The Impact of HIV on Child Health and the Health System

Giovanni Andrea Cornia, Mahesh Patel and Fabio Zagonari

Introduction

This chapter focuses on the impact the HIV epidemic has had on the health sector and the health status of children in 40 countries with medium to high HIV prevalence. With the rise in prevalence at antenatal clinics reaching 50 per cent (as in some areas of Botswana), and with adult prevalence of over 20 per cent in several parts of Africa, the health sector has been particularly hard hit. It now suffers from attrition of personnel, while at the same time it needs to perform at well above its pre-epidemic levels in order to control the spreading contagion and to care for those affected. In countries with adequate economic growth and low infection rates, increases in health budgets will often be sufficient to cope with the crisis. But in several highly indebted poor countries, where the health sector has been deteriorating since the 1980s, most markedly following the adoption of structural adjustment programmes, infection rates are high (Simms et al. 2000). In most of these countries, HIV has also caused a rapid increase in the demand for hospital-based treatment, which has led to weakening of health care at the primary level. How to control the negative effect of HIV, without weakening other essential interventions, is the main health sector challenge faced by the policymakers of many low- and middle-income countries.

The health sector response to the HIV pandemic initially focused on **prevention** of the contagion and treatment of opportunistic infections. In some middle-income countries, the response has gradually also included the **treatment** of HIV-affected newborns, mothers and – in some cases – adult males. However, in all countries, the public policy response to **mitigation** of the health impact of HIV on children and their families has been limited. Families have had to cope with the devastating effects of HIV – poor health, impoverishment and social marginalization – themselves. Thus, the optimal policy for the health sector in HIV-affected countries is still the subject of an evolving debate.

To try to answer these questions, the second section assesses the impact of the HIV pandemic on the functioning of the health sector, the main aim being to understand the changes in actual demand for, and supply of, public and private health services for HIV- and non-HIV-related ailments. The third section reviews the impact of AIDS on child mortality and the availability of health services for children. Unlike in the educational sector, where HIV appears to have had a so far limited impact on enrolments (see chapter 9), there is evidence that AIDS has had a devastating impact on child mortality in many countries. The health policies and programmes introduced to combat the pandemic and the comparatively neglected issue of antiretroviral drug treatment are discussed. Then the measures that have been, or could realistically be, introduced to sustain health care provision for children and mothers in AIDS-affected countries are examined.

Framework of analysis

Short-term impact of HIV and AIDS: the demand for health services

The spread of HIV has massively increased demands on the health sector: as the HIV virus weakens people's immune systems, it increases their susceptibility to a host of other diseases, such as TB and meningitis. In sub-Saharan Africa, up to 50 per cent of people with HIV develop TB.

Whether or not the surge in latent need for health care to deal with these opportunistic infections is transformed into an increase in effective demand for such care depends on a number of factors. To start with, it depends on 'prices', including the price of the health care itself and the price of other essential items, such as food and funeral services. The second main factor is the change in household income of people affected by HIV, and the third is social stigma. It is likely that HIV increases demand for health care more than other diseases because it is considered to be more lethal (Nandakumar 2000). On the other hand, the social stigma of HIV has the opposite effect (see Muyinda et al. 1997 on Uganda). When a patient is unaware of his or her condition, the demand for health care also depends on the behaviour of the health care personnel. Gibney et al. (1999) show that physicians in Zimbabwe frequently choose not to test patients for HIV, fearing that they would be traumatized, and even commit suicide.

The spread of HIV may give rise to a substitution, or 'crowding out', effect, by which the demand for health care for non-HIV-related diseases declines due to the increase in the burden of disease, the high cost of HIV treatment or an increase in user fees. Conversely, the HIV epidemic can lead to a complementary, or 'crowding in', effect due to a reduction in the cost of care for non-HIV-related diseases, if, for example, a patient takes advantage of a health care visit for HIV problems to seek treatment of other ailments. The evidence reviewed below suggests that in high-prevalence and low-income countries, the 'crowding out' effect dominates.

The most relevant changes that have taken place in this area over the last decade can be summarized as follows.

(i) Overall demand for health care has increased sharply due to HIV. Worldwide, AIDS is now the fourth most important cause of death, ahead of TB, malaria and diarrhoeal diseases.

For the year 1999–2000, AIDS was by far the main cause of death in the 'high-prevalence countries' of sub-Saharan Africa (see table 1), despite possible under-reporting and underestimation of its prevalence due to classification problems. In Zambia, about 70 per cent of the 40,000 TB cases recorded annually are related to AIDS (Silungwe 2000). Yet, AIDS is not the main cause of death in all African countries. In 2000 in Ghana, with an HIV prevalence of 3.6 per cent, malaria was the reason for 40 per cent of all outpatient visits, and all the TB, AIDS, measles and leprosy cases combined totalled only one fifth of the number of malaria cases. Moreover, malaria is the main cause of death among children under five years of age and accounts for 25 per cent of all deaths in that age group (Senaya 2001).

Table 1. Rank and percentage burden of disease for the first 10 causes of death in sub-Saharan Africa (2000)

Rank	Disease	Percentage of deaths
1	AIDS	20.6
2	Acute lower respiratory infections	10.3
3	Malaria	9.1
4	Diarrhoeal diseases	7.3
5	Perinatal conditions	5.9
6	Measles	4.9
7	Tuberculosis	3.4
8	Cerebrovascular disease	3.2
9	Ischaemic heart disease	3.0
10	Maternal conditions	2.4

Source: Elaboration of data from WHO 2000.

The main causes of morbidity and mortality among children tend to be different from adults, particularly in low-prevalence countries. Young children generally only contract HIV at birth or during breastfeeding, and it is other types of ailments such as measles, diarrhoea and malaria that affect most children and are still the main cause of child deaths. Yet, in countries with a comparatively low level of U5MR before the onset of AIDS, and a large increase in HIV prevalence over the last 10–15 years, AIDS has become the most important cause of death among children.

Even in medium-prevalence countries – such as Thailand – the relative importance of AIDS as a cause of death remains high. Tangcharoensathien et al. (2001) show, for instance, that during the period 1993–1997, AIDS was the sixth cause of death, despite the under-reporting of such deaths outside hospitals. In many cases, AIDS deaths are attributed to diseases such as malaria, TB, respiratory infections and fever. If classification bias is taken into account, AIDS becomes one of the top three causes of death in Thailand too.

In low-prevalence countries, HIV still remains a serious public health problem for certain population subgroups. Saavedra (2000) shows that in 1997 in Mexico (1999 prevalence of 0.3 per cent), AIDS represented only the 15th cause of death among the general population, but the ninth among the population of working age. In specific subpopulations, the problem is more acute. Avila-Figueroa (1999) suggests that AIDS is the first cause of death in men between 25 and 44 years old in Brazil, Mexico and Venezuela.

The impact of HIV on the health sector can also be gauged by examining service utilization data. The demand for HIV-related health care services increased in relative terms as a share of the total demand for health care in practically all countries with HIV prevalence above 2 per cent.

Information on bed usage by patients with HIV-related illness is available from major hospitals in a number of countries (WHO 2001a). For several hard-hit countries, loss of hospital capacity for non-HIV-related patients could be over 50 per cent, as indicated by the data in table 2 and the literature surveyed below.

Table 2. Percentage of hospital beds occupied by HIV-positive patients in selected developing countries with medium to high prevalence (circa 1995)

City	Hospital	% beds occupied by HIV-positive patients
Chiang Mai, Thailand	Provincial	50
Kinshasa, D.R. Congo	Mana Yemo	50
Kigali, Rwanda	Central	60
Bujumbura, Burundi	Prince Regent	70
Nairobi, Kenya	Kenyatta National	39
Kampala, Uganda	Mulago	56

Source: World Bank 1999a.

Already in 1988–1993, the share of bed occupancy by patients who were HIV-positive and with HIV-related illness in selected urban hospitals in Abidjan, Kampala, Kigali, Kinshasa, Lusaka and two Zambian hospitals was close to 60–70 per cent (Buvé 1997). In Zimbabwe, bed occupancy for AIDS rose tenfold during the 1990s. In Zambia, hospital bed occupancy for AIDS is expected to swell from about 6 per cent

to 43 per cent between 1990 and 2005 (Mpundu 2000). In Botswana, at least 60 per cent of hospital beds are occupied by patients with HIV-related disorders (Makhema 2000). Similar results are reported by Colvin et al. (2001) for South Africa and Tembo et al. (1994) for Uganda. Thus, in high-prevalence countries, HIV clearly has a major effect on the supply of non-HIV-related health services.

In high-prevalence countries, data on medical consultations tell a similar story. In Rwanda (prevalence of 11.2 per cent in 1999), a study of some 350 HIV-positive people shows that on average each had 10.9 annual outpatient visits, as opposed to a meagre 0.3 for the general population (Nandakumar et al. 2000). The study also reveals that the increased demand for outpatient services was characterized by considerable inequity of access and income. Patients in urban areas utilized services 10 times more than those in rural areas (due to easier access and higher incomes), with those in the top quintile doing so twice as often as those in the bottom quintile, and the married patients 40 per cent more than the single or widowed ones. In addition, the study indicates that only 30 per cent of the sample patients were able to pay the full cost of the visits themselves; the majority had to resort to assistance, selling assets or borrowing money from a bank or relatives.

Even in low- to medium-prevalence countries, there is local evidence of such 'crowding out' effect. In the Maechan hospital in Thailand, the share of the total budget spent on HIV rose from 20 per cent to 40 per cent between 1995 and 1997, while that of cases treated for HIV rose from 3.7 per cent to 7.1 per cent (Tangcharoensathien et al. 2001).

(ii) There is evidence that in several countries the demand for, and effective treatment of, HIV-related diseases has crowded out that for non-HIV-related diseases. The above Thai study shows that HIV-related costs rose at the expense of the non-HIV health budget. A study on Zambia (Mpundu 2000) describes a similar trend – a trend that also entailed a greater concentration of health resources on tertiary care and the slashing of precious resources formerly assigned to district health centres. In some districts in Kenya, the high hospital bed occupancy by patients with HIV-related illness prevents access to care by people with other conditions (Rachier 1999). One of the reasons for the higher allocation to HIV is that it is far more expensive to treat. A study on Zimbabwe (Hansen et al. 1998) shows that, due to longer average length of stay in hospital and higher daily costs (medication, laboratory tests and X-rays), hospital care was twice as expensive for patients with HIV-related illness as for non-HIV-related.

Short-term impact of HIV and AIDS: the supply of health services

HIV and AIDS affect the various tiers of health care systems to a different extent. National health care systems usually provide services (often for a fee to supplement scarce public funds and external donations) through a three-tiered structure, such as outlined below:

- Village-based **public health centres**, staffed by one or two low-paid public health workers who receive limited training on the screening and treatment of the most common ailments and support for the implementation of public health campaigns. They refer cases they are unable to treat to higher levels of care.
- The city-based **health centres/district hospital**, staffed by trained nurses and, in some cases, general practitioners. While they provide mainly outpatient care, they can often also provide inpatient care in small wards. There is generally a fee for these services, though the preventive component ought to be free. Fees for services tend to be higher in these institutions than at the primary level, yet evidence shows that public health centres are utilized much less than the local or central hospital infrastructure.
- **General and specialized hospitals**, located in the provincial and national capitals. They are staffed by nurses, general practitioners and specialists and have specialized wards (e.g. for infectious diseases). They provide outpatient care and a range of curative, mostly inpatient, care services. The patients, except for those who are public employees covered by health insurance, pay for hospital-based care. User fees are designed to discourage people from seeking care for simple diseases in such hospitals.
- **The private health care sector**. This is generally staffed by doctors who often hold dual employment, in both the public and private sectors (Chawla 1997). It includes traditional healers as well as modern units that provide good but expensive care to high-income people. In middle-income countries, the private sector caters to patients with health insurance and the staff of large enterprises (Kikumbih et al. 1997).

In low-income countries, the public sector dominates in terms of numbers of patients treated (over 90 per cent of the total) as well as of funds expended. In Rwanda, 68 per cent of total health expenditure is in the public sector, 9 per cent is allocated to NGOs and the rest to the private sector (Schneider 2001). In Thailand, of the total health expenditure in 1994, 36 per cent was spent on purchasing care from public providers, 32 per cent from private providers, 6 per cent on administration and 9 per cent on all other public health programmes. Roughly half the total financing originated from the public budget and the rest from private sources.

Three types of constraints on the ability of the health sector to supply services will be considered: a reduction, or slower growth, in the supply of labour due to greater mortality/morbidity among health care providers, including their declining morale and/or efficiency; changes in the demand for health services; and constraints on recurrent budgets.

High HIV prevalence among health workers is one of the main reasons for decline of health services. Epidemiological surveys from sub-Saharan Africa have shown that HIV incidence has been disproportionately high among people with

high human capital such as doctors, nurses and hospital administrators who are likely to be part of the 'mobile population' posted away from their families and thus exposed to a high risk of contagion. In Zambia, mortality among nurses rose from 2/1,000 in 1980–1985 to 26.7/1,000 in 1989–1991, while absenteeism reached 16 per cent (Buvé et al. 1994). Overall, the World Bank (1999a) estimated that a country with a stable 5 per cent prevalence could expect that between 0.5 per cent and 1 per cent of its health care providers would die from HIV-related diseases annually. A country with a 30 per cent prevalence would lose 3–7 per cent of its health workers to the epidemic each year (ibid.).

The 60 countries most affected by the epidemic employ about 2.5 million physicians, 2.2 million nurses and 100,000 midwives, totalling nearly 5 million (WHO 2001b). Many of these are HIV-positive, but the impact on the functioning of the health sector is more dependent on the number of AIDS cases and deaths than on HIV infections, which remain latent for some years. As the mortality rate is normally about 10 per cent of the prevalence, there would be some 5,000 deaths annually among the approximately 5 million health sector staff. But these figures conceal wide national variations. While for sub-Saharan Africa overall an average 8 per cent of staff are infected and mortality could be about 1 per cent, in countries such as Botswana, Lesotho, Namibia, South Africa, Zambia and Zimbabwe, the adult prevalence is between 20 per cent and 30 per cent, so up to 25 per cent of the health staff may be infected and 3 per cent already dead.

In the short term, a loss of 3 per cent in the health sector is not catastrophic, but the medium-term implications are more serious. A national infection rate of around 30 per cent implies that up to one third of health sector staff may need to be replaced over the next six to seven years. This means that the intake of medical and nursing schools would need to approximately double. This has been the case in Uganda, where the number of nurses and doctors rose from about 2,200 and 1,200 in 1990 to 6,700 and 4,500 respectively in 2000 (chapter 2). However, such increases in the number of health staff are not taking place elsewhere, and some countries may face a staff deficit of up to one third of current levels.

A study on Zambia (Foster 1993) attributed an increase in the mortality of nurses between 1986–1988 and 1989–1991 to AIDS due to occupational exposure. Another study from South Africa (Gounden and Moodley 2000) found that 13 per cent of the staff reported injuries with HIV-positive patients. Health personnel also suffer from 'occupational burnout' due to stress caused by the epidemic.

The quantity/quality of health services may also have eroded due to greater absenteeism, low morale and refusal of staff to be transferred to high-prevalence regions. Rising morbidity/absenteeism among nurses and doctors has serious implications for staffing planning and the ability of the health system to cope. In countries with high prevalence, there has for many years been a shortage of nurses and even more so of doctors, particularly in remote and rural areas. The decline in

salaries and the perceived greater risk of dealing with HIV-positive patients has led to demands for 'special AIDS allowances', which – where these have not been met – have led to an exodus to the private sector or to countries with higher salaries, such as South Africa and the United Kingdom.

The demand for HIV-related services has been directed mainly to the intermediate and upper tiers of the health system, not the primary level. HIV testing and counselling, and palliative care for TB and other opportunistic infections, as well as treatment with antiretrovirals, tends to be carried out at higher levels of care, despite the fact that their unit costs are higher than at lower level.

While the primary and secondary levels of health care provision may have been less affected by the new demand for HIV care, they may have suffered because of the drainage of resources towards higher levels of care. With broadly constant health budgets, as much as 50 per cent of the funds may have gone to hospital care for patients with HIV-related illness, causing a drop in resources assigned to the primary and secondary levels of care. In Thailand, during the recent economic downturn and budgetary stringency, district hospitals in the northern provinces had to cap drug expenditure on opportunistic infections. Moreover, district hospitals referred patients to upper levels of care (Pothisiri et al. 1998).

AIDS-induced changes in public and private recurrent expenditure on health

Total health expenditure as a percentage of GDP in low- and middle-income countries is not fundamentally different from that of some industrialized countries (table 3). In 1998, with a share of 4–6 per cent of GDP allocated to public and private health expenditure, Rwanda, Ghana and Zimbabwe were in a similar situation to that of low health expenditure OECD countries (UNAIDS 2000a).

Table 3. Total public and private health expenditures as a percentage of GDP in late 1990s

	Total health expenditure	Public health expenditure*	Private health expenditure
Ghana	4.7	1.8	2.9
Zimbabwe	6.4	3.1	3.3
Rwanda	5.0	3.0*	2.0
United Kingdom	6.4	5.4	1.0

Source: Ghana and Zimbabwe: UNAIDS 2000a, Rwanda: Schneider 2001.
Note: * Includes also international assistance; in Rwanda, 2.5 per cent of the 3 per cent was foreign aid.

However, while the percentages may not differ greatly, the actual sums involved do. In 40 HIPCs, health expenditures average $10 per capita, well below the $60 minimum expenditure suggested by WHO and 20 per cent to 40 per cent lower

than the cost of the World Bank basic package of health services. To put this $10 expenditure in context, in poor economies, the health sector expenditure required for prevention alone has been estimated at $5 per capita (Patel 2000). Current expenditure on prevention is only about $0.20 per capita, of which government expenditures amount to $0.02. Care services are similarly constrained.

The most common response has been to require patients to cover most of the cost of HIV care, thus limiting treatment to those who can afford it. In addition, while in industrialized countries public expenditure accounts for 80–90 per cent of total health expenditure, in low- and middle-income countries it is between 40 per cent and 50 per cent (including aid). In Uganda, the Government spends only $4 per capita annually on health, while per capita health spending from both public and private sources rose from $8 in 1994–1995 to $10.79 in 1997–1998, while foreign aid declined from $1.28 in 1994–1995 to $1.09 in 1997–1998 (table 4). At the local level in Thailand, Tangcharoensathien et al. (2001) report that in 1997 in Chiangrai province, the householders' share of HIV-related health expenditure was 43 per cent, and in Phayao province it was as high as 65 per cent. Mexico and Brazil show two extreme situations. In Mexico, subsidies cover only 26 per cent of the cost of HIV care, but 76 per cent of the costs for non-HIV treatments. In Brazil, antiretroviral therapy is free, whereas only 33 per cent of other health services are subsidized.

Table 4. Recurrent per capita health expenditure in $, total and by source, Uganda, 1994–1998

	1994–1995	1995–1996	1996–1997	1997–1998	1998 minus 1994
Total recurrent expenditure	11.22	12.19	13.84	14.27	3.05
– Private	8.00	8.82	9.75	10.79	2.79
– Public	1.94	2.05	2.91	2.38	0.44
– Foreign aid	1.28	1.32	1.18	1.09	-0.19

Source: Elaboration on Mirembe et al. 1998.

What has been the impact of HIV on health expenditure? In low-income countries, despite its depressive effect on family incomes, the epidemics triggered an increase in private health spending that led to a reduction in household consumption of basic items. In contrast – with a few exceptions, such as Uganda – public health expenditure stagnated owing to budgetary restrictions and, in some cases, to restrictive adjustment policies and mounting debt service obligations. On average, from 1990 to 1996, public health expenditure as a share of GDP stagnated at 1.1 per cent in low-income countries and rose moderately from 3.0 per cent in middle-income ones. This pattern of stable public, and rising private, health expenditure is well illustrated by table 4.

The changes in health spending were less dramatic in middle-income countries with health insurance and low prevalence. In these countries, the HIV epidemic has often been accompanied by an increase in public health expenditure and stagnant private health expenditure. In Brazil, the federal expenditure on antiretroviral drugs rose from $34 million in 1996 to $224 million in 1997 and to $332 million in 2000 (Sarna 2001). In Thailand, the HIV budget expanded from Baht 6 million (in constant 1995 prices) in 1988 to 218 million in 1991, then to 2,066 million in 1996, only to decline in the wake of the Asian crisis to around 1,200 million for the period 1998–2000 (Tangcharoensathien et al. 2001, and chapter 5).

The long-term impact of HIV and AIDS on the health status of children

Child mortality trends in the AIDS era

Most of the recent debate on the mortality impact of HIV has focused on changes in adult death rates and neglected the impact on the elderly, infants and young children. In fact, the impact of HIV on child mortality remains controversial. One view is that, in countries with moderate adult prevalence, the impact is negligible. An examination of trends in services for children (vaccination, delivery care and oral rehydration therapy) for the last 20 years in 40 countries with adult HIV prevalence greater than 1 per cent, leads to the conclusions summarized in table 5. There are four main country groupings:

(i) **Countries with high adult HIV prevalence (>6.5 per cent), high pre-AIDS coverage of child health services and low pre-AIDS U5MR, showing a marked or moderate reversal of the trend towards lower U5MR**. Such reversal started in the late 1980s in countries with 'mature epidemics' such as Kenya, and from the early to mid-1990s in countries with 'recent epidemics' such as Botswana, South Africa, Zambia and Zimbabwe. The average extent of the reversal is 20–30 per cent; but in Botswana, U5MR declined from 84 to 58 per 1,000 between 1980 and 1990 and then jumped to 101 per 1,000 by 2000 – a 75 per cent rise in U5MR in a decade. In other words, HIV more than erased the gains in child mortality achieved in the 1980s.

In a second group of four countries with a high adult prevalence that had achieved a rapid expansion of child health services coverage during the 1980s and 1990s, the U5MR rise was less, 5–10 per cent, as any increase due to perinatal HIV transmission was in part offset by the decline in non-HIV-related child deaths.

(ii) **Three countries (Angola, the Democratic Republic of Congo and Liberia) with a moderate increase in U5MR**. The prevalence of HIV and paediatric AIDS mortality rose only moderately, but child health care coverage was so low, due to conflicts and social turmoil, that they had not previously managed to reduce child deaths from causes other than AIDS.

(iii) **Countries with consistent downward trend of U5MR (11 cases) or slower than expected decline (7 cases)**. In countries such as Benin, Burkina Faso, the Dominican Republic and Ghana, with low pre-AIDS coverage of child health services and high pre-AIDS U5MR, the surge in AIDS-related child mortality was more than offset by a decline in child mortality due to expansion of immunization, maternity care and other interventions in the 1980s. This effect was less pronounced in the 1990s, as coverage levelled off. To a certain extent, these countries followed the trend of the first group and were able to benefit from the 'basic health services dividend'.

(iv) **A country able to maintain the U5MR downward trend**. Thailand was able to control HIV prevalence through an effective prevention campaign and thus avoided a large rise in perinatal HIV cases, while at the same time sustaining coverage of the usual basic health services for children.

Table 5. Countries grouped according to changes in U5MR trends, increases in HIV infection rates and basic health services coverage

	Low 1980–1985 **coverage of health services for children**	***Low 1980–1985*** **coverage of health services for children**	***High 1980–1985*** **coverage of health services for children**
	1985–2000 health service coverage *stagnates*	1985–2000 health service coverage *expands*	1985–2000 health service coverage *remains high*
Low–medium HIV prevalence in the 1990s (<6.5%)	**(ii) U5MR trend rises moderately** Angola, DR of Congo, Liberia	**(iii) U5MR falls on trend** Benin, Gambia, Ghana, Guinea, Honduras, Mali, Madagascar, Panama, Niger, Nigeria*, Uganda* **(iii) U5MR falls more slowly than the trend** Burkina Faso, Cent. African Rep.*, Dominican Rep., Gabon, Haiti, Namibia*, Senegal, Togo **[U5MR trend rises moderately** Cambodia*]	**(iv) U5MR falls on trend** Thailand
Medium–high HIV prevalence in the 1990s (>6.5 %)		**[U5MR falls on trend** Ethiopia*, Mozambique*] **(i) U5MR trend rises moderately** Burundi, Cameroon, Cote d'Ivoire, Rwanda	**[U5MR falls on trend** Lesotho*, Malawi*] **(i) U5MR trend rises rapidly** Botswana, Congo, Kenya, South Africa, Swaziland, United Republic of Tanzania*, Zambia, Zimbabwe

Source: Compilation by the authors, based on UNAIDS 2000a, US Bureau of Census, UNICEF and WHO.
Note: *Indicates a trend that is apparently inconsistent, but might be due to lack of up-to-date surveys for accurate U5MR measurement.

Causal analysis of changes in child mortality in AIDS-affected countries

The four-way classification proposed in table 5 sheds some light on the factors explaining the child mortality changes during the last 20 years, but needs to be complemented by a more rigorous approach that takes into account all the factors, including HIV, that influence child mortality rates.

Impact of HIV on child mortality: HIV affects child mortality rates in three ways: First, infants born to an HIV-positive mother have a 30 per cent probability of being infected by the virus, contracting AIDS and dying within one or two years, although the impact of paediatric HIV can be offset by the treatment of the newborn with nevirapine or other programmes to prevent mother-to-child transmission. Second, child mortality due to infectious and waterborne diseases may increase over the short term if the increasing demand for palliative care and the care of opportunistic infections absorbs funds otherwise devoted to immunization, oral rehydration therapy and delivery care, as well as the capital expenditure on the maintenance and development of the health infrastructure.[1] HIV could also affect U5MR because of the decline in the stock of doctors, nurses, paramedics and PHC workers due to an HIV-induced rise in mortality, attrition, out-migration and burnout among them and inadequate training of new staff. The weakening of the overall health care sector should also be demonstrated by an increase in child mortality due to **infectious and waterborne diseases**. Third, mortality among children may also increase because of the HIV-induced impoverishment of the family in which the child lives. Chapter 7 shows that average incomes drop by up to 50 per cent in families whose head died from HIV-related infections during the prior 18 months. This effect ought to be captured by a rise in U5MR due to **malnutrition and other poverty-related diseases**. Finally, it is worth noting that all these effects are exacerbated if the virus is of the HIV-2 type rather than the HIV-1 type.

Changes in the traditional determinants of U5MR: In countries with high pre-AIDS U5MRs, the upward shift in aggregate U5MR may have been more than compensated by changes in the 'traditional determinants' of child mortality, i.e. income per capita, income distribution, female education, access to fresh water supply and coverage of basic health services.

Between 1980 and 2000, income per capita stagnated in most AIDS-affected economies, and in a few it fell for several years. In those affected by large falls (e.g. Zambia), low-income groups and their children reduced food intake and thus became less resistant to infection. In contrast, acceptable growth was recorded in Burkina Faso, Ghana and Thailand (where U5MR fell on trend), as well as in Uganda (where it first stagnated and then fell) and Botswana (where it rose sharply from 1990). A worsening distribution of income (proxied by changes in the Gini coefficient) may have also contributed to the changes in U5MR in AIDS-affected countries. Here too, however, the limited information available suggests that this

is unlikely to be a key factor in explaining the changes in U5MR in the AIDS-affected countries. For instance, inequality rose in Kenya in the decade 1982–1992, while U5MR declined. This was also true of Thailand over the last two decades of the 20th century.

Meanwhile, female literacy – a key determinant of U5MR – changed slowly in most AIDS-affected countries and is therefore unlikely to explain much of the observed changes in U5MR. Finally, the coverage of fresh water supply and of highly effective pro-child interventions such as maternity care, child immunization, oral rehydration therapy, promotion of breastfeeding and micronutrient and food supplementation expanded rapidly during this period. However, in several countries, progress in these areas slowed down or was reversed in the late 1990s, either as result of the 'crowding out' of primary health care by the increasing demand for HIV care or because of the fiscal crisis affecting many AIDS-affected countries.

New confounding factors: U5MR has also been affected by a surge in the number of armed conflicts, humanitarian emergencies and natural disasters that have not spared the AIDS-affected countries (table 6). Major food shortages, often reaching famine proportions, have been common in sub-Saharan Africa, and the number of fully-fledged wars in many AIDS-affected countries – especially in sub-Saharan Africa – steadily escalated. These conflicts have increasingly exposed the civilian populations, particularly the children, to great suffering and caused a rise in the number of refugee and internally displaced children with no access to food, fresh water and health care.

Table 6. Refugees and internally displaced persons (IDPs) in 1995

	Refugees	IDPs	Total	Share
Rwanda	1,545,000	500,000	2,045,000	24.45
Angola	313,000	1,500,000	1,813,000	82.74
Liberia	725,000	1,000,000	1,725,000	57.97
Sierra Leone	363,000	1,000,000	1,363,000	73.37
Ethiopia	500,000	111,000	611,000	18.17
Mozambique	97,000	500,000	597,000	83.75
Eritrea	325,000	200,000	525,000	38.10
Burundi	290,000	216,000	506,000	42.69

Source: Cornia and Mwabu 2000.

Measurement error: Any empirical analysis of the causes of child mortality is influenced by the quality of the data that – in the absence of survey data – are obtained by extrapolating the pre-AIDS trend, an approach that can lead to underestimation. However, the distortion can be tackled by introducing a dummy variable

(NOSURVEY) that takes the value of 1 in case there is no survey for the years of rapid increase in HIV prevalence.

Cornia and Zagonari (2002) built an eclectic model of child mortality, comprising five sets of explanatory variables, i.e. (i) AIDS-related variables: the prevalence of HIV, the type of virus (whether HIV-1 or HIV-2) and the coverage of PMTCT; (ii) the usual determinants of child mortality: family income per capita, income distribution, female literacy, access to fresh supply; (iii) the coverage of the main health programmes for children; (iv) the impact of large-scale conflicts, disasters and humanitarian emergencies affecting 10 per cent or more of a country's population; (v) the lack of recent survey data on child mortality. The model can be written as follows:

U5MR = f {(HIV, DUMMY HIV2, PMTCT), (GDP/C, GINI, FL, WS), (DC, IMM, ORT, BF), (CONF), (NOSURVEY)} (1)

Before carrying out a regression analysis, Cornia and Zagonari (2002) tested the model and found that there appeared to be an upward shift in both child and infant mortality during the period 1995–2000, but in countries lacking recent U5MR survey data, the test shows that such effect is significant only for the countries without surveys after 1994. Also, HIV-2 appears to have a statistically significant greater impact on U5MR than HIV-1.

The factors that appear to have the strongest impact on child mortality are (in descending order of importance): female illiteracy, access to fresh water, DPT coverage[2] and income per capita. The result confirms that income per capita does not appear to be – as often argued – the most important determinant of child health, and that female literacy has the greatest impact on child mortality. As expected, immunization has a greater impact on child mortality than on infant mortality.

HIV prevalence and – to a lesser extent – the frequency and intensity of natural and artificial disasters are also strongly significant. The coefficient of HIV adult prevalence was found to be 1.93. This means that, in countries where adult prevalence had risen by 10 percentage points, U5MR rose – all other things being equal – by 19.3 points per thousand. This result confirms that the effect of HIV on U5MR was almost imperceptible in countries where adult prevalence remained below 2–3 points. Expanding the coverage of maternity care and oral rehydration therapy by 10 percentage points was found to reduce U5MR by 5.4 and 0.2 points per thousand. The impact of such programmes is thus considerably less pronounced than that of a similar improvement in female illiteracy (that would reduce U5MR by no less than 11 U5MR points), coverage of fresh water supply (reduction of 2.6 U5MR points) and DPT (reduction in 5.8 U5MR points). But the impact on U5MR of maternity care and oral rehydration therapy improved markedly when women were literate and better able to understand and benefit from such programmes, confirming prior findings about the benefits of female education and awareness on the impact of a broad range of health interventions.

Cornia and Zagonari (2002) also attempted to measure the impact of breastfeeding during the first three months and between 6 and 9 months of age. The issue of breastfeeding in HIV-affected countries is controversial, as it tends to increase the risk of mother-to-child transmission. In low- and middle-income countries, breastmilk substitutes are often associated, however, with an even greater risk of mortality due to diarrhoea and undernutrition. The results of the regression estimates show that breastfeeding between 0–3 months of age (but not between 6 and 9 months) was found to significantly reduce child mortality. An increase of 10 percentage points in the 0–3 month breastfeeding rate reduces U5MR by 2.6 points per thousand, and this effect increases in case of literate mothers.

Table 7. Impact on U5MR of a variation in the selected variables

	Impact on U5MR of a 10% increase in HIV adult prevalence, or of the presence of conflicts, or the HIV-2 virus		Impact on U5MR of a 10% increase in selected programmes
HIV RATE	19.29	GDP/C	-0.09
CONF	15.50	FIL	-9.94
HIV-2	13.11*	DPT	-5.76
		WATER	-2.64
		DC	-5.44
		ORT	-0,22*
		BF 0-3	-2.63

Source: Calculation by authors.
Notes: * Indicates that the parameter is not statistically significant though it has the correct sign.

Table 7 points to a few conclusions about child mortality: First, the rate rose in all countries where adult prevalence exceeded 6.5 per cent and in a few 'failed states' with a lower prevalence but stagnant coverage of child health services. Due to a lack of data on paediatric HIV it is not possible to differentiate between the effects of mother-to-child transmission and impoverishment induced by HIV, though evidently most of the observed increase in U5MR can to be attributed to the first factor. This is a strong rationale for stepping up programmes to provide universal coverage of nevirapine to newborns. Second, while ethnic conflicts exacerbate child mortality, child health interventions such as immunization, oral rehydration therapy, delivery care, breastfeeding and child nutrition appear to have a significantly positive effect on child mortality, especially when the mothers are educated. Unfortunately, the favourable impact of these programmes is more than offset in countries with high HIV adult prevalence. Pending an expansion of antiretroviral programmes for infants, a 10 per cent rise in adult prevalence requires an expansion of 15 points in all the child health programmes discussed above. This is certainly a difficult objective in economies impoverished by HIV, but one that should be given top priority by policymakers.

Health sector responses to the HIV and AIDS challenge

The response to the HIV pandemics has varied substantially across countries. Some – such as Senegal and Thailand (chapters 3 and 5) – launched a nationwide HIV prevention programme in the early stages of the epidemic and were thus able to control and then reduce its prevalence. Even these 'model' countries, however, are only now beginning to deal with the treatment of the HIV-positive people. Other countries – as in Uganda (chapter 2) – prevented the spread of the epidemic but only when prevalence had reached 10 per cent. Some nations – such as China and South Africa (chapters 4 and 6) – only recognized the implications of HIV with considerable delay, so are still unable to control its spread and will have to face a rise in both HIV adult prevalence and, possibly, in U5MR in the years ahead.

Prevention

Based on current growth rates, each HIV-infected person is currently infecting 2.4 other people, on average, before dying. In order to control HIV, the number of people infected during the lifetime of each case has to be reduced to 1, while to eliminate it, the number of transmissions should be reduced to less than 1 per case, a reduction of 60 per cent over current levels. There exists quite a wide range of effective techniques to interrupt or reduce transmission of HIV.

Main prevention programmes

Information and awareness-raising campaigns: These include a variety of communication campaigns carried out through radio and TV spots, popular theatre and peer education that aim to increase awareness of the way HIV is transmitted and to modify sexual and other risky behaviour such as high alcohol consumption. Such programmes do not focus only on the passive transfer of knowledge but also on teaching empowering life skills.

Provision of condoms, especially among target groups (sex workers, IDUs, young people, people with high mobility, etc.). The experience of Senegal, Thailand and Uganda and – more recently – Zambia, suggests that increased condom usage rates reduce HIV prevalence. Bought in bulk, a condom costs $0.03, so supplying an average of 25 condoms to the 800 million sexually active men in HIV-affected countries annually would require 20 billion condoms, at a cost of $600 million, i.e. $0.20 per capita or about 0.03 per cent of those countries' GDP.[3]

Safe blood transfusion: In the United Republic of Tanzania, it has been demonstrated that safe blood transfusion can be achieved for an annual expenditure of $0.07 per capita. Blood testing is labour intensive and so costs would be higher in high-wage countries. At a cost of $0.10 per capita, this measure would cost 0.02 per cent

of GNP, affordable in all countries. However, infection through blood contamination is a small fraction of total transmission.

Testing and treatment of sexually transmitted infections (STIs): Treating all STIs would reduce the risk of transmission by about half. In Kenya, STI therapy is mainly provided at the hospital level at a cost of $30–200 (Rachier 1999), but in the United Republic of Tanzania, it was estimated that STI testing, treatment and counselling could be provided for $1 per capita. Allowing $1.50 per head, the total cost of covering all those eligible in the 60 most affected countries would be $2.25 billion a year, or 0.2 per cent of their GNP.

Circumcision: Epidemiological surveys show that the HIV epidemic is much less severe in countries where male circumcision is widely practised, including in many countries in West and North Africa. As circumcision is estimated to have a 50 per cent protective effect, it is probably the single most cost-effective intervention. At a unit cost of approximately $1.00, universal male circumcision could probably more or less stop the epidemic, on its own, at a one-off cost of $500 million – or 0.2 per cent of the GNP of the countries affected. This is clearly a very culturally sensitive issue, but it has been asserted that a modest fee for service payments to providers and the provision of certificates would greatly increase circumcision rates.

Prevention of mother-to-child transmission (PMTCT): Mother-to-child transmission can be greatly reduced by a short course of antiretroviral therapy. Implementation of such a programme requires that all pregnant women be screened and counselled and, if necessary, treated. Screening costs only about $2 per test. With the recent price reductions of drugs, treatment for those affected is relatively low and the cost of counselling can be estimated at $1 in a low-income economy.

Voluntary counselling and testing (VCT) among selected populations (pregnant women, sex workers): VCT is normally considered an essential component of behavioural change programmes. In Uganda, it costs $14 per client, but those attending tend to self-select. Per capita costs at a national level would be under $1, since retesting is not required on an annual basis. However, there is insufficient evidence of impacts on behaviour change and transmission rates to rely on it as a key to prevention (Kaleeba and Kalibala 1997).

Quarantine: Isolation of HIV-positive individuals is rarely practised. Cuba's compulsory testing of 13 million people and the establishment of *sidatorios* were exceptional measures that did result in the HIV prevalence remaining very low, but quarantine and compulsory testing remain highly controversial as they infringe on the rights of those who are HIV-positive.

The main problems identified in the prevention programmes are:

1. **Information campaigns and promotion of condom use.** Evaluations of information and condom distribution campaigns show that levels of awareness about

HIV and its transmission modes do rise, but only after a considerable time lag. Moreover condom usage is frequently limited, due to distribution problems, religious institutional resistance and lack of behavioural change (Caldwell 2000).

2. **PMTCT and treatment of STIs.** Although antiretroviral treatment for pregnant women and newborns is cost-effective, such programmes are limited in scope, even in Thailand (chapter 5). Voluntary HIV testing remains an obstacle to the expansion of the programme. This is also true of STI prevention and treatment, particularly in countries with weak health infrastructures (Gibney et al. 1999).

Mitigation

There has been a wide variety of therapeutic responses to HIV. UNAIDS (2000a) refers to the three packages classification:

i) **The essential package** includes voluntary HIV testing and counselling, psychological support for HIV-positive people and their families, treatment of pneumonia, oral thrush, vaginal candidiasis and pulmonary TB (DOT), and prevention of infections for symptomatic HIV-positive people. Such a package is delivered through home-based care via community or hospital-instituted schemes, hospice-based care, or by subcontracting NGOs. But these interventions tend to cover only a low proportion of those affected (e.g. less than 10 per cent in Zambia and Zimbabwe; Gilks 1998).

ii) **The intermediate package** includes all interventions included in the essential package, plus active case finding and treatment and preventive therapy for TB for HIV-positive people, systematic antifungal treatment, treatment of Kaposi sarcoma with essential drugs, surgical treatment of cervical cancer, treatment of extensive herpes. Such a package is relatively widespread and cost-effective. The inclusion of proactive TB prevention and therapy is essential as it is the leading HIV-associated opportunistic disease in low- and middle-income countries. Success in TB control has been largely dependent on the strength of the whole health care system. A review of some 30 published cost studies from low-income sub-Saharan African countries estimates that the costs of palliative care, together with care for opportunistic infections, per patient per year ranges between $247 and $359 depending on the level of coverage. In middle-income African countries, such as Botswana, Mauritius, Namibia, South Africa and Swaziland, the cost of the basic package would be $471 to $698. But O'Malley (1998) notes that in Burkina Faso, community groups rallied to deliver care to patients with HIV-related illness in highly underserved areas for only $20 per month.

iii) **The advanced package** includes all interventions included in the essential and intermediate packages plus ARV therapy, and diagnosis and treatment of opportunistic infections difficult to diagnose or expensive to treat.

Treatment with antiretrovirals

Triple combination therapy (known also as highly active antiretroviral therapy – HAART), entails an individualized combination of three different drugs, taken for life and continuously followed up with monitoring and testing.

While such therapy has been common for over a decade in the industrialized nations, where it raised substantially the survival and quality of life of patients with HIV-related illness, despite recent reduction in drug costs, it is still rare in low-income countries. In Uganda, in the year 2000, only 1 per cent of the HIV-positive people had access to it (Wendo 2001).

The situation is better in countries with medium GDP per capita, greater coverage of health insurance, lower prevalence and the capacity to manufacture ARV drugs. Brazil's experience has been the most successful. The National Network of Laboratories supports the drug distribution programme with 133 testing and counselling centres and 424 drug dispensing units. In 1992, the Brazilian authorities decided to manufacture generic ARV drugs, so that they were able to deliver cheap home-produced drugs to 90,000 people, and thus reduced HIV-related mortality by 50 per cent between 1996 and 1999, saving $506 million on hospitalization and treatment of opportunistic infections from 1997 to 1999 (Sarna 2001, Teixeira 2000).

The main obstacle to the extension of antiretroviral therapy coverage, besides cost, is the complexity of the protocol. The drugs have to be administered under close medical supervision and require an advanced laboratory infrastructure to control possible side effects and carry out tests. An additional problem is that some patients appear either not to tolerate the ARV drugs or to comply only occasionally with the daily drug-taking routine, thus reducing the effectiveness of the therapy.

Best practice policy responses

Best practice policies clearly vary from country to country, according to the economic and social situation, but in all countries – with low/high prevalence, rich/poor, able/unable to manufacture ARV, etc. – prevention remains the pillar of the overall health policy. It requires strong political commitment (as in Senegal and Uganda) and social mobilization (as in Thailand) and demands – to start with – a clear recognition of the HIV problem and of its impact on society.

The initial successes recorded in the field of PMTCT and other preventive programmes – such as blood screening and the introduction of mono-use syringes – show that they are very cost-effective, both in terms of lower IMR and U5MR and savings on the costs of treating paediatric AIDS cases. PMTCT is affordable even in low-income economies with high prevalence.

Voluntary testing for HIV has been shown to reduce transmission, but in many cases it is hampered by the patient's fear of the results of the test, so this is an activity that

requires supporting efforts in the fields of privacy protection, counselling and treatment with palliative care.

Intensifying efforts at mitigating the impact of HIV on people and the health system

These measures have the advantage of lengthening life expectancy, improving the quality of life and the social usefulness of HIV-positive people by treating those infections that most frequently kill them.

An overall effort at strengthening the primary health care: In parallel with the spread of the HIV virus, several countries have experienced a weakening of the PHC system. So, a first response must be in the field of personnel supply and training. Secondly, any urban vs. rural and regional imbalances in the infrastructure need to be corrected. Binswanger (2001) suggests, for instance, that in Uganda the number of patients on ARV therapy can rise fivefold from 1,000 to 5,000 by better use of the existing infrastructure, while the establishment of three regional centres can increase access to ARV treatment for 10,000 patients at $100–150 per patient.

A first priority is thus to 'shelter' the essential activities that are part of PHC, while at the same time seeking synergies between the treatment of HIV and non-HIV-related ailments by strengthening those programmes, such as the Essential Drugs Programme, that play a key role in the response to AIDS and other diseases. In view of their limited development, such programmes need to be sustained and, in many cases, expanded, as indicated by table 8.

Table 8. Estimated number of HIV-infected people and their access to essential drugs in 1999 in some African countries

Country	Number of HIV-infected people	Access to essential drugs*
Burkina Faso	350,000	60%
Côte d'Ivoire	760,000	80%
Kenya	2,100,000	35%
Nigeria	2,600,000	10%
South Africa	4,200,000	80%
Uganda	820,000	70%
Zimbabwe	1,500,000	70%

Source: UNAIDS 2000a and World Bank 2000.
Note: * Access to minimum of 20 most essential drugs continuously available at public or private health facilities within 1-hour walk.

The treatment of opportunistic infections has so far been carried out in a hospital setting and is, for this reason, rather costly. This requires a redefinition of the management of TB and similar diseases through the development of community

and home-based care and greater use of the district health care infrastructure that can greatly reduce costs (Floyd and Gilks 1997).

Barnett et al. (2001) discuss the contracting of NGOs in Brazil and Guatemala as a mechanism to deliver essential components of HIV care such as VCT and palliative care, improving both the quality and extent of the programme while reducing its cost.

Gradually making ARV treatment accessible to all

Despite many obstacles, a gradual expansion in ARV coverage would bring notable benefits. The main arguments in its favour are: First of all, lack of treatment would abandon 36 million infected adults and children to certain death. Although there are many other diseases that are endemic in the developing world, none of them is as lethal as AIDS. Second, the possibility of treatment is necessary to optimize prevention, as in the absence of a cure, there are no incentives to take an HIV test. Third, treatment reduces the hospitalization and drug costs for palliative care and the treatment of opportunistic infections. Fourth, a gradual expansion of the treatment with antiretrovirals would involve the strengthening of the overall health system. Finally, treatment with antiretrovirals would avoid a number of the devastating effects that cripple HIV-affected economies, including high mortality and attrition rates among people in the most productive age group, the impoverishment of a large section of society, and the social stigma and deprivation experienced by a mounting number of orphans.

Reducing the cost of ARV drugs: The cost of antiretroviral therapy varies, depending on the country's capacity to manufacture domestically or to import generics from other low- and middle-income countries, but the price of both branded and generic antiretrovirals is declining. The countries that have expanded treatment with ARV the fastest are Brazil, India and Thailand, all of which can produce most of the drugs and distribute them through the public health care sector or pharmacies specializing in the sale of generic drugs (Saavedra 2000).

The UN can help in reducing costs by assisting with international procurement, quality assurance, and certification, as previously done for the UNICEF–WHO Essential Drug Programme that purchased generic drugs on the international markets in bulk, at prices up to 50 times less than the price of branded products.

There are a number of possible strategies for reducing the cost of ART further. These include drugs being given or sold at discount by the pharmaceutical companies, as in Senegal, the adoption of dual pricing systems (as proposed by some transnational corporations), or both production and import of generic drugs competing on the open market with branded products. Success in reducing the cost of antiretroviral drugs could mean that even some low-income countries could start to gradually expand the number of adults being given ART. With the spread of the generic drugs and the simplification of therapeutical protocols, the target for a reduced price is $300 a year, a sum equal to the entire annual income of many people

in HIV-affected countries. This need not necessarily matter from an economic and public health perspective. If prevalence is low, then the cost of treatment could be subsidized through health insurance, public spending or community mechanisms. The impact that such arrangements would have on the proportion of the national GDP required to treat all those infected is a function of prevalence, drug price and GDP per capita in the state or community concerned, and can easily be calculated, using the following formula:

$$\text{Per cent of GDP needed} = \frac{\text{prevalence (for the entire population)} \times \text{drug cost per year}}{\text{GDP per capita}}$$

If the prevalence of the entire population (i.e. not only those 15–59 years of age) is 1 per cent, the treatment costs $300 per year, and the average GDP per capita is $300 per year, then only 1 per cent of GDP would need to be spent on antiretroviral treatment. Similarly, if 10 per cent of the community were infected, the drug costs $300 per year, and average per capita income is $300, then 10 per cent of the GDP would be required. In Brazil, which has a low HIV population prevalence and a relatively high GDP per capita, all cases could be treated for less than 0.05 per cent of GDP, as, indeed, they are for free by the health service. In Botswana, where the population prevalence is one of the highest in the world, a drug price of $300 per year would require spending about 2 per cent of GNP, slightly more than Botswana's total public health expenditure. An important and difficult, but yet feasible, national effort would be required to provide treatment for all cases. The situation is more problematic in countries such as Kenya with medium prevalence but a low GDP per capita, meaning that about 10 per cent of the national GDP would be required to cover all infected people (Kimani 2000). This percentage is almost Kenya's total government expenditure, so it is clearly impossible to allocate such an amount of money to treatment of just one disease. But, without massive external and domestic effort to extend treatment, about 10 per cent of the population of Kenya will have died from AIDS within six to seven years.

Table 9. Simulation of the percentage of GDP required to treat the HIV population under a given assumption about the cost of the treatment, prevalence and GDP per capita

Country	Population prevalence %	Hypothetical 'low' annual drug price $	GDP per capita $	% of GDP required for ARV treatment of all infected
Brazil	0.5	300	3,000	0.05
Botswana	20	300	3,000	2
Kenya	10	300	300	10

Source: Author's calculations.
Notes: Figures used here are rounded off for ease of calculation. Except for the drug price, which is still significantly higher than $300 for a year of treatment, the data closely approximates the true situation in the countries considered. If the drug price in the country were double the figure used here, then the proportion of GNP required would also be doubled.

These figures are purely conjectural but help identify the conditions in which treatment can gradually be extended. While cost-sharing in various forms may be of assistance in low-prevalence, high-income countries, the necessary total economic resources are simply not available in high-prevalence, low-income countries, even if costs fall to $300 per year. While this analysis does paint a rather bleak picture for some countries, it can also serve to give some indication of what an affordable price might be. In a country such as Kenya, treatment of all cases would require that the cost of one year of treatment with ARVs be reduced to $20–30.

Introducing simpler therapeutic protocols: The second obstacle to the extension of HIV treatment is the complexity of the treatment protocols and the weak public health infrastructures, but considerable experimentation is already going on in this area. Given the shortage of doctors in affected countries, they could be replaced by nurses with specific training in the field to administer and monitor the treatment. In Haiti, there are innovative attempts to implement treatment with a community-based 'barefoot doctor approach', entailing a simplification of the tablets-taking cycle (Farmer et al. 2001).

Finally, there is a need to develop simpler health delivery systems, based on outpatient, home-based and hospice care. The vast literature on care provision generally shows that community and home-based care – particularly if carried out in collaboration with provincial hospitals – is as effective as hospital-based care, and considerably less costly. In urban and periurban areas, this approach noticeably reduces administrative and hospital costs and costs for transport, meals and other items paid by the patients themselves (Haile 2000, Drew et al. 1997). Through such savings, more eligible people could be covered. Some studies, such as Hansen et al. (1998), show that home-based care is not cost-effective for patients with HIV-related illness in scattered hamlets in rural areas. The cost of a visit in a rural home-based care programme in Zimbabwe was equal to the cost of 2.7 inpatient days in a district hospital as two thirds of the cost was spent just getting to the patient.

Improving resource mobilization and diversifying the sources of funding: While drug procurement policies and simplification of the therapeutic protocols may help reduce the unit cost of treatment, the proposed gradual expansion of ART entails the mobilization of additional health resources. As noted above, in low-income countries, the increase in total health expenditure during the last 10 years was borne by the household sector, a fact that may have entailed the exclusion of the poor from health care.

According to UNAIDS in 2004, global spending on AIDS was just under US $5 billion in 2003, but by 2007 US $20 billion would be needed for prevention and care in low- and middle-income countries (UNAIDS 2004). This would cover ART for just over 6 million people, support for 22 million orphans, HIV counselling and testing for 100 million adults, AIDS education for 900 million students and peer counselling for 60 million young people not in school. But the range of the

plausible estimates varies a lot. While this is a huge sum, the problem of financing HIV and AIDS care will be particularly intense in low-income countries. In countries such as Argentina, Brazil and Mexico, the cost of an ambulatory service package was estimated in 2001 to represent respectively 0.02 per cent, 0.11 per cent and 0.06 per cent of GDP.

The situation in low-income African countries is more complex. Examples of different health financing approaches are available (Contact Group meeting 20 May 2001; see also case studies by Abt Associates on Guatemala, Rwanda and Senegal). Except for a few growing African economies – such as Uganda – the increase in HIV resources cannot come from individual patients. Greater efforts ought to be placed therefore on increasing resources in ways that would **distribute more equitably the burden of HIV** within the countries affected and internationally. This objective could be reached by means of: co-payments by well-off individuals; the development of risk-pooling arrangements at the local level; the development of health insurance for those employed in the formal economy; the re-allocation of public expenditures from low to high priority sectors; and an increase in earmarked taxation. International resources need also to be increased through debt-for-AIDS swaps or fresh money raised from the Global Health Fund adopted by the G-8.

An important component of the financing strategy against HIV and AIDS is risk-pooling arrangements to spread the cost of HIV treatment among a broad pool of people and to avoid the impoverishment of HIV-affected families. Such arrangements include the national health insurance (fairly developed in South Africa and Zimbabwe) and municipal or provincial pre-payment schemes (common in Thailand). Public funding is the broadest form of collective insurance and several countries subsidize the treatment of HIV to some extent. Mexico covered 76.1 per cent of the total health expenditure but only 49 per cent of the HIV expenditure. The state of Sao Paolo in Brazil and Thailand, in contrast, subsidized 36 per cent and 76 per cent of the cost of the HIV treatment but only 20 per cent and 55 per cent of the general health care.

Traditionally, private companies have turned a deaf ear to the possibility of insuring their staff against HIV. Things are starting to change, however. The power company of Côte d'Ivoire, for instance, realized that it can be cheaper to cover the cost of ARV treatment than that of extended illness and hospitalization of HIV-positive employees. Also, inability of entering an ARV treatment programme can result in higher payments for disability allowances or survivor benefits, and in high costs of recruiting and training replacement employees (Binswanger 2001). Moreover, a private insurance company working in East Africa has been able to cover treatment for enrolees in the early stages of the disease (Feeley 2000). Insurance companies in Mexico took interest in a re-insurance programme for asymptomatic HIV-infected people. Be that as it may, it is clear that extending health insurance holds a considerable potential for

making ARV treatment available to many infected people in middle-income countries, though in these countries, the spread of health insurance will be limited by a high unemployment rate and the size of the informal sector.

In low-income countries, risk-pooling arrangements have to expand massively. Mutual health organizations are a form of community-based and non-profit health insurance that enable members to pay dues when they are well and little or nothing when sick. From 1999 to 2000, the Project of Health Reform team developed performance indicators for projects undertaken in Côte d'Ivoire, Ghana and Senegal. They showed that these health insurance schemes can represent a short-run solution (until viable national solutions emerge), but for priority services only. Also such schemes seem unable to reach the extremely poor.

Finally, in low-income countries, the public budget has a key role to cover the poor and, especially, the extremely poor. And this brings us back to the decade-long debate on taxation levels and public finance priority in low-income countries. Nothing new can be said here in relation to the debate of the 1980s and 1990s, which has highlighted the overall benefits of a pro-poor allocation of public expenditure and the importance of generating adequate levels of revenue. The only additional argument that can be made here is that the **cost of inaction** is far bigger than in the case of low expenditure in health and education.

Balancing prevention and treatment in countries with different infection rates

The prior sections have suggested that the challenge of AIDS requires simultaneous efforts in the fields of prevention, mitigation and treatment. Given that public resources assigned to such a response are extremely limited in most countries, the policymaker has to choose how best to allocate them among competing alternatives. The choice of the optimal mix of interventions is obviously conditioned by the HIV prevalence of a country, its GNP per capita and distribution; the strength of its health infrastructure; the relative cost and efficacy of various interventions; the coverage of health insurance; the strength of pressure groups aiming at diverting public expenditure to their advantage; and the time horizon within which any programme has to be implemented.

So far, the literature has recommended concentrating the response to AIDS on prevention, palliative care and the treatment of opportunistic infections, especially in countries with high prevalence. The main reason adduced to justify this position is the higher unit cost of treatment. This approach is rational when policy is guided by the objective to '**minimize HIV prevalence**'. Even in this case, however, a truly rational decision must take into account the interaction between prevention and treatment. In fact, treatment helps optimize prevention, because in the absence of a cure, people have no incentives to undergo voluntary testing and to modify

their sex behaviour. In addition, treatment reduces the viral load and thus minimizes the probability of transmitting the virus to others.

The optimal mix of interventions may also change if the dominant policy objective is '**maximizing the years of life**'. In this case, the benefits of ARV treatment would emerge more clearly as such therapy lengthens the life of those already infected. Prevention also lengthens the life of those reached by preventative messages, though these do not always entail a behavioural modification. The average cost per person who effectively modify sex behaviour is thus much higher. If the number of those reached by prevention programmes who change their behaviour is half of all those exposed to the message, costs per capita of prevention rise to $20–100 per capita. Moreover, the benefits of ARV treatment would be even more evident if the dominant policy objective were the full evaluation of **all costs and benefits of an anti-AIDS strategy**. In this case, one should include among the benefits of ARV treatment a slower rise in the number of orphans lacking parental guidance; the lower demand for sickness and orphan allowances and early retirements; the savings on palliative care and the cure of opportunistic infections; the loss of income by the working-age population infected or dead. Finally, as repeatedly noted, the cost of the antiretroviral treatment has been falling rapidly during the last 2–3 years, while the international aid targeted to the treatment of HIV is rising (as suggested by the International Health Fund of $1.3 billion launched in 2001).

All these arguments suggest that the policy response to HIV and AIDS may change, depending on whether the effects of treatment on improving the efficacy of prevention is taken into account, and the choice of the objective – to minimize HIV prevalence, or to maximize the years of life for PLHIV. The choice of the best policy mix can typically be represented as an optimization problem. Illustrated in annex 1 is a simple model, identifying the optimal combination of prevention and treatment measures given different assumptions concerning their costs and effectiveness, the choice of policy objective and the interactions between prevention and treatment.

Two numerical examples illustrate this point. In the first case, the objective is to minimize prevalence. Given the real (i.e. observed) values of the parameters measuring the effectiveness of prevention and treatment activities, the public health expenditure for HIV will be almost entirely assigned to prevention, with ARV treatment receiving residual funds only (see table 10). Furthermore, even if the relative cost-efficiency of ARV treatment improves because, for instance, of a moderate fall in the cost of ARV (under hypothesis A the unit cost of treatment c_t is 15 times greater than the unit cost of prevention, while under hypothesis B it is 10 times greater), the allocation of public resources does not change, with ARV treatment receiving residual funds only. Likewise, even if the relative efficacy of preventions falls sharply, the percentage allocation of public expenditure assigned to prevention still does not decline.

Table 10. Percentage distribution of public expenditure between prevention and treatment with antiretroviral therapy, assuming the policy is to minimize HIV prevalence

Objective function: minimize prevalence	Percentage of health expenditure assigned to preventative activities	Percentage of PLHIV treated
Hypothesis A: unit cost of treatment is 15 times that of prevention	86%	10%
Hypothesis B: unit cost of treatment is 10 times that of prevention	81%	20%
Hypothesis C: unit cost of treatment is 10 times that of prevention – and – efficacy of prevention falls to one quarter of its original value (from z =5 to z=1)	81%	20%

Note: in hypotheses A, B and C all parameters of the model are unchanged (i.e. z_t=2, z_t^e=0, z_t^p=5, c_p=1, r_0=0.1, e_0=1.1, d=0.1) except that under hypothesis C in which it is assumed that z_t^p=4.

By contrast, if the objective of the policymaker is to maximize the numbers of years lived (either through prevention or through care) then, given the same realistic value of the parameters, currently relevant costs and the effectiveness of prevention and treatment activities, the allocation of public resources will be assigned to prevention to a lesser extent (see table 11). Furthermore, if the relative cost-efficiency of treatment improves (because, for instance, of a fall in the cost of ARV) then the proportion of public resources allocated to treatment will reach a consistent amount. Likewise, if the efficacy of prevention falls, the share of resources to be assigned to the therapy with antiretrovirals rises further.

Table 11. Percentage distribution of public expenditure between prevention and treatment with antiretroviral therapy, assuming the policy is to maximize the number of years lived

Objective function: maximize the number of years lived	Percentage of health expenditure assigned to preventative activities	Percentage of PLHIV treated
Hypothesis A: unit cost of treatment is 15 times that of prevention	79%	14%
Hypothesis B: unit cost of treatment is 10 times that of prevention	33%	72%
Hypothesis C: unit cost of treatment is 10 times that of prevention and the efficacy of prevention falls to one quarter of its original value (from z=5 to z=1)	24%	82%

Note: in hypotheses A, B and C all parameters of the model are unchanged (i.e. z_t=2, z_t^e=0, z_t^p=5, c_p=1, r_0=0.1, e_0=1.1, d=0.1) except that under hypothesis C in which it is assumed that z_t^p=4.

References and Bibliography

Ainsworth, M. and M. Over. 1994. AIDS and African development. *The World Bank Research Observer*, vol. 9(2), pp. 203–240.

Avila-Figueroa, C. 1999. The AIDS epidemic and the health sector reform. In *AIDS in Latin America and the Caribbean: a Multidisciplinary View*, ed. J.A. Izazola-Licea et al., chapter 6. Mexico City: Mexican Health Foundation.

Barnett, C. et al. 2001. *Contracting Non-Governmental Organizations to Combat HIV/AIDS*. Partners for Health Reform (PHR), Special Initiatives Report no. 33. Bethesda.

Binswanger, H.P. 2001. HIV/AIDS treatment for millions. *Nature*, vol. 292(5515), pp. 221–225.

Brown, L. et al. 2002. Predictors of retention among HIV/haemophilia health care professionals. *General Hospital Psychiatry*, vol. 24(1), pp. 48–54.

Buvé, A. 1997. AIDS and hospital bed occupancy: an overview. *Tropical Medicine and International Health*, vol. 2(2), pp. 136–139.

Buvé A. et al. 1994. Mortality among female nurses in the face of the AIDS epidemic: a pilot study in Zambia. *AIDS*, vol. 8(3), p. 396.

Caldwell, J.C. 2000. Rethinking the African AIDS epidemic. *Population and Development Review*, vol. 26(1), pp. 117–135.

Chawla, M. 1997. *Dual-Job Holding by Public Sector Physicians in India*. Working Paper. Cambridge, USA: Harvard School of Public Health, Harvard.

Colvin, M. et al. 2001. Prevalence of HIV and HIV-related diseases in the adult medical wards of a tertiary hospital in Durban, South Africa. *International Journal of STD and AIDS*, vol. 12(6), pp. 386–390.

Cornia, G.A. and G. Mwabu. 2000. Health status and health policy in sub-Saharan Africa: a long-term perspective. In *Essays in Honour of Philip Ndegwa*, ed. Dharam Ghai. Basingstoke: McMillan.

Cornia, G.A. and F. Zagonari. 2002. The impact of HIV/AIDS on child mortality: an econometric investigation. Mimeo. Florence: University of Florence.

Decodas, J. and A. Whiteside. 1996. The effect of HIV on health care in sub-Saharan Africa. *Development Southern Africa*, vol. 13(1), pp. 89–100.

Drew, R.S. et al. 1997. Estimating coverage of a community-based home care programme. *Tropical Doctor*, vol. 27(4), pp. 210–214.

Farmer, P. et al. 2001. Community-based approaches to HIV treatment in resource-poor settings. *The Lancet*, vol. 358, pp. 404–409.

Feeley, R. 2000. *The Role for Insurance Mechanisms in Improving Access to Private Sector Primary and Reproductive Health Care*. Washington DC: Deloitte Touche Tohmatsu and USAID.

Floyd, K. and C. Gilks. 1997. Cost and financing aspects of providing ARV therapy: a background paper. Presentation at WHO, Geneva.

Forsythe, S.S. 2000. *The Affordability of ARV Therapy in Developing Countries: What Policy Makers Need to Know*. Washington DC: USAID.

Foster, S. 1991. Supply and use of essential drugs in sub-Saharan Africa: some issues and possible solutions. *Social Science and Medicine*, vol. 32(11), pp. 1201–1218.

Foster, S. 1993. *Cost and Burden of AIDS on the Zambian Health Care System: Policies to Mitigate the Impact on Health Services*. Lusaka: USAID, London School of Hygiene and Tropical Medicine.

Gibney, L. et al. 1999. HIV testing practices of Zimbabwean physicians and their perspectives on the future use of rapid on-site tests. *AIDS Care – Psychological and Socio-Medical Aspects of AIDS/HIV*, vol. 11(6), pp. 663–673.

Gilks, C. 1998. *Care and Support for People with HIV/AIDS in Resource-Poor Settings*. London: DFID Health and Population Occasional Papers.

Gilks, C. 2001 Implementing VCT: lessons learned from Kenya. *Policy Briefings for the Health Sector Reform*, vol. 3, pp. 1–7.

Gounden, Y.P. and J. Moodley. 2000. Exposure to HIV virus among healthcare workers in South Africa. *International Journal of Gynaecology and Obstetrics*, vol. 69, pp. 265–270.

Haile, B. 2000. Affordability of home-based care for HIV/AIDS. *South African Medical Journal*, vol. 90(7), pp. 690–691.

Hansen, K. et al. 1998. The cost of home-based care for HIV/AIDS patients in Zimbabwe. *AIDS Care – Psychological and Socio-Medical Aspects of AIDS/HIV*, vol. 10(6), pp. 751–759.

Kaleeba, N. and S. Kalibala. 1997. Participatory evaluation of counselling, medical and social services of the AIDS Support Organization (TASO) in Uganda. *AIDS Care – Psychological and Socio-Medical Aspects of AIDS/HIV*, vol. 9(1), pp. 13–26.

Khandwalla, K.E. et al. 2000. Knowledge, attitudes, and practices regarding STI among general practitioners and medical specialists in Karachi, Pakistan. *Sexually Transmitted Infections*, vol. 76(5), pp. 383–385.

Kikumbih, S.N. et al. 1997. Consequences of adult HIV infection for outpatient morbidity and treatment costs: a prospective study in a factory clinic in Tanzania. *Health Policy and Planning*, vol. 12(3), pp. 234–239.

Kimani, Joshua. 2000. *ARV Drugs: Availability and Access Survey in Kenya*. Nairobi: UNICEF ESARO.

Lew-Ting, C.Y. and S.J. Twu. 1997. AIDS risk, physicians' clinical precautions and willingness to treat AIDS patients. *Chinese Journal of Public Health*, vol. 16(3), pp. 231–243.

Makhema, M.J. 2000. Health care costs for patients with HIV/AIDS. Presentation at the national conference on HIV/AIDS, Botswana.

Mirembe, F. et al. 1998. *Reproductive Health in Policy and Practice*. Kampala: Population Reference Bureau (PRB).

Mpundu, M. 2000. The burden of HIV/AIDS on the Zambian health system. *AIDS Analysis Africa*, vol. 10(5), p. 8.

Muyinda, H. et al. 1997. Social aspects of AIDS-related stigma in rural Uganda. *Health and Place*, vol. 3(3), pp. 143–147.

Nandakumar, A.K. et al. 2000. *Use of and Expenditures on Outpatient Health Care by a Group of HIV-Positive Individuals in Rwanda*. Special Initiatives Report no. 28. Washington DC: Partnerships for Health Reform (PHR).

O'Malley, J. 1998. Responding to HIV/AIDS – capacity building in local health and development NGOs: models and lessons from the International HIV/AIDS Alliance. Presentation at the World Bank, Washington DC.

Patel, M. 2000. *Evaluation of the Financial Implications of HIV/AIDS for Africa*. Nairobi: UNICEF ESARO.

Pinstrup-Andersen, P., M. Jaramillo and F. Stewart. 1987. The impact on government expenditure. In *Adjustment with a Human Face: Protecting the Vulnerable and Promoting Growth*, ed. G.A. Cornia, R. Jolly and F. Stewart, vol. 1, pp. 76–82. Oxford: Clarendon Press.

Pothisiri, P. et al. 1998. Funding priorities for the HIV/AIDS crisis in Thailand. Presentation at the funding and policy session, World AIDS Conference, Geneva.

Prescott, N. 1997. *Setting Priorities for Government Involvement with ARV*. Geneva: UNAIDS.

Rachier, C. 1999. AF-AIDS Message 315, Africa-AIDS Electronic Conference Forum AIDS (AF-AIDS).

Saavedra, J. 2000. *The Process of Access to ARV Therapy in Mexico: a Case Study*. Mexico: CONASIDA.

Sarna, A. 2001. A profile of the AIDS epidemic in Brazil: the impact of the new AIDS drug policy. *Journal of Community Health*, vol. 26(2).

Schneider, P. 2001. Estimating HIV/AIDS expenditures in Rwanda using an NHA framework. PHR end of project conference. Washington DC: USAID.

Semakula, J.K. 2001 Cheaper drugs for HIV/AIDS in Africa: what happens next? Suggested strategies for distributing HIV drugs. In www.medlinks.org, 9 April 2001.

Senaya, N. 2001. Why you should worry about malaria. In www.allAfrica.com, 6 August 2001.

Silungwe, W. 2000. Zambia has 40,000 TB cases every year. In Africa News Service, 18 January 2000.

Simms, C., M. Rowson and S. Peattie. 2000. *The Bitterest Pills of All: The Collapse of Africa's Health Systems*. London: Save the Children.

Tangcharoensathien, V. et al. 2001. The potential demand for AIDS vaccine in Thailand. *Health Policy*, vol. 57, pp. 111–139.

Teixeira, P.R. 2000. Universal access to ARV therapy: the Brazilian experience. Presentation at the II Meeting of the UNAIDS Contact Group on Accelerating Access to HIV/AIDS-related care, Rio de Janeiro.
Tembo, G. et al. 1994. Bed occupancy due to HIV/AIDS in an urban hospital medical ward in Uganda. *AIDS* vol. 8(8), pp. 1167–1171.
UNAIDS. 1998. *HIV-Related OD, UNAIDS Technical Update*. Geneva: UNAIDS.
UNAIDS. 2000a. *AIDS: Palliative Care, UNAIDS Technical Update*. Geneva: UNAIDS.
UNAIDS. 2000b. *Caring for Carers: Managing Stress in Those Who Care for People with HIV and AIDS*. Geneva: UNAIDS.
UNAIDS. 2000c. *HIV and Health Care Reform in Phayao: from Crisis to Opportunity*. Geneva: UNAIDS.
UNAIDS. 2004 *Report on the Global AIDS epidemic*. Geneva: UNAIDS.
UNECA. 2000. Costs of scaling HIV programme activities to a national level in sub-Saharan Africa: methods and estimates. UNECA, African Development Forum 2000, Addis Ababa.
Wendo, C. 2001. Uganda launches HIV/AIDS treatment and training centre for Africa. *The Lancet*, vol. 357, p. 1957.
WHO. 2000. *The World Health Report 2000*. Geneva: WHO.
WHO. 2001a. HIV/AIDS and hospital services: a review of literature. Draft manuscript. November.
WHO. 2001b. *WHO Estimates of Health Personnel: Physicians, Nurses, Dentists and Pharmacists (around 1998)*. Geneva: WHO.
WHO/UNAIDS. 2000. *Key Elements in HIV/AIDS Care and Support*. Geneva: WHO.
Wood, E. et al. 2000. Extent to which low-level use of ARV treatment could curb the AIDS epidemic in sub-Saharan Africa. *The Lancet*, vol. 355, pp. 2095–2100.
World Bank. 1999a. *Confronting AIDS: Public Priorities in a Global Epidemic*. New York: Oxford University Press.
World Bank. 1999b. *Intensifying Action Against HIV/AIDS in Africa: Responding to a Development Crisis*. Washington DC: Africa Region, The World Bank.

Notes

1 A review of public expenditure changes during periods of budgetary stringency (Pinstrup-Andersen, Jaramillo and Stewart 1987) shows that, of all types of expenditures, capital expenditure is invariably cut the most.
2 The use of measles, polio or BCG coverage – instead of DPT coverage – yields practically identical results.
3 If a good carries very high public health benefits, as is the case for vaccines for infectious diseases, it is normally assumed that the correct price for that commodity is zero. A similar conceptual framework could be applied to condoms. It is hard to imagine that the campaign to eliminate smallpox would have been successful if people had been charged for the vaccine.

Annex 1

A Simple Model to Choose the Optimal Policy Mix Between Prevention and Treatment

(i) **Modelling the effects of treatment on prevention and vice versa**. The purpose of this model is to discuss the choice of the optimal mix of prevention and treatment policies. For the sake of simplicity we will compare the effectiveness and costs of two alternative policies only: a combination of the several preventive policies (condom, MTCT, circumcision, blood screening programmes, information campaigns promoting a decline in the number of sexual partners, a more consistent condom use, and an increase in the age of sexual debut) and a policy focusing on the treatment of HIV-positive people with antiretrovirals. We first normalize the population size to 1. For the sake of simplicity, we will compare the effectiveness of the two policies chosen only at time 0 and time 1 where the difference between time 0 and time 1 is equal to the average number of years gained by an infected person undergoing treatment with antiretrovirals.

The evolution over time of HIV prevalence can be described by a continuous non-linear function where its value at time 1 depends on its value at time 0. At time 1, HIV prevalence would increase (or decrease) with respect to time 0 at a given inertial rate d, representing the endogenous dynamics of the epidemics (hereafter called 'the HIV natural dynamics') in the absence of any policy measure. The HIV prevalence at time 0 and time 1 are denoted by r_0 $(0< r_0 <1)$ and r_1 $(0< r_1 <1)$ respectively. **Prevention policy** reduces HIV prevalence at time 1 by a factor $(z_p x_p)$ where x_p $(0 < x_p < 1)$ is the percentage of the population reached by the prevention campaign and z_p represents the effectiveness of the prevention policy in terms of its impacts on awareness improvements and behavioural change. Similarly, the **treatment policy** reduces HIV prevalence at time 1 by the factor $(z_t x_t)$ where x_t is the percentage of the HIV-infected population being treated and z_t depicts the effectiveness of the treatment policy in terms of its effects on virus loads and behavioural change. Therefore, at time 1, the **HIV prevalence** is formally given by:

$$r_1 = r_0(1 + d)(1 - z_p x_p - z_t x_t r_0) \qquad (1)$$

At time 1, the proportion of the population still surviving is the proportion of the population not infected at time 1 plus the percentage of people living with HIV under treatment at time 0. Therefore, at time 1, the **overall surviving rate** is given by:

$$1 - r_1 + x_t r_0 = 1 - r_0(1 + d)(1 - z_p x_p - z_t x_t r_0) + x_t r_0 \qquad (2)$$

Both prevention and treatment policies have costs that are borne at time 0. The costs per year per capita of prevention and treatment are c_p and c_t respectively. However, the health expenditure to be borne at time 0 (e_0) is influenced by the following two effects: First, treatment increases the effectiveness (or reduces the average unitary cost) of prevention. It is assumed that c_p decreases by z_t^p for each person with HIV under treatment at time 0. Moreover, a treatment policy improves the perceptions among donors of the robust response to HIV and AIDS by the national government and so triggers an increase in international aid earmarked to HIV and AIDS, which in turn softens the domestic budget constraints. This is shown by assuming that e_0 decreases by z_t^e for each person living with HIV under treatment at time 0. Therefore, at time 0, the health expenditure needed in order to implement the chosen combination of prevention and treatment policies can be expressed as:

$$e_1(1 + z_t^e x_t r_{tt}) = e_2(1 - z_t^p x_t r_{tt})x_2 + c_t x_t r_t \qquad (3)$$

Given these three relations, the policymaker can choose two different policy objectives, i.e. minimize prevalence at time 1 or, alternatively, maximize the number of years lived at time 1. For each of them, given a fixed health budget, we can identify the optimal combination of prevention and treatment measures.

(ii) **Solving the model given different objective functions at time 1**. If the policy objective is to minimize prevalence at time 1, the optimal solution of equation (1), subject to constraint (3), is expressed by:

$$\min_{x_t, r_t} \quad x_1 = x_0(1 + d)(1 - z_p x_0 - z_t x_t r_t)$$

$$s.t. \quad e_1(1 + z_t^e x_t r_t) = e_{tt}(1 - z_t^p x_t r_{tt})x_{tt} + c_t x_t r_t$$

In contrast, if the objective is to maximize the number of life years saved at time 1, the optimal solution of equation (2), subject to constraint (3), is expressed by:

$$\max_{x_t, r_t} \quad 1 - r_1 + x_1 r_1 = 1 - x_0(1 + d)(1 - z_p x_t - z_t x_t r_t) + x_t r_t$$

$$s.t. \quad e_1(1 + z_t^e x_t r_t) = e_{tt}(1 - z_t^p x_t r_{tt})x_{tt} + c_t x_t r_t$$

(iii) **Some general analytical results.** The solutions to the first and the second optimization problems (see Cornia and Zagonari 2002) highlight the following general insights: If the optimal proportion of the general population reached by prevention (x_p*) and the optimal proportion of PLHIV undergoing treatment (x_t*) are represented as functions of the effectiveness of prevention (z_p) and of the other parameters introduced above to represent the feedback effects between treatment and prevention, three qualitatively different patterns emerge in three subsequent ranges. If z_p takes low values (below a specified L), then the general population reached by prevention activities (x_p*) should be constant at a non-negative percentage, while the optimal proportion of PLHIV reached by care activities should be 100 per cent (x_t*=1); if z_p takes intermediate values (between specified L and H), then x_p* is an increasing and concave function, while x_t* is a decreasing and convex function; if z_p takes high values (above a specified H), then the general population reached by prevention activities should be 100 per cent (x_p*=1), while the optimal proportion of PLHIV reached by care activities (x_t*) should be constant at a non-negative percentage. Thus, whichever objective is adopted, the relative costs and effectiveness could lead to a solution whereby a single optimal policy is implemented, or to an intermediate solution whereby both policies are implemented.

Next, comparing the solutions of the two optimization problems led us to deduce that the three relevant subsequent ranges of the effectiveness of prevention activities (z_p) for the maximization problem are shifted forward with respect to those for the minimization problem so that L (MAX) > L (MIN) and H (MAX) > H (MIN). Thus, for given relative costs and effectiveness of prevention and treatment, a movement from minimizing HIV prevalence to maximizing the years of life for the general population and for PLHIV could lead to decreasing the optimal proportion of the general population reached by prevention (x_p*) and increasing the optimal proportion of PLHIV treated with antiretrovirals (x_t*). In other words, more of the PLHIV should be given ARV treatment if the policy objective is maximization of the years of life lived, rather than minimization of prevalence.

(iv) **Some numerical examples.** The analytical results sketched above lead us to deduce that relative, rather than absolute, values of both costs and effectiveness of prevention and care activities are the relevant factors driving the allocation of public health expenditure on HIV and AIDS. Let us normalize both c_p and z_p to 1 so that c_t becomes the relative unit cost of care with respect to prevention, e_0 becomes the health expenditure per capita per year over the unit cost of prevention, and z_t becomes the relative effectiveness of care with respect to prevention. Numerical simulations are then carried out by assigning to the variables expressing the costs and effectiveness of prevention and treatment activities their values currently observed in real life. In particular, we assume that treatment is twice as effective as prevention, that a 1 per cent increase in the coverage of treatment reduces prevention costs by 50 per cent at 10 per cent HIV prevalence, that available resources

do not depend on the coverage of treatment, and 'the HIV natural dynamic' is 10 per cent in the period under consideration. The analytical results, combined with the numerical simulations, allow us to draw the following conclusions:

1. Treatment of a positive proportion of the population is an optimal policy only when the policy objective is to maximize the number of years lived.
2. Resources required to achieve a consistent coverage rate for treatment are lower than usually stated: the tables in the text assume a health expenditure per capita per year only 10 per cent higher than the unit cost per capita per year of prevention.
3. A one third reduction in the unit cost of treatment will make treatment of a substantial proportion of the HIV-positive population an optimal policy even when prevalence is high.