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The Impact of HIV/AIDS on the Health Transition Among Under-Five Children in Africa

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1. Introduction

Child survival improved dramatically throughout the world over the past century. Measured as the under-five death rate (the probability of dying before reaching the fifth birthday), child mortality declined from values as high as 300 to 600 per 1000 live births to values as low as 5 to 10 per 1000 in most advanced countries, sometimes even lower, and values around or below 100 per 1000 in most developing countries. [Stolnitz, 1955 & 1965; United Nations, 1982; Ahmad et al., 2000] In industrialized countries this mortality decline was associated firstly with the development of hygiene, clean water supply, sanitation, improved nutrition, and more recently with major advances in preventive and curative medicine. [Szreter, 2003] In developing countries of Africa and Asia, child mortality decline seems more associated with preventive and curative medicine, and less so with hygiene and nutrition, although these have also improved in most cases. [Preston, 1980; Feachem and Jamison, 1991; Ahmad et al., 2000; Jamison et al., 2006]

Beyond regular improvements associated with economic development, social change and modern medicine, reversals in the health transition might occur as a result of external shocks, such as emerging diseases. When a new very lethal disease appears, it may cause an increase in child mortality, despite a decline in mortality from other causes of death. Since 1980, the most important of these emerging diseases is HIV/AIDS, and the continent the most hardly hit by HIV is sub-Saharan Africa. [Newell et al., 2004; UNAIDS, 2010; Jamison et al., 2006] In addition to emerging infectious diseases, other heath threats could also contribute to increasing mortality, for instance various pollutions or exposure to health hazards which may cause cancer, and behavioural changes such as smoking, substance abuse and obesity, although these are more likely to affect adults than under-five children.

Sub-Saharan Africa is very heterogeneous in terms of level of income, level of education, hygiene and sanitation, as well as culturally. Some countries are already quite advanced and modern (e.g. countries in the Southern cone), whereas others lag behind, with low income, low education, low hygiene and poor public health (e.g. Sahelian countries). The effects of an external shock such as an emerging disease are therefore likely to differ among these countries, partly because the spread of the disease might differ, partly because the response to it might differ, and partly because baseline values also differ. Trends in under-five mortality are also determined by other dynamics, and are often related with political

stability (or crises) and with economic growth (or recessions), and with the local development of public health, so that the whole picture might appear confusing at first glance.

HIV stroke Africa in the mid-1970's, and spread rapidly throughout the continent, and extensively in Eastern and Southern Africa, with some pockets in West and Central Africa. [Buve et al., 2002; UNAIDS, 2010] By the mid-1990's HIV prevalence was already high in about half of African countries and increasing rapidly, with values ranging from 5% to 15%, well beyond the 1% threshold considered necessary for a rapid spread in the general population. By the mid-2000's the epidemics had stabilized, and HIV prevalence was declining in most countries. Data on HIV prevalence deal primarily with adults aged 15-49 years, and often ignore the children. However, mother to child transmission of HIV is common, either before birth, during delivery or after delivery through breastfeeding, so that a significant proportion of newborns are infected with the virus, and likely to die shortly afterwards. Until recently, HIV infection to children born to HIV positive mothers was common and resulted in high mortality. Since then, efforts were made to limit the mother to child transmission by various means, and to treat infected children with newly available drugs.

The dynamics of HIV epidemics in Africa vary widely, with some countries heavily infected (as in Southern Africa) and some other hardly touched by the disease (as in Sahelian West Africa). As a result, the net effect of HIV/AIDS on child mortality is likely to be contrasted, depending on the country.

Several studies have tried to estimate the net effect of HIV/AIDS on child mortality in Africa. [Houweling et al. 2006; Korenromp et al., 2004, Mahy, 2003]. Adetunji [2000] provided an overview by comparing point estimates of under-five mortality in the late 1980's and early 1990's with the late 1990's, using published estimates from Demographic and Health Surveys (DHS). He showed an increase in mortality in countries with high HIV seroprevalence, but a decline in others. He found that in Africa HIV mortality accounted from 13% to 61% of under-five mortality depending on the country. Newell et al. [2004] conducted a similar exercise by using parameters of survival after HIV infection drawn from empirical evidence, and concluded that by year 2002 some 10% of deaths of children were caused by HIV/AIDS. Zaba et al. [2003] compared several countries, and found that HIV/AIDS could account from 10% of deaths of under-five children (in Malawi) to 60% (in Botswana). Walker et al. [2002] found 7.7% of under-five children due to HIV in 1999 in 39 African countries, with a range from 0.4% to 42% (in Botswana). Several authors have reproduced the figures recently issued by UNAIDS, and quote a value of 4.4% of under-five deaths due to HIV/AIDS in Africa [Black et al., 2010; Stanecki et al., 2010].

The aim of this paper is to provide a synthesis on the probable impact of HIV/AIDS on child mortality trends in Africa, in a broad historical context since 1950. We will stop in year 2005, the time when HIV/AIDS mortality was the highest among children. The situation changed after this date with respect to mother to child transmission and treatment with anti-retroviral therapy. Furthermore, data were lacking after 2005 for many of countries selected for the study. We will focus on long term trends, and on the heterogeneity between countries, summarized in large areas or groups of countries. This study is an extension of earlier work which presented a full scale reconstruction of under-five mortality trends in countries of sub-Saharan Africa since 1950. [Garenne, 1996; Garenne & Gakusi, 2004 & 2006a]

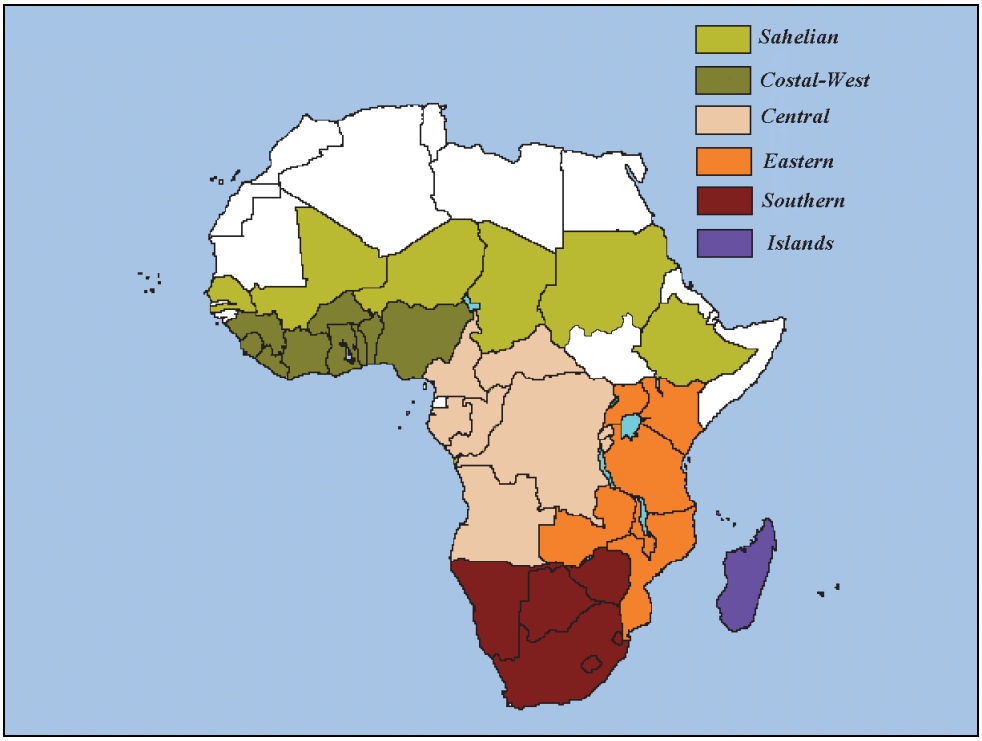

Fig. 1. Sub-Saharan African countries with DHS surveys, by large area

2. Data

Data on under-five mortality were drawn from the maternity histories recorded in Demographic and Health Surveys (DHS). These surveys provide data that allow one to compute age specific death rates by period, and therefore the under-five death rate by calendar year. All 38 countries for which data were available were kept for the final analysis, covering most of continental sub-Saharan Africa, and several islands (see Figure 1). Data on HIV seroprevalence among pregnant women were taken primarily from the UNAIDS database. [UNAIDS, 2008] When necessary, they were completed with data from DHS surveys in a few countries. Data on Gross Domestic Product (GDP) were drawn from the data base built by Angus Maddison and colleagues in its latest edition [2010]. These income data are given in Purchasing Power Parity (PPP), and in constant 1990 dollars.[1]

3. Methods

The method for reconstructing under-five mortality trends has been explained in details in other documents [Garenne & Gakusi, 2004]. In brief, age specific death rates are computed

[1]'Purchasing Power Parity' corrects for the value of a common basket of goods across countries. 'Constant value' of the dollar corrects for inflation overtime.

from maternity histories, by calendar year, for each DHS survey conducted in sub-Saharan Africa, unless access to data was restricted. When several surveys were available for the same country, they were merged by adding events (deaths) and exposure periods (person-years at risk) for the same year and the same age groups. Trends were fitted on monotonic periods with a Linear-Logistic model. Changes in trends were tested using standard T-tests, and only those changes significant at $P< 0.05$ were kept for final analysis. For the early years, the DHS data were sometimes supplemented with other sources, such as census data or data from other sample surveys. All together, under-five mortality trends were reconstructed for all selected countries, year by year from 1950 up to 2005.

Estimating HIV/AIDS mortality among under-five children was completed using a basic model. Firstly, trends in HIV seroprevalence among pregnant women were estimated by year and country using the UNAIDS database, in its latest edition [UNAIDS, 2008]. Second, a standard mother to child transmission rate was assumed, at 25%, consistent with UNAIDS recommendations. Third, a standard AIDS mortality schedule was applied to infected children, so that 60% were assumed to die before age 5, which is consistent with empirical data, and with the UNAIDS recommendations. [UNAIDS, 2002]

Once the database was constructed by year and country, countries were grouped into 6 major areas, selected for their different profiles of HIV infection: Sahelian countries, Coastal West-Africa, Central Africa, Eastern Africa, Southern Africa, and Islands. The details of these countries are shown in Figure 1.

4. Results

4.1 Characteristics of selected countries

Out of the 51 countries counted in sub-Saharan Africa, 38 countries with appropriate mortality data were kept for the final analysis. (Table 1) They account for most of the population of sub-Saharan Africa, and only tiny countries were excluded. The six areas

Large area	Percent Population	HIV prevalence (percent)	GDP-PPP (1990 $)	Number of countries Total	in DHS sample
Sahelian	25.2	1.5	775	11	7
Coastal West	27.4	3.1	1117	10	8
Central	15.1	3.8	633	9	8
Eastern	19.7	7.9	819	6	6
Southern	9.7	17.4	3284	6	6
Islands	3.0	0.3	1497	9	3
Total	100.0	5.1	1119	51	38

Sources: Population from United Population Division; HIV prevalence among adults 15-49 from UNAIDS, 2010 Global Report; GDP-PPP from Maddison (2010)

Table 1. Main characteristics of sub-Saharan African countries

selected were all well covered: 7 out of 11 countries in Sahelian Africa, 8 out of 10 countries in Coastal West Africa, 8 out of 9 countries in Central Africa, all countries in Eastern and Southern Africa. Many tiny islands were excluded, but the largest (Madagascar) accounts

already by itself for 95% of the population of this group. Islands have a very low prevalence of HIV, followed by the other groups in the order presented in Table 1. Average seroprevalence ranged from 1.5% in the Sahelian group to 17.4% in the Southern group, a major difference in terms of potential impact on child mortality. Note that if the Southern group is the wealthiest and the Sahelian group among the poorest, there is no linear relationship between income and HIV prevalence. For instance the Eastern group has almost the same income level as the Sahelian group, but five times more HIV, whereas the Islands group is the second wealthiest, but has the lowest HIV prevalence.

4.2 Basic calculations and order of magnitude

To illustrate the rationale of the calculations, one could firstly present aggregate values. According to the UNAIDS database, some 5.1% of adults of both sexes were infected by year 2005 in sub-Saharan Africa. This corresponds to about 6.1% women aged 15-49 infected, and to about 7.3% pregnant women infected. The coefficients used for deriving these numbers were taken from the African DHS surveys with data on HIV seroprevalence, found in 20 countries. The differences are due to higher infection rates among young women compared with young men, and to higher infection rates at the peak of fertility (around age 30 years) compared with younger and older women. Among the babies delivered by these women, some 1.8% will become infected, and 60% of them will die before age 5, so that AIDS mortality will be about 11 per 1000 live births. Compared with an average under-five mortality of 123 per 1000 in year 2005, this leads to an estimate of about 9% of deaths of under-five children attributable to HIV/AIDS. Of course, this is a rough estimate for the whole continent; however it provides an order of magnitude for the effect of HIV/AIDS on overall mortality levels. Since there is a strong interaction between level of mortality and HIV prevalence (the countries the most affected by HIV are also those with the lowest mortality), the formal calculations by country are likely to be somewhat different (see below).

4.3 Overview of mortality trends by area

The mortality decline has been steady for the continent as a whole since 1950. (Table 2, Figure 2) For this group of 38 countries, the under-five death rate was estimated at 346 per 1000 in 1950, 229 per 1000 in 1970, 166 per 1000 in 1990, and 123 per 1000 in 2005. The pace of mortality decline averaged -2.1 per cent per year from 1950 to 1970, somewhat less (-1.6 per cent per year) from 1970 to 1990, and -2.0 per cent per year from 1990 to 2005, the period where HIV spread and hit these countries the hardest. Overall, HIV/AIDS did not change radically the speed of the mortality decline, which remained at an average level between 1990 and 2005. This decline was even somewhat faster than between 1970 and 1990, a period of turmoil for many countries, and of long lasting economic recession. [see Garenne & Gakusi, 2006b, Gakusi & Garenne, 2007 for more details on the impact of political and economic crises]

Mortality levels and trends differed quite significantly among the six groups of countries. Firstly, the levels at baseline differed: countries from the Southern and the Islands groups had much lower levels of mortality in 1950 as well as in 1970. By 1990 the situation was different, since Madagascar underwent a major rise in mortality for about 13 years for reasons other than HIV/AIDS. By 1990, Southern Africa had from far the lowest mortality, but this favourable trend reversed dramatically because of HIV, so that mortality in 2005 was much higher than in 1990, with an average rate of increase of +2.5 per cent per year.

This is the only case of serious reversal for the six groups considered. In contrast, the Islands groups continued with a fast decline, and by 2005 had almost recovered on trends that prevailed before 1970. This group had virtually no HIV/AIDS over the 1990-2005 period.

	Under-five mortality Per 1000 live births				HIV mortality		Mortality decline, Average per year		
Large area	1950	1970	1990	2005	2005	Relative impact %	1950-1970	1970-1990	1990-2005
Sahelian	372	273	195	124	8	6.3	-0.015	-0.017	-0.031
Coastal West	349	231	189	149	9	5.7	-0.021	-0.010	-0.016
Central	348	229	154	133	9	7.0	-0.021	-0.020	-0.010
Eastern	367	222	165	105	21	20.0	-0.025	-0.015	-0.030
Southern	250	143	58	85	52	60.8	-0.028	-0.045	+0.025
Islands	283	188	157	77	1	0.7	-0.021	-0.009	-0.048
Total	346	229	166	123	15	12.3	-0.021	-0.016	-0.020

Source: Author's calculations from DHS surveys

Table 2. Effect of HIV on under-five mortality, 38 countries in sub-Saharan Africa

For the other groups, mortality trends were favourable, and apparently not correlated with HIV prevalence. Over the 1990-2005 period, the Sahelian group and the Eastern group had a fast mortality decline (-3.1 and -3.0 percent per year respectively), despite slower mortality decline in the previous period (-1.7 and -1.5 percent per year respectively between 1970 and 1990). The Coastal-West and the Central groups did not perform as well, although they also had a regular decline (-1.0 and -2.0 percent per year respectively).

In conclusion, the HIV/AIDS epidemic had only a minor impact on under-five mortality trends, except in the Southern Africa region where it led to a strong reversal in mortality trends. This area accounts only for 10% of the total population, so that its contribution to trends in the sub-continent remains small.

The fact that mortality trends remained favourable over the 1990-2005 period, and in fact went faster than in the previous period (1970-1990), except in the Central and Southern groups, is due to other phenomenon: increase in the ratio of physicians per capita, large scale public health programs, in particular EPI vaccination, treatment of diarrhoeal diseases and of acute respiratory infections, prevention and treatment of malaria and of malnutrition. These important actions overcame the effect of HIV/AIDS in many countries.

4.4 Discounting for HIV/AIDS mortality

If one subtracts the estimated HIV/AIDS mortality from the observed mortality, one finds a declining trend that is even faster (Figure 2). Without HIV/AIDS, under-five mortality would have been about 108 per 1000 live births in 2005, and the pace of mortality decline in the 1990-2005 period would have been –2.2%, basically as fast as during the favourable years 1950-1970 during which income per capita increased steadily by about the same absolute value (+2% a year). This gives a measure of the progresses that were achieved in these recent years once the effect of HIV/AIDS is discounted. Note that this later period (1990-2005) is also associated with a rise in income per capita, again by about +2% a year, whereas the 1970-1990 was associated with a recession of about -1% per year in GDP-PPP.

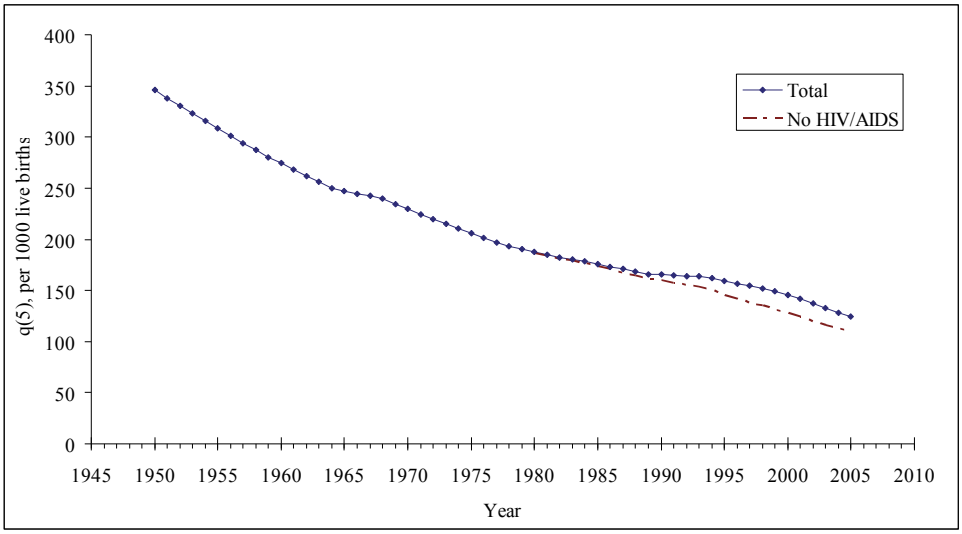

Fig. 2. Trends, with and without HIV/AIDS, 38 countries in sub-Saharan Africa

4.5 Contribution of HIV to mortality levels

Even if HIV/AIDS did not change much the overall trends in mortality, its contribution to mortality levels is still noticeable. According to our calculations, HIV/AIDS mortality accounted for about 12% of total under-five mortality in 2005. This is somewhat higher than our raw estimate presented above (9%), and due to the interaction between mortality level and HIV prevalence. Indeed, the contribution of HIV/AIDS is the largest (61%) in the Southern group, which had the lowest mortality at baseline, because of high HIV mortality combined with low non-HIV mortality. It is also significant (20%) in the Eastern group, for the same reason: higher HIV mortality combined with lower than average non-HIV mortality. Elsewhere the contribution of HIV is smaller (less than 10% in Sahelian, Coastal-West and Central groups), and negligible in the Islands group.

5. Discussion

Under-five mortality decline continued after 1990, despite the HIV/AIDS epidemic. This is due to a balance between very positive effects, associated with continuous improvements in public health and medicine and in income per capita, despite the negative effects of HIV. Even if this decline is not fast enough to meet the Millenium Development Goal 4, which implies an average annual decline -4.4 per cent per year, sub-Saharan Africa appears still on the right tracks. Note that a -2.2% annual mortality decline compares with the path of European countries between 1880 and 1939, at similar mortality levels, as in Sweden (-2.6% per year) or in England and Wales (-2.7% per year) [data from Human Life Table Database, 2008].

Some of our mortality figures may be somewhat under-estimated, because we neglected the interaction between mother's survival and child survival. When a mother dies, she may leave behind young orphans, who were found repeatedly to be at higher risk of mortality, even when seronegative. Of course, this woman will not be interviewed in a DHS survey, so

that we may undercount the mortality of children by selecting out mothers who were still alive at time of survey and whose children were under five year of age. However, when women are in an advanced stage of AIDS, and therefore likely to die shortly, they tend to have lower fertility, so that the bias might be smaller that anticipated.

Our estimates of the contribution of HIV/AIDS to under-five mortality are consistent with some of the early estimates quoted above, but differ from some of the more recent estimates. Most of those are based on the method developed by the UNAIDS / UNGASS group, which is more sophisticated than ours, and takes into account numerous other parameters. Our approach was simpler, and matched basic information about mother to child transmission and AIDS mortality found in case studies. Until the early 2000's these figures were probably correct, since prevention of mother to child transmission and access to HAART (highly active anti-retroviral therapy) took off only in these years. Why the estimates are so different while using similar parameters remains to be further analyzed. The UNAIDS estimates might have been over-optimistic on recent developments of the epidemiology of HIV and its treatment, while ours might be over-pessimistic by assuming that until recently AIDS mortality was quite natural. In particular, some of the estimates quoted by Black et al., [2010], such as the proportion of under-five deaths caused by HIV/AIDS in Botswana, seem abnormally low compared with our estimates, with estimates made by other authors, and with the fast increasing mortality trend seen since 1988.

We tried to check the validity of our estimates on the relative contribution of HIV/AIDS in under-five mortality by comparing with independent sources. In South Africa, under-five mortality was decreasing rapidly before 1992, then it increased from 46 per 1000 in 1993 to 85 per 1000 in 2006. According to previous trends, mortality was expected to be about 25 per 1000 in 2006, which, assuming that all the mortality increase was attributable to HIV, suggests that HIV contributed to some 70% of the total in 2006. Similarly, in Zimbabwe, mortality trends predicted a value of 38 per 1000, whereas an under-five mortality of 85 per 1000 was found in 2005, suggesting that 55% of deaths were due to HIV. In Agincourt, a Demographic Surveillance System (DSS) located a rural area of South Africa where causes of death are available, in 2006 HIV/AIDS accounted for 66% of deaths of under-five children, and a similar proportion (64%) was found in nearby hospitals. [updated from Kahn et al. 2007] In Hlabisa, a DSS located in Kwazulu Natal, some 41% of deaths of under-five children were attributed to HIV/AIDS. [Garrib et al., 2006] However, in Manhiça, a DSS located in Mozambique heavily affected by malaria, HIV/AIDS accounted for only 8.3% of the deaths of children age 0-14 years, but possibly more if one considers that deaths attributed to other causes (tuberculosis, malnutrition, diarrhoea, pneumonia) could be also HIV/AIDS deaths. [Sacarlal et al., 2009]

The large differences in HIV prevalence among African countries remain to be explained. African countries differ in many indicators of economic development as well as in many social indicators. We have argued in another paper that sexual behaviour associated with different marriage patterns, in particular with women's mean age at first marriage, and with permissiveness measured by premarital fertility, were key factors of the dynamics of HIV epidemics. [Garenne & Zwang, 2008; Bongaarts, 2007] This in turn explains some of the patterns found in this study. In more advanced countries of Southern Africa, HIV spread much faster because of later marriage and more permissiveness, and had a stronger relative impact because mortality was much lower at baseline. On the other side of the spectrum, in Sahelian countries, marriage was much earlier, permissiveness much less prevalent, and

baseline mortality was much higher, so that the relative impact appeared much lower. This combination of various factors linked both to economic development and to the social make up of African societies could explain a great deal of the variations in the contribution of HIV to under-five mortality levels and trends.

We presented available data by large groups of countries, based on geographical clustering. Of course, these groupings are masking differences by country, and even within countries differences between urban and rural areas, and between provinces or districts. It is beyond the scope of this paper to detail more these differences. As examples of such local patterns, let us remind that in Cote d'Ivoire, and in particular in Abidjan its capital city, under-five mortality increased markedly as a result of fast spreading of HIV in the 1980's. [Garenne et al., 1996] Likewise, in Kenya and in Uganda, and in particular in the areas bordering Lake Victoria, mortality increased also markedly as a result of rapid spread of HIV in the 1980's. [Timaeus, 1998]

The cold mortality data presented in this paper do not reflect the numerous social and economic costs of the HIV/AIDS epidemic for African families, and largely ignores the fate of the many orphans who lost one or both parents because of this disease. Discussing these issues has been done in other documents. [UN Millennium Project, 2005]

The prospects for future trends in HIV/AIDS mortality are not as grim as they were in 1990. Since then, efficient strategies to control mother to child transmission were developed and put in place. Furthermore, HAART treatments became available not only for adults, reducing furthermore the risk of transmission from mother to child, but also for children. The combination of these factors should lead to achieve low AIDS mortality among children. Combined with the progress made for other causes of death, one could hope further improvements in child survival in the years to come. [Ndondoki et al., 2011]

We did not address the issue of adult mortality, simply because available data are much weaker, and no comprehensive reconstruction of trends is yet available. However, some attempts have been made by other authors and by modelists to estimate the impact of HIV/AIDS on adult mortality. [Timaeus, 1998] In turn, adult mortality trends seem to have reversed recently, after a long period of increase, in the most infected countries of Southern Africa, primarily as a consequence of HAART treatments. Here again the prospects for future adult mortality trends appear more favourable than thought at the height of the epidemic in the mid-1990's, before anti-retroviral therapy became available. Further improvements will require a continuous effort in screening and treating the persons who are infected with the HIV virus.

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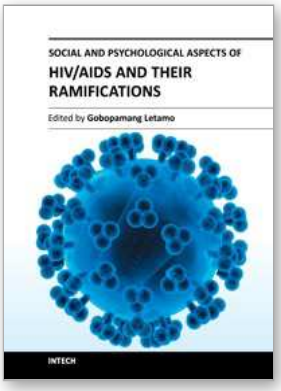

Social and Psychological Aspects of HIV/AIDS and their Ramifications

Edited by Prof. Gobopamang Letamo

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This book has assembled an array of chapters on the social and psychosocial aspects of HIV/AIDS and their impact on HIV/AIDS and related behaviours. The book addresses key areas of HIV and AIDS, including, but not in any way limited to, care-seeking behaviour, adherence, access, psychosocial needs and support services, discrimination and the impact the epidemic has on various sectors of the economy. The book has seventeen chapters; seven chapters deal with social aspects of HIV/AIDS, four with psychosocial aspects of HIV/AIDS, and the remaining six chapters with the impact of social and psychosocial factors on HIV/AIDS and related behaviours. The book is an essential reading for academics, students and other people interested in the field of HIV and AIDS.

How to reference

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