omega_t(a,\tau) = \sum_{r=1}^{4} \sum_{i=15}^{49} A(i,r,t,\tau,a)$$

It is then possible to express $\Omega'_t(a,\tau,n)$ in the form

$$\Omega'_t(a,\tau,n) = \sum_{r=1}^{4} \sum_{i=15}^{49} A(i,r,t,\tau,a)\left[P_{t-a}(i,r,i+a-(n+1)) - P_{t-a}(i,r,i+a-n)\right]$$

If Ω'_t is the total number of double orphans at time t, then

$$\Omega'_t = \sum_{a=0}^{14} \sum_{\tau=0}^{a} \sum_{n=0}^{a} \Omega'_t(a,\tau,n)$$

As before, the upper index on the first summation can be changed to reflect different age definitions of orphanhood.

Once the method for calculating the number of double orphans is understood, the extension of the method to calculate numbers of paternal orphans is simple. While the double orphans calculation requires the projection of paternal mortality for only those births where the mother subsequently dies before the orphan cut-off age, the paternal orphans calculation requires the projection of paternal mortality for all births, irrespective of whether the mother dies.

Appendix B: Demographic and Health Survey results

Country	Year	Percentage of children that are			Paternal: maternal	Double: maternal
		Maternal orphans	Paternal orphans	Double orphans		
Kenya	1993	1.7	5.7	0.3	3.35	0.18
Kenya	1998	2.7	7.7	0.9	2.85	0.33
Malawi	1992	4.2	5.7	1.1	1.36	0.26
Mozambique	1997	5.3	7.9	1	1.49	0.19
Namibia	1992	2	5.7	0.4	2.85	0.20
Rwanda	1992	3	7.3	0.7	2.43	0.23
South Africa	1998	2.1	8.7	0.7	4.14	0.33
Tanzania	1992	2.3	5.2	0.4	2.26	0.17
Tanzania	1996	2.9	6.3	0.6	2.17	0.21
Uganda	1995	4.9	10.1	1.9	2.06	0.39
Zambia	1992	2.8	5.7	0.6	2.04	0.21
Zambia	1996	4.4	8.9	1.5	2.02	0.34
Zimbabwe	1994	2.6	7.4	0.7	2.85	0.27
Zimbabwe	1999	4.6	11.9	2.1	2.59	0.46
Average:		3.25	7.44	0.92	2.46	0.27

Source: Timæus and Grassly (2001)