

**Vulnerability and Resilience**  
**Determinants of under-five mortality changes**  
**in Zambia**

**By**  
**Michel Garenne (1)**  
**And**  
**Eneas Gakusi (2)**

(1) PhD, Directeur de Recherche, IRD/ISD, Paris

(2) PhD, Research Associate, CERDI, Clermont-Ferrand

Revised February 11<sup>th</sup>, 2004

Address for correspondence:

M. Garenne, IRD/ISD, 15 rue de l'école de médecine, 75270 Paris Cedex 06

Email: [mgarenne@bhdc.jussieu.fr](mailto:mgarenne@bhdc.jussieu.fr); [Eneas.Gakusi@bhdc.jussieu.fr](mailto:Eneas.Gakusi@bhdc.jussieu.fr)

## Abstract

Trends in under-five mortality were favorable in Zambia in the twelve years following independence (1964-1975), as a result of favorable political and economic context and generous health, education and social policies, largely financed by the exports of copper minerals, the main economic resource of the country. In 1975, the international prices of copper decreased suddenly, and exports of copper continued to diminish in volume. This created a tremendous economic shock to the country, and seriously affected both the state budget and private income. During the long-lasting economic crisis, income per capita was strongly reduced, and most economic indicators collapsed or were strongly reduced as well: imports, agricultural production, private and public consumption, savings, and industrial investments. The health sector was also affected: health expenditures declined, imports of medical drugs and supplies declined, and as a result of declining salaries some physicians left the country. School attendance was reduced somewhat later, in the 1980's, and had long term effect on the mean level of education of adult women. Under-five mortality increased in the years following the copper crisis, up to a maximum in year 1992, after which under-five mortality went down again, despite a significant impact of HIV/AIDS. A regression model indicates that most of the increase in mortality after discounting for the effect of HIV/AIDS is attributable to the direct and indirect effects of the copper crisis and the declining income. Both trend analysis and regression analysis indicate that mortality in 1992 was more than double what it should have been in the context of a regular health transition and positive economic development. The mortality decline after 1992 seems to be due to the resumption of the health transition, the implementation of new health policies, and continuous investments in health personnel and health infrastructure. These changes occurred in the context of structural adjustment policies. Issues about vulnerability and resilience are discussed in light of economic and political choices made in the earlier periods and recent changes in policies.

**Key Words:** Under-five mortality, Mortality trends, Economic crisis, Copper price, Economic policies, Health policies, Structural adjustment policies, Education, Nutritional status, HIV/AIDS, Malaria, Developing countries, sub-Saharan Africa, Zambia.

## **Introduction**

Many countries in the world underwent major transitions during the 20<sup>th</sup> century: a demographic transition, dominated by steady mortality decline followed somewhat later by fertility decline, an economic transition symbolized by increasing income per capita, rapid urbanization and industrialization, and as a consequence, increased food availability and better nutritional status. These major phenomenon's were accompanied by major changes in levels of education and literacy, and by a variety of social changes. Some of the changes were primarily the product of economic and social policies (health, education, and housing), others were more the product of market forces, increasing economic activity, and internal as well as international trade. In the most advanced countries, economic and social changes took place together during the same period of time, and were very pronounced, such as in Western Europe, in Northern America, and in some countries of the Far East and Southern Pacific. Other countries underwent rapid social change without much change in income per capita, such as some of the former Socialist countries, whereas others witnessed rapid economic growth without much modernization at first, such as some oil exporting countries, although rising income almost always had social implications eventually. The situation in sub-Saharan Africa since 1950 appears as contrasted as elsewhere (Gwatkin, 1983). For instance, countries such as Kenya underwent slow but sustained economic growth, low level of urbanization, a large mortality decline until 1990, and major improvements in education, whereas Senegal underwent a major mortality decline without any significant change in income and minor improvements in level of education. In contrast, a country such as Botswana witnessed fast and sustained economic growth, rapid urbanization, a strong increase in level of education and fast mortality decline, until HIV/AIDS stroke the country in the late 1980's.

The situation of Zambia in Southern Africa appears quite atypical, and has drawn the attention of scholars on many grounds since it is a case of declining income per capita and rising under-five mortality, both trends opposite to expectations. For instance the Demographic and Health Survey (DHS) reports of 1992, 1996, and 2001 mention the situation of increasing under-five mortality long before HIV/AIDS became an important cause of death, one of the few such cases on the continent. Nsemukila (1994) analyzed extensively the trends in mortality, morbidity and their determinants over the 1965-1992 period, using survey data and data from the health information system. He identified the 1970's as the turning

point in mortality trends, and argued that mortality increase was concentrated in urbanized areas (Copperbelt, Lusaka), and among working women, and women with some education. He also pointed out the possible deterioration of the nutritional status of children. He attributed the rising trends in mortality to the worsening economic conditions, especially among urban dwellers, who were the prime beneficiaries of earlier public policies. Simms et al. (1998) and Simms (2000) have studied the reasons for the rise in childhood mortality in Zambia. They deny the rise in morbidity and the deterioration in nutritional status, and attributed the mortality increase primarily to decreasing income and its main consequence, the lower government health expenditures, especially in rural areas. Freund (1986a,b) has analyzed extensively the deterioration of the health system during the early years of the crisis (1974-1984). He attributed the crisis to the decline in copper price since 1977, the rapid increase in the cost of production in the mining sector and the worsening of the balance of payments. This resulted in a decrease of foreign reserves, an increase of prices, a reduction of imports, a cut in government subsidies and expenditure, a rise in indebtedness, a reduction of government revenue and the devaluation of the local currency (kwacha). This situation had serious consequences for the health system in terms of health manpower, facilities per capita, morbidity, nutrition, health services expenditure, and availability of medicines. He pointed out that trends in health personnel were negative between 1981 and 1985, and in particular that a large number of physicians seem to have left the country in the early 1980's. His study also insisted on the effects of long term policies: the current economic imbalances seemed to stem from the pattern of colonization which focused on copper-oriented mono-economy, and neglected industrial and agricultural development. This situation resulted in an over-urbanization and undermined rural economy due to adult male rural-urban migration. Kelly (1991) has studied extensively the Zambian education system. He also considers that falling copper prices in 1975 plunged Zambia into deep and serious economic difficulties, which affected all sectors including education. Consequently, there was a substantial reduction in expenditure per student, resulting in steadily diminishing funds for educational materials and supplies, leading for instance by 1985 to a depreciation of teachers real income to about 40 per cent of their 1975, a greater reliance on community for building and equipping schools, an increased calls on the private sector to participate in the provision of education, and a growing dependence on foreign aid for support to the education sector. His analysis indicates that the quality of the education declined, teaching and learning materials and school furniture were in short supply and were distributed unevenly, though the student's performance remained at a mediocre level and did not deteriorate.

White et Nsovu (1997) did a comprehensive study of mortality trends and determinants in Zambia. They document the rise in mortality, which they locate from the mid 1970's to the mid 1990's. They found a narrowing of mortality differentials between urban and rural areas, and argue that the rise in mortality affected primarily the more advantaged groups. They acknowledge the role of HIV/AIDS, especially in urban areas, though argue that other causes could explain the rise in mortality in the countryside. They recognized that chronic malnutrition among children has increased from 1992 to 1995, and probably from 1970 to 1990, though to a lesser extent than expected from the decline in income. But they found that malnutrition was declining as a recorded cause of death. They attribute increasing mortality from diarrheal diseases to repeated outbreaks of cholera and dysentery in the mid 1980's and early 1990's. They argue that the increase in malaria morbidity and mortality could be explained by a decline in control measures after 1964, by the appearance of new opportunities for the mosquitoes in shanty towns and among recent urban settlers, by an erratic antimalarial drug supply, and the emergence of drug resistant malaria strains. Analysis of other determinants and differentials gave mixed results, with classic relationships with mother's education and a significant effect of immunization of mother and child on under-five mortality. Their main conclusion, however, is that mortality rise "will not be catered for by Zambia's faltering growth performance".

This paper is an attempt to analyze more systematically the under-five mortality trends in Zambia, and to study the broad economic, political, epidemiological and social contexts that explain the mortality increases and declines. The approach followed focused on long term trends over the 1960-2000 period. In order to do so, we gathered all available information, primarily quantitative but also qualitative, about trends in economic, demographic and social indicators and tried to place this information in a broad context of economic, political and social change. The links between the variables were also investigated using a variety of econometric models. Authors had access to a variety of published and unpublished material, and one of them (EG) had the opportunity to visit Zambia, where he had talks with a number of persons knowledgeable in local statistics and in the country complex situation. This study is part of a larger program aiming at documenting and analyzing reversals in mortality trends in Africa conducted by the same authors.

# 1. Demographic trends

## Population dynamics and urbanization

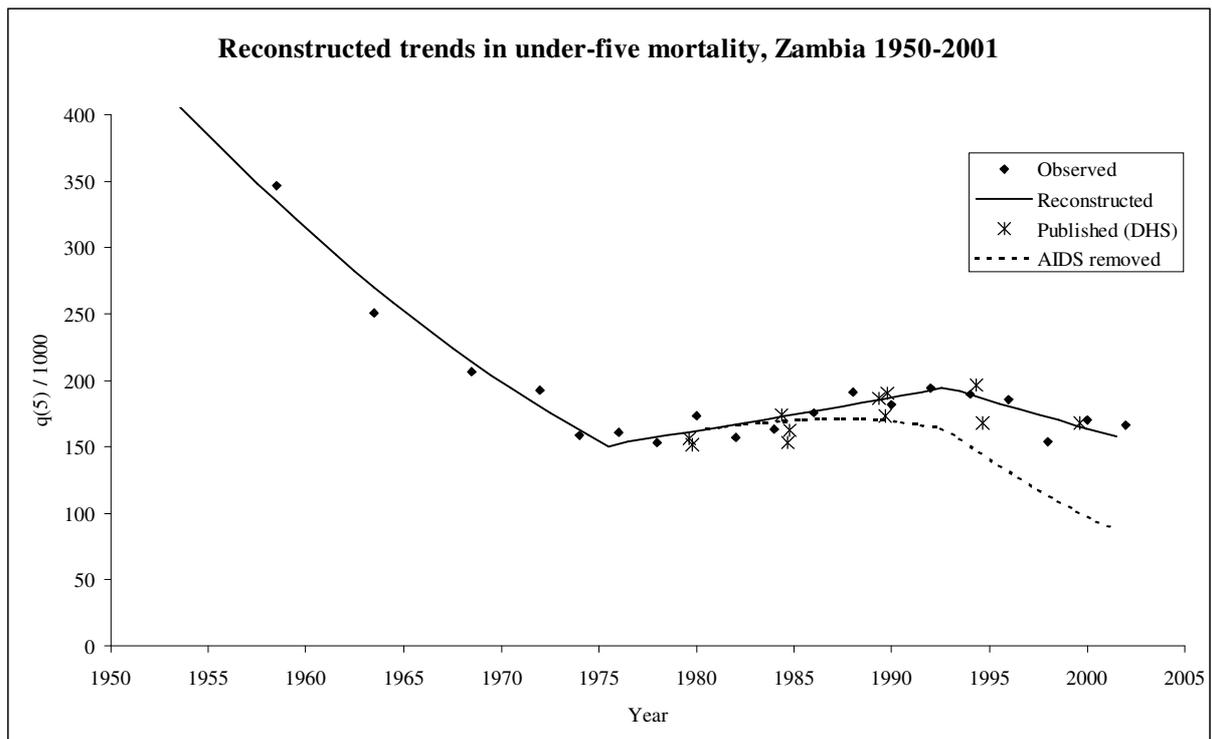
Zambia is a landlocked country in central Africa. Its area is medium size (752 612 - km<sup>2</sup>), and its population density remains low (14 inhabitants per km<sup>2</sup> in year 2000), because large parts of the country are inappropriate for farming (the proportion of arable land is only 7%), and because parts are unhealthy due to the presence of tsetse flies and trypanosomiasis. The current spatial distribution of the population is dominated by the recent history and the development of urbanization and mines. Two provinces, Lusaka, where lies the capital city, and Copperbelt, where the mines are located, are accounting for about 30% of the population. Population growth has been quite rapid in the second half of the 20<sup>th</sup> century, averaging 28 per 1000, due a large excess of birth rate (about 46 per 1000) over death rates (about 18 per 1000). Although no formal life table is available, official documents indicate a decrease in life expectancy after 1980, from an estimated value of 51 years in 1970 to an estimated value of 45 years in 1995 (CSO web site).

A striking feature of population dynamics of Zambia is the changing rate of urbanization. Before independence, migration controls limited urbanization to what was considered needed by the colonial authorities. After independence, urbanization grew very quickly in Zambia, from 20% in 1963 to 40% in 1980, at a rate of 6.8% per year. Most of the migrants to the cities were coming from deserted rural areas of the country, although there were also some migrant workers from nearby countries, in particular Malawi, and refugees from surrounding countries ruined by civil wars, Angola, Mozambique and Zaire, as well as South Africans from the ANC fleeing the apartheid policy. Fast urbanization was made possible by the lift on moves controls, by the new opportunities created by the boom in copper prices, and by the generous social policies for housing, education and health (see below). However, this rapid rate of urbanization stopped suddenly, and after 1980 the proportion of the population living in urban areas declined slightly instead (39.4% at the 1990 census and 38% at the 2000 census). Migration flows to the Copperbelt province, which were highly positive in the 1960's, became negative, population growth in Lusaka became hardly higher than natural increase, and provinces which were losing people in the 1960's (Northern and Luapulu) received positive flows of migrants after 1990. These are the signs of a very serious crisis in the last two decades of the 20<sup>th</sup> century.

## Under-five mortality changes

Under-five mortality was estimated at 197 per 1000 live births at the 1996 Demographic and Health Survey (DHS), a relatively high value by African standards. Changing trends in under-five mortality have already been noted by the Central Statistical Office (CSO): they were significant in both the 1992-DHS, the 1996-DHS and the 2001-DHS, and are also visible in the estimates published by the World Health Organization (Ahmad et al. 2000). We reconstructed the trends in under-five mortality by analyzing death rates by 2-year period and by merging the data of the three DHS surveys. Details of the method for reconstructing under-five mortality trends were presented elsewhere (Garenne & Gakusi, 2003). Results reveal the times at which reversals in mortality trends occurred (figure 1). Under-five mortality was estimated at 301 per 1000 in 1960, and was declining at a fast rate (logit slope = -6.1% per year) until 1975, date after which it started to rise at a high rate (logit slope = +1.8% per year) until 1993, when it reached a level of 192 per 1000. In the last years available, under-five mortality declined again, to reach a value of 158 per 1000 in 2001. The first change in slopes (from 1958-1975 to 1975-1993) was highly significant ( $P < 10^{-10}$ ), as well as the second (1975-1993 to 1993-2001:  $P < 10^{-7}$ ).

Figure 1: Reconstructed trends in under-five mortality, Zambia 1950-2001



Part of the increase in mortality in the 1990's could be attributed to the impact of pediatric AIDS. Details of the computation of the mortality impact of HIV/AIDS on under-five mortality were given elsewhere (Garenne and Gakusi, 2003). The principle of this estimation is simply a multiplication of HIV seroprevalence among pregnant women by a ratio of mother to child transmission and by expected mortality, all calculations done by yearly birth cohort. The HIV seroprevalence among pregnant women was high in Zambia, estimated at 27% in 1996 and 35% in 2001, and the effect on under-five mortality was estimated by our model at 52 per 1000 and 69 per 1000 in the same years. Discounting for the effect of AIDS, infant and child mortality would have been declining since 1990 from an estimated value of 169 per 1000 to 127 per 1000 in 1996, and 88 per 1000 in 2001, which would make the mortality slope without AIDS in the 1990's even more significant (see figure 1).

Table 1: Reconstructed trends in under-five mortality, Zambia 1958-2001

| Area          | Period    | q(5) per 1000      |                  | Intercept | Slope   | Standard error on slope |
|---------------|-----------|--------------------|------------------|-----------|---------|-------------------------|
|               |           | At start of period | At end of period |           |         |                         |
| <b>Zambia</b> |           |                    |                  |           |         |                         |
|               | 1958-1975 | 324                | 150              | 119.599   | -0.0614 | 0.0077                  |
|               | 1975-1993 | 150                | 192              | -36.238   | +0.0175 | 0.0025                  |
|               | 1993-2001 | 192                | 158              | 56.597    | -0.0291 | 0.0082                  |
| <b>Urban</b>  |           |                    |                  |           |         |                         |
|               | 1958-1975 | 277                | 121              | 161.618   | -0.0828 | 0.0135                  |
|               | 1975-1993 | 121                | 155              | -65.649   | +0.0322 | 0.0045                  |
|               | 1993-2001 | 155                | 154              | 1.180     | -0.0014 | 0.0150                  |
| <b>Rural</b>  |           |                    |                  |           |         |                         |
|               | 1958-1975 | 333                | 175              | 97.920    | -0.0504 | 0.0093                  |
|               | 1975-1993 | 175                | 212              | -18.601   | +0.0087 | 0.0030                  |
|               | 1993-2001 | 212                | 160              | 84.134    | -0.0429 | 0.0098                  |

Regression model is :  $\text{logit}[q(5)] = a + b \cdot \text{year}$

Therefore, there is no doubt that mortality rose between 1975 and 1990, and tended to decline thereafter, though this trend was compounded by the rising effect of AIDS on under-five mortality, which prolonged the all causes mortality increase until 1993 (table 1). The rise in under-five mortality was more pronounced in urban areas (logit slope = +3.2%) than in rural areas (logit slope = +0.9%), the difference being highly significant ( $P = 1.2 \cdot 10^{-5}$ ), and the decline in mortality after 1993 was more pronounced in rural areas (logit slope = -4.3%) than

in urban areas (logit slope= -0.1%), the difference being again significant (P= 0.020). Of course, the HIV epidemic could not explain the rise after 1975, since it started to have a visible impact (> 20 per 1000) only after 1990. Reasons for this unexpected rise in mortality between 1975 and 1990 are explored thereafter.

## **2. Socio-Political context**

To analyze the multi-faceted crisis that Zambia went through after 1975, it is important to go back to the recent history of this newly established country. The territory was first colonized by British settlers at the end of the 19<sup>th</sup> century. The beginning of the formal colonization is usually dated in 1899, when the British South Africa Company (BSA) ran by Cecil Rhodes was given the mandate of administering the territory. The territory was placed under British protectorate in 1924, and the capital city moved to Lusaka, its current location, in 1935. For a long time the colony, known as Northern Rhodesia, had closed links with Southern Rhodesia and Nyasaland, under the umbrella of the « Central African Federation », which disappeared with the independence movements in 1963. The country became independent in 1964, and took the name of Zambia.

The actual Zambia was never a major destination for British settlers, and it was estimated that no more than 74 000 Europeans lived in the territory (1961 figures). The main reason seemed to be the poor quality of the soils, which strongly limited the potential for farming (1300 settlers in 1964). The main reason for European settlement was the mines. The first mines (lead and zinc) were discovered in 1907, and attracted both Europeans and Africans. A railway was soon built (1909), which linked South Africa to Katanga, in South-Eastern Congo, where major mines had been discovered, and crossed the country from North to South. The construction of the railway paved the way to the construction of the new country along its path. Economic boom started somewhat later, with the discovery of the copper mines (1927) in the actual Copperbelt province. The development of the copper mines had many consequences: expropriation of African farmers around the mines and along the railway, attraction of Europeans and international capital, creation of job opportunities for miners, and rapid urbanization. By the time of independence, Zambia was a relatively wealthy colony, well endowed, with a relatively developed state infrastructure. Expropriated land had been given back to Africans in 1947, and development plans had been put in place as early as

1947. Until recently, Zambia was the third producer of copper in the world, after the USA and Russia.

Independence was proclaimed on October 24, 1964. The first president, Kenneth Kaunda, a teacher by training, was a humanist and an African socialist, and known for its sympathy for non-violence in politics and for the anti-apartheid movement. He stayed in power for 25 years, and had to go through severe crises (see below). After independence his main policy was to establish state control on the economy. In 1972, he imposed a unique political party (UNIP: United National Independence Party). In the 1980's he had to face a series of political and social unrest, which culminated in 1990. The constitution was changed in 1990, multiple parties were allowed in 1991 and free elections were organized. The opposition won the elections, and Mr. Chiluba became president. He was re-elected in 1996 for another 5-year term, and changed again the constitution. A coup d'Etat was organized in 1997, Kaunda tried to come back but was jailed. Contrary to his predecessor, Chiluba was a liberal, in favor of multipartism, and open to privatization policies in vogue at that time (Daloz and Chileshe, 1996).

### **3. Economic policies and economic downturns**

#### Economic policies

The first government after independence, directed by Kenneth Kaunda, had in mind to correct what was seen as the errors of the colonial policies. It followed an "African Socialism" line, aiming at correcting economic inequalities, and redistributing equitably the wealth of the country (Burdette, 1987). The official policies were "state control" of the economy, and the monopoly of political power by the single UNIP party. The ideology behind state control was a quite popular economic paradigm at that time, and was based on the concepts of imperfect markets, lack of a class of local entrepreneurs, and lack of national financial capital. Therefore, the state was viewed as the leading economic actor, sole able to mobilize resources for promoting development, and to control production, prices, credit, domestic and international trade (Srinivasan, 1990; Coussy, 1991). The government did seek aid and directions from the socialist countries, in particular China, Yugoslavia, and Warsaw Pact countries (Scott, 2001).

Control of the economy started in 1968, after the so-called Mulungishi declaration. The idea was to control all major sectors of the economy, production and distribution, including retail trade in urban and rural areas. The first parastatal companies, in which the state was the dominant stakeholder, were created in 1968-1969 (Turok, 1989). By 1969, the state had a participation of at least 51% in the major mine companies, which were the backbone of the economy (Anglo-American Corporation and Roan Selection Trust in particular). By 1972, only 5% of the industrial capital was owned by independent entrepreneurs, primarily in small enterprises, and in the 1980's the state controlled directly 80% of the economy (Turok, 1989; Dubresson 1996).

In 1969, the government created the National Agricultural Marketing Board (NAMBOARD), through which the state could control agricultural production and trade through a network of cooperatives spread all over the country. In return, the state was providing inputs (seeds, fertilizers etc.), was organizing storage, and was providing subsidies when needed. In addition, prices given to producers were fixed, as well as prices of some vital consumer goods such as maize, oil, salt, milk and soap. In 1975, the "Conversion of Titles Act" permitted to nationalize all agricultural land. By that time 97% of peasants had yet no property rights, which is considered a major handicap for future development and agricultural productivity, because there is no incentive to investment (Adams, 2003). In addition, for the first 10 years of his rule, the government promoted massive social investments, in health, education and housing in particular (see below), financed primarily by high copper prices on the international market.

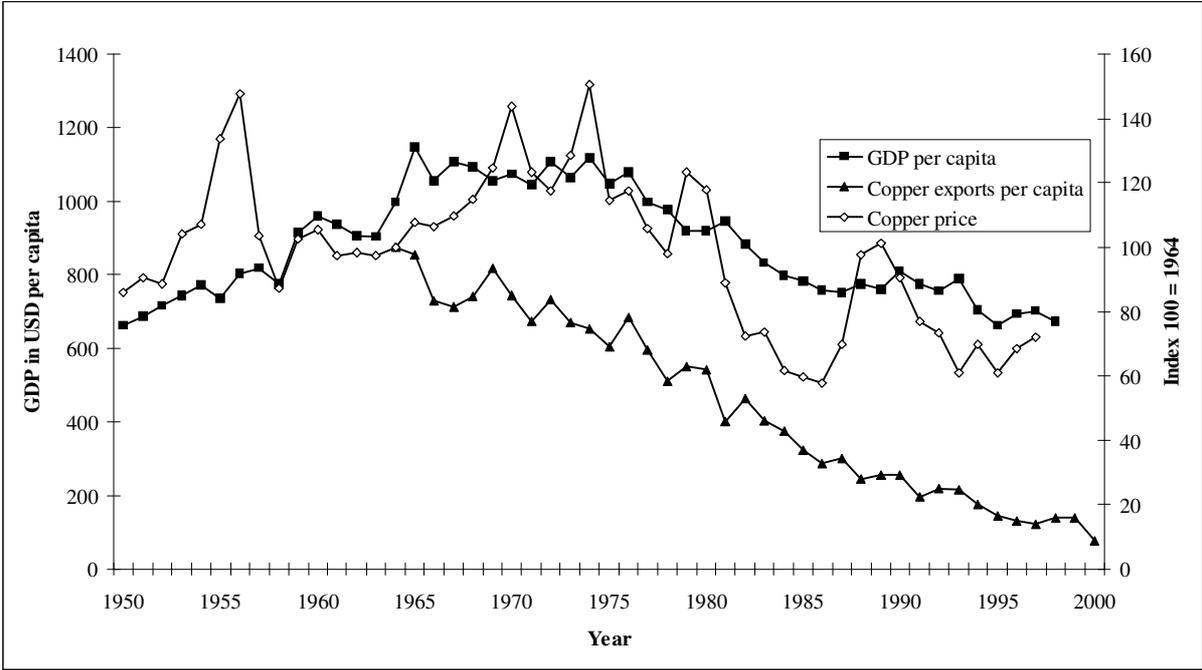
By the early 1980's, the government started to change the main orientation of its economic policies, primarily to answer the difficult situation on food markets since state control was initiated, and the growing discontent of the population (Rakner et al. 2001; Seshamani, 1992). In 1982, the IMF and the World Bank were asked to help setting up a first Structural Adjustment Plan (SAP), which was planned for the following three years (1983-1985). The Kwacha was devaluated twice by 20% in late 1982 and late 1983, prices for food products were liberalized, some of the subsidies were suppressed, urban wages were blocked, and recruitment in the public sector was halted. In 1985 further measures were taken for international trade: import quotas were lifted, and tariffs were aligned on international standards. However, the government stopped this first attempt at liberalizing the economy on May 1, 1987, as a response to serious civil unrest. A new attempt at liberalizing prices was conducted in 1989, also resulting in urban riots. Further liberalization occurred after 1992, when Chiluba came to power. Large parastatals were sold to the private sector, the kwacha

was left free to fluctuate and was devaluated several times, and prices were liberalized. One of the main result of the SAP policies was a mild reduction of poverty in rural areas, from 88% in 1991 to 83% in 1998, and an small increase of poverty in urban areas, from 49% in 1991 to 56% in 1998 (CSO, 2000).

### Copper prices and GDP

GDP per capita, in parity purchasing power, was increasing steadily in Zambia in the last years of the colonial period, from 661 USD per capita in 1950 to 996 USD per capita in 1964, an average rise of 2.9% per year (Maddison, 2001). Increase in income continued for ten years, though at a lower rate (1.2% per year), and stopped suddenly after 1974. The maximum income of 1120 USD per capita in 1974 was never attained again, and instead GDP per capita declined dramatically thereafter, to reach 694 USD in 1998, an average decline of -2.1% per year since 1974 (see figure 2). By 1998, GDP per capita was basically at the 1951 level, that is no growth over half a century. This is a situation quite different from the whole African continent, in which GDP per capita increased over the same period, by about 1% a year since 1950. GDP growth was faster in Zambia than in the average of the continent between 1950 and 1964 (2.9 versus 1.9%), slower between 1964 and 1974 (1.1 versus 2.2%), and the recession was more pronounced between 1974 and 1998 (-2.1 versus -0.1%). In 1964, Zambia ranked average in African countries (19<sup>th</sup> out of 38 countries), whereas it was one of the poorest (30<sup>th</sup> out of 38 countries) in 1998. Zambia was classified by the World Bank as a 'middle income country' until the late 1980's, and then as a 'low income country'. Similarly, the United Nations now considers Zambia among the 'Least developed countries' since 1991. Only a few African countries underwent such a dramatic downturn over the same period, such as Angola, Liberia, Madagascar, Sierra Leone and Togo.

Figure 2: Trends in GDP per capita, exports of copper per capita, and international copper prices, Zambia 1950-1999



Reasons for the major downturn in economic growth can be sought for in analyzing the international price of copper and the Zambian production system. Copper was the leading export of the country, representing some 95% of total exports, and the leading source of income for the state, the main economic actor. Demand for copper was high for a long period of time, since the early years of the 20<sup>th</sup> century, primarily due to the development of electricity all over the world, and the choice of copper for electric wires. Demand for copper dropped suddenly around 1975, owing to the end of Vietnam war during which large stockpiles of copper had been built, and to recession following the first oil price boom. This resulted in a major drop in international prices, and a reduction in exports from countries like Zambia. Copper prices, in constant 1997 USD, were increasing from 1950 (141 USD per ton) to 1974 (246 USD per ton), year at which the highest price was recorded (Makridakis, et al., 1998). Thereafter, the price of copper on international markets dropped to a low 118 USD per ton in 1997. Price of the Zambian copper followed the same pattern, leading to a major drop in GDP in the country.

In addition to prices, copper production also went down. In fact, copper exports in volume were declining since independence, and over the whole period the decline was dramatic: 681 000 tons in 1964, 643 000 tons in 1975, 399 000 tons in 1992 and 165 000 tons

in year 2000. Expressed in constant 1999 USD per capita, the value of exports dropped from 918 USD in 1964, to 497 USD in 1975, 91 USD in 1992, and 72 USD in year 2000 (figure 2).

Copper mines were privatized in year 2000. However, since then the production cost of Zambian copper (85 cents a pound) became higher than the international market price (75 cents a pound), so that production is no longer profitable, and mines are likely to close. The failure of the Zambian copper mines is primarily attributed to poor economic policies, mismanagement, and lack of investments for a long period (The Economist, June 1, 2002).

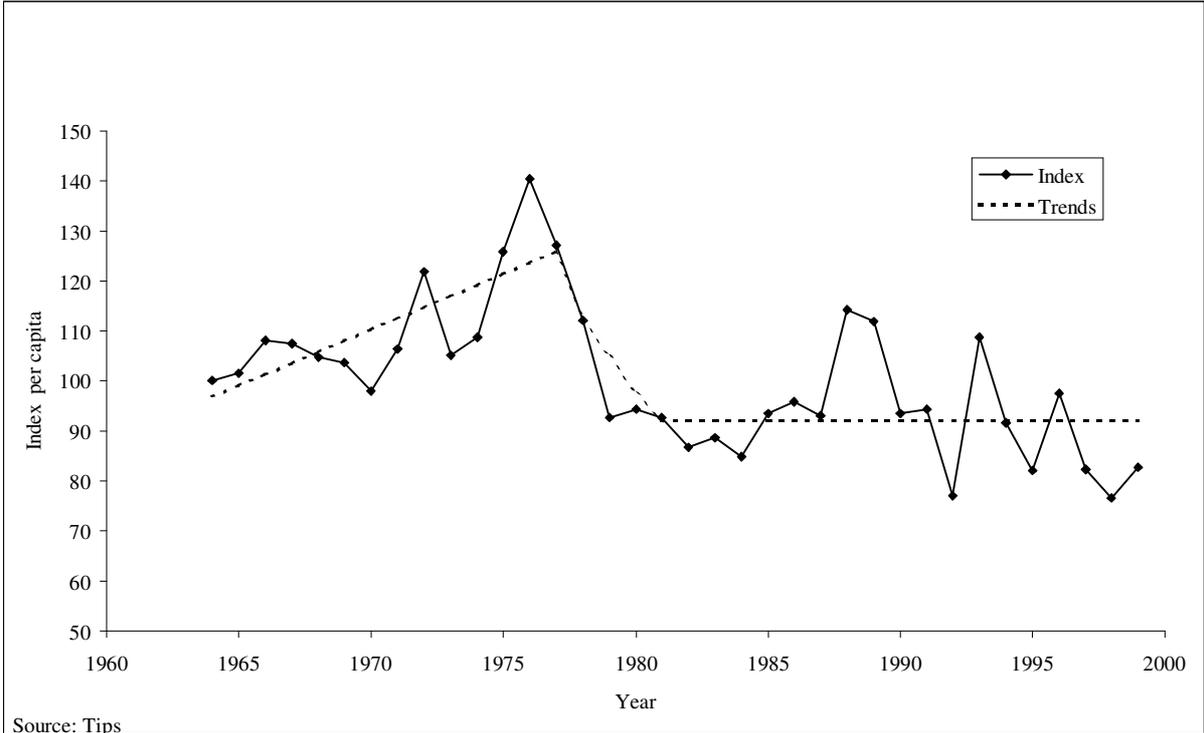
This drop in copper prices, which occurred quite suddenly in 1975 (from 246 to 187 USD per ton, a decline of 24% in one year), and the decline in volume of copper production and exports, had major long term consequences and produced a break in the whole development process of the country. Most of the indicators which were favorable prior to 1975 became negative afterwards, at least until 1992 (table 2). We recomputed growth rates in many economic indicators from available time series. GDP per capita was increasing prior to 1975 (+1.8% a year) declined after at about the same speed (-1.9% a year); state budget (resources and expenditures) were fast increasing before 1975, and declined at rates of -3.4 and -3.5% a year afterwards; health expenditures per capita in real terms were fast increasing before 1975, and fast decreasing afterwards (-13.1% a year); imports of goods and services were expanding before 1975 and were reduced after (-3.6% a year); imports of pharmaceutical products were expanding by +6.4% a year before 1975, but dropped by -6.9% a year after 1975. As a results, the savings rate and the investment rate dropped dramatically (-5.8% a year and -7.3% a year respectively), and the state deficit as well as international debt increased dramatically, putting the whole country under serious economic strains.

Furthermore, many of the food production indicators also evolved negatively over the 1975-1992 period (figure 3). The index of food production per capita declined by -2.8% a year after 1975, when it was increasing at +1.2% a year before 1975; the production of maize per capita declined dramatically by -9.7% a year after 1975, when it was increasing before 1975.

Table 2: Mean average annual changes in critical indicators, by period, Zambia 1950-2000

| Indicators   | Year series start | Years series end | Periods |           |           | Observations                            |
|--|-------------------|------------------|---------|-----------|-----------|---|
|  |                   |                  | < 1975  | 1975-1992 | 1992-1998 |   |
| <b><i>Socio-demographic</i></b>  |                   |                  |         |           |           |   |
| Total population   | 1950              | 2000             | 2.6     | 3.2       | 2.1       |   |
| Under-five mortality   | 1950              | 2000             | -4.4    | 1.7       | -1.9      |   |
| -- mortality, urban  | 1950              | 2000             | -5.3    | 2.7       | -1.8      |   |
| -- mortality, rural  | 1950              | 2000             | -3.6    | 1.3       | -2.1      |   |
| Education progression rate from grade 7 to 8                             | 1970              | 1994             |         | -2.7      | 6.1       | Periods: 1970-83 & 1983-94              |
| Hospital beds per 1000 persons   | 1964              | 1995             | 2.7     | -1.4      | -1.2      | (hospital and health centers)           |
| <b><i>Economic &amp; Health</i></b>                                      |                   |                  |         |           |           |   |
| GDP per capita (PPP)   | 1950              | 1998             | 1.8     | -1.9      | -1.9      |   |
| Government revenue (USD per capita)                                      | 1965              | 1998             | 8.0     | -3.4      | -3.9      |   |
| Government expenditure (USD per capita)                                  | 1965              | 1998             | 14.1    | -3.5      | -3.3      |   |
| Government expenditure on health (USD per capita)                        | 1964              | 2000             | 13.9    | -13.1     | 2.4       |   |
| International copper price index   | 1958              | 1997             | 0.8     | -2.6      | -0.4      |   |
| Export of copper (Kg per capita)   | 1964              | 1998             | -3.3    | -6.0      | -7.7      |   |
| Mine production index  | 1962              | 1994             | 1.6     | -1.6      | -13.6     |   |
| Industrial production index  | 1969              | 1998             | 0.6     | -0.3      | -9.5      |   |
| Imports of goods and services per capita (USD)                           | 1964              | 1998             | 10.3    | -3.8      | 2.3       |   |
| Exports of goods and services per capita (USD)                           | 1964              | 1998             | 2.1     | -3.6      | 3.0       |   |
| Index of food production per capita                                      | 1961              | 1998             | 1.2     | -2.8      | 1.6       |   |
| Agricultural imports per capita (real USD)                               | 1961              | 1997             | 6.0     | -8.2      | 17.2      | Periods are <1975, 1975-1991, 1991-1997 |
| Maize production per capita (kg)   | 1961              | 1998             | 3.0     | -9.7      | 2.6       |   |
| Total external debt per capita (current USD)                             | 1970              | 1999             | 11.6    | 5.0       | -2.5      |   |
| Total per capita consumption (real USD)                                  | 1965              | 1999             | 1.1     | -2.7      | -7.7      |   |
| Private per capita consumption (real USD)                                | 1965              | 1999             | 0.4     | -2.7      | -6.6      |   |
| General government consumption per capita (USD)                          | 1965              | 1999             | 4.7     | -2.6      | -13.4     |   |
| Gross domestic investment as % of GDP                                    | 1965              | 1999             | 4.8     | -7.3      | 5.5       |   |
| Gross domestic savings as % of GDP                                       | 1965              | 1998             | 1.7     | -5.8      | -11.0     |   |
| Consumer price index : 1994=100  | 1965              | 1998             | 5.1     | 36.0      | 42.9      |   |
| Official development assistance per capita (USD)                         | 1960              | 1998             | 25.8    | 10.3      | -18.6     |   |
| Imports of pharmaceutical products per capita (Real 1999 USD per capita) | 1964              | 2000             | 6.4     | -6.9      | 5.9       |   |

Figure 3: Trends in food production index per capita, Zambia 1950-1999



The situation after 1992 is more contrasted. Although copper prices and production continued to decline, as well as state budget, some of the indicators recovered a positive path. For instance, the real value of state expenses in health increased by 2.4% a year after 1992, imports of good and services also (+2.3% a year), as well as per capita food production (+1.6% a year), maize production (+2.6% a year), imports of agricultural goods (+17.2% a year), imports of pharmaceutical products (+7.6% a year). All of these, both in food availability and health services and goods, could have a positive effect on mortality indicators, and explain the mortality decline after 1991, once the net effect of HIV/AIDS is discounted.

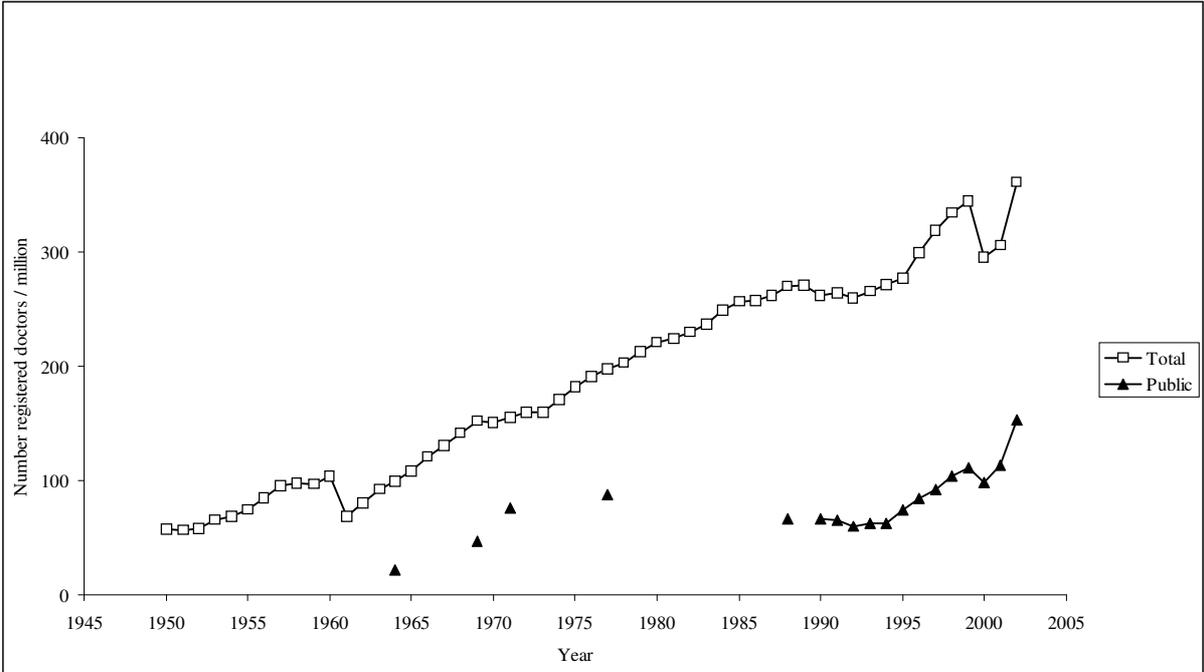
#### 4. Social policies

##### Health policies

During the colonial period, the health system in Zambia appeared somewhat more complex, and more developed than elsewhere in Africa, because of the revenues of the mines. The mining sector was running a comprehensive system of hospitals and health centers, for blacks and whites separately. The public sector was present primarily in urban areas, and

along the line of rail. The rural areas were covered mostly by missionary hospitals and health centers, with varied coverage owing to the scattered nature of settlements. By the time of independence, the population benefited of free and comprehensive services for all. Most medical services were integrated around the health posts. The existing infrastructure was developed, and increased faster than population. The number of hospitals went from 46 in 1964 to 75 in 1975, and 84 in 1992; some of the health centers were upgraded later, so that the number of hospitals jumped to 153 in 1999. The number of health centers increased from 306 in 1964, 631 in 1975, 1037 in 1992 and 1261 in 1996. Similarly, major efforts were done to train health personnel. The ratio of population to physician went from 1 doctor for 17600 persons in 1950 to 1 per 10000 in 1964, 1 per 5500 in 1975, 1 per 4400 in 1992 and 1 per 3400 in 2000 (figure 4). The public sector however, suffered from departures during the crisis years: the ratio of public doctors per million population for instance declined from 88 in 1977 to 60 in 1992. It recovered thereafter, and increased to 152 in 2002. The proportion of physicians employed in the public sector dropped from 45% in 1977 to 23% in 1992, and increased again to 42% in 2002. If there was no shortage of physicians in Zambia, availability of public physicians providing free health care was markedly reduced during the 1975-1992 period, though improved afterwards.

Figure 4: Trends in medical personnel, Zambia 1950-2002



The country ran typical international health programs after independence: Maternal and child health (1969), family planning (1973), training of TBA (1976), Primary health care (1980), National immunization campaigns (1978) boosted by the UNICEF sponsored EPI (1985), and control of diarrheal diseases (1985). With the appearance of HIV, a National AIDS Prevention and Control Program was set up in the mid 1980's. In addition, special project for community outreach programs were developed, and the "Bamako Initiative" was adopted in late 1980's. Therefore, there was no shortage of efforts during the main crisis years (1975-1990). However, several authors mention problems with drug availability in the public clinics during this period, as well as lack of personnel due to departures of physicians and nurses (Freund, 1986a and b; Kalumba and Freund 1989, Kasonde and Martin, 1994).

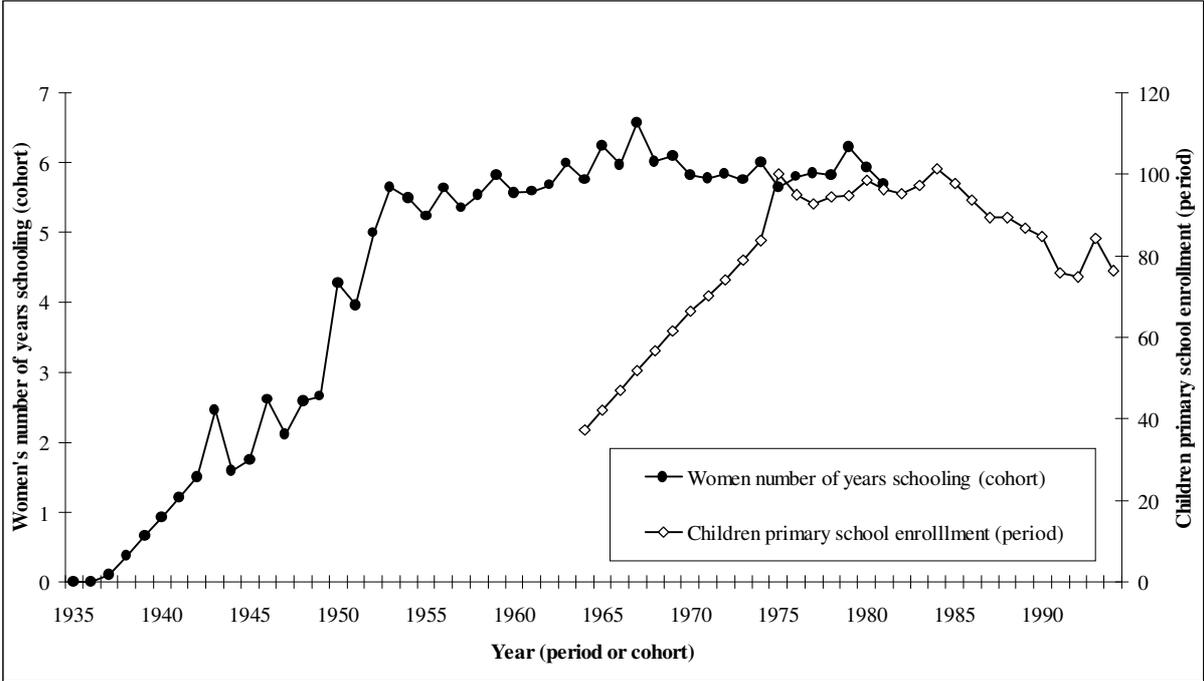
With the new government, the National Health Policies and Strategies were revised in 1991. (Møgedal et al. 1995; Atkinson, 1997; Blas and Limbambala, 2001 a,b; Kalumba, 1997) The new system focused on decentralized and district based health system. The financing was changed, with cost sharing for health care and user fee introduced in 1993. A prepayment scheme was developed for hospitals, though hospital care remained free for under five children and the elderly. The medical supplies were reorganized, and according to witnesses improved in the 1990's. The training effort was maintained, and quality assurance was reinforced. In addition to routine EPI, National Immunization days were introduced in 1991 (White & Nsovu, 1997).

### Education policies

In the first phase of colonization, education was run primarily by missionaries, as elsewhere in Africa. With the first development program (1947-1956), a public infrastructure of primary and secondary schools was developed, and by 1964 the average level of education in Zambia was among the highest in Africa, slightly higher than that of Kenya, though the country had very few university graduates. During the first 10 years of his rule, Kaunda continued to promote public education, and the level of education continued to increase rapidly. He also started the University of Zambia in 1966. From 1964 to 1975, primary school enrollment increased by 7.8% a year, and from 1970 to 1975 secondary school enrollment increased by 6.6% a year, much faster than the population growth rate. However, by 1975 trends were reversed. The rate of increase of primary school enrollment (3.1% in 1975-1980) hardly matched that of the population in age of schooling, and likewise for secondary school

enrollment. As a result, the level of education stopped increasing. We built an index on primary school enrollment in grade 7, based on the population aged 10-14 (figure 5). The index was rising fast before 1975, then stagnated for about 10 years and tended to decline between 1984 and 1994. Similarly, using DHS data, we computed the mean number of years of schooling for adult women by birth cohort. This number increased from 1 year schooling on the average for women born in 1940 (age 15 in 1955) to 5.8 years schooling for those born in 1960 (age 15 in 1975), but was basically the same 20 years later: 5.9 years schooling for women born in 1980 (age 15 in 1995), whereas during the same period (1975-1995) it increased from 5.6 to 7.5 years of schooling in Kenya. Another indicator of the difficulties of schooling in Zambia is the rate of passing from primary to secondary school (grade 7 to grade 8): this rate dropped from 22% in 1970-1974 to 17% in 1975-1983, and was restored only later (28% in 1984-1994).

Figure 5: Trends in levels of education, Zambia 1935-1994



Kelly (1991) has analyzed in-depth the difficulties of the education sector in Zambia during the main crisis years (1975-1985). Kelly presents numerous evidence of the effect of the economic and financial crisis on public education, which he attributes almost entirely to the fall in copper prices in 1975. In particular, mean public real expenditure per student declined, teaching and learning material became in short supply, and most important real income for teachers dropped by about 40% of its 1975 value. As a consequence, some

teachers started other jobs, and the quality of teaching declined. Student's performances deteriorated somewhat in the terminal primary school examination. The economic crisis also undermined the faith people had in the public education system. The difficulties in financing the public sector were only partly compensated by private funding. More and more families were asked to contribute to the education costs, with increasing difficulty for the poorer people. Foreign aid also contributed to fill the gaps, though was mostly directed towards secondary schools and the university. The situation seems to have improved since the late 1980's: the number of teachers is increasing, school enrollment is catching up, though there are questions about the quality of the education. It should be noted that the timing of the crisis in the education sector matches quite closely that of the mortality crisis, underlying the same factor: the financing of the social sector.

## **5. Epidemiological evidence**

### Malnutrition and food availability

Data on malnutrition of young Zambian children are limited, and some are controversial (Bloom, 1996; Hunt et al. 1994). Three sources of data could be used: DHS surveys, the health information system, and special surveys. The three DHS surveys conducted in 1992, 1996, and 2001 provide consistent estimates of prevalence of malnutrition among under-five children. The health information system developed by the Ministry of Health provides estimates of the prevalence of under-weight children among the health center attendants, and the mortality of children admitted to hospitals for malnutrition, broken down in two age groups: infants and 1-14 years. Other nutritional studies among under-five children were conducted in the country in 1971 (National Nutrition Survey), in rural areas in 1989 (Crop Forecasting Survey), in 1991 and 1993 (the Priority Surveys I and II), and in 1995 (FHANIS). Other data are mentioned by Hanmer and White (1999), with estimates for 1972, 1974, 1980, and 1985, although we could not locate the original source. Available evidence indicates a high level of stunting among children, and some evidence of increasing stunting among children from survey to survey (table 3). Comparing estimates of stunting among rural children in 1971 with those of the DHS surveys indicate a steady increase in stunting, from 38.0% (1971) to 46.3% (1992), 48.7% (1996) and 51.3% (2001). Comparison with data from

other surveys tend to indicate even higher levels of stunting, though are not fully comparable with DHS data. Data from the health information system also indicate an increase in malnutrition. Compared to the population under age 15, the number of outpatients consulting for malnutrition increased by 37% from 1976 to 1992. Hospital admissions for malnutrition increased by some 50% between 1976 and 1986, and hospital mortality from malnutrition doubled during the same period. Two years had outstanding number of hospital admissions for malnutrition: 1983 and 1984 (+61%), which were years of drought throughout Africa, and in particular in Zambia. Other more recent drought years (1992, 1994-1995) did not show the same increase, which emphasizes the acuteness of the 1983-1984 crisis.

Table 3: Trends in indicators of malnutrition and nutritional status, Zambia, selected published data

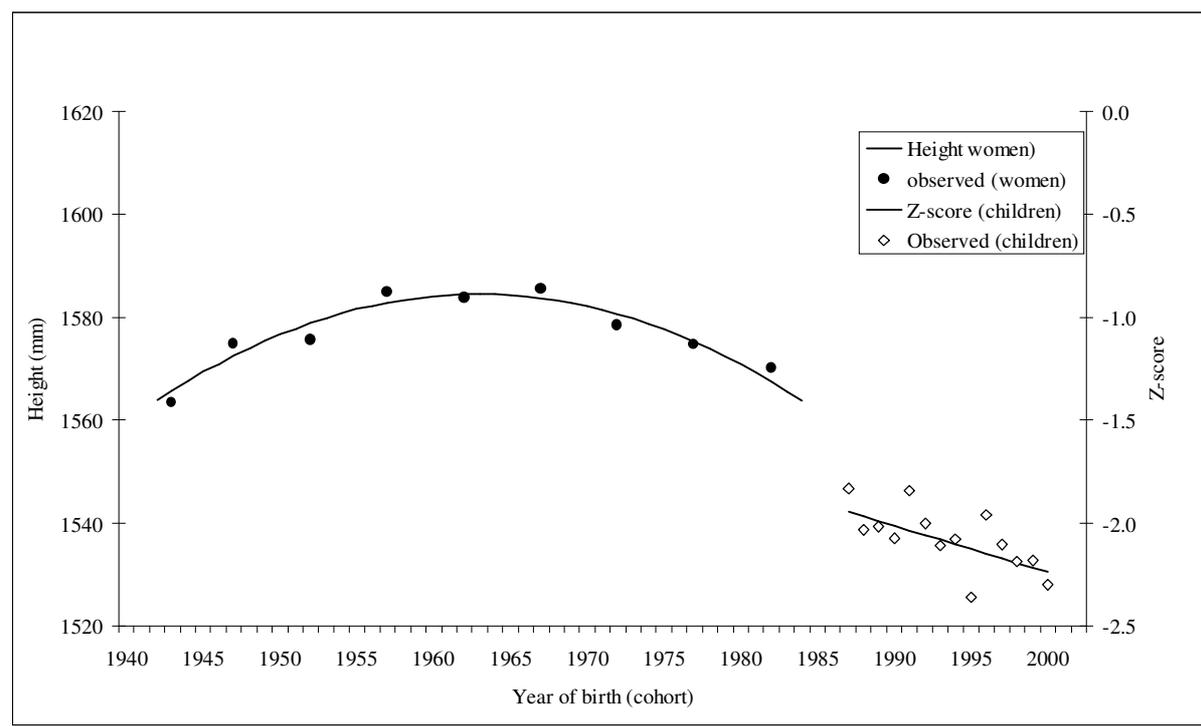
| Year                   | Malnutrition consultations and mortality in health services |            |           | Prevalence of malnutrition % |   |       |
|------------------------|---|------------|-----------|------------------------------|---|-------|
|                        |   |            |           | In national surveys          |   |       |
|                        | Outpatient  | Inpatients | Mortality | Low weight for age           | Prevalence of stunting (low height for age) |       |
|                        |   |            |           | Prevalence                   | Urban                                       | Rural |
| Index, base 100 = 1976 |   |            |           |                              |   |       |
| 1971                   |   |            |           |                              | 38.0  |       |
| 1976                   | 100   | 100        | 100       | 6.3                          |   |       |
| 1977                   | 113   | 107        | 102       | 6.2                          |   |       |
| 1978                   | 117   | 128        | 149       | 6.0                          |   |       |
| 1979                   | 113   | 103        | 122       | 7.0                          |   |       |
| 1980                   | 132   | 113        | 130       | 6.1                          |   |       |
| 1981                   | 134   | 112        | 116       | 6.8                          |   |       |
| 1982                   | 123   | 129        | 107       | 7.3                          |   |       |
| 1983                   | 136   | 159        | 184       | 6.4                          |   |       |
| 1984                   | 135   | 163        | 206       | 9.2                          |   |       |
| 1985                   | 150   | 148        | 197       | 13.6                         |   |       |
| 1986                   | 140   | 147        | 196       | 14.4                         |   |       |
| 1987                   | 131   |            |           | 17.7                         |   |       |
| 1988                   | 134   |            |           | 20.2                         |   |       |
| 1989                   | 131   |            |           | 15.3                         |   |       |
| 1990                   | 144   |            |           | 24.5                         |   |       |
| 1991                   | 119   |            |           | 26.2                         |   |       |
| 1992                   | 137   |            |           | 27.1                         | 32.6  | 46.3  |
| 1996                   |   |            |           |                              | 32.7  | 48.7  |
| 2001                   |   |            |           |                              | 36.8  | 51.3  |

Sources : Ministry of Health, Major Health Trends 1976-1986, and 1982-1992; DHS reports.

We re-analyzed the data on nutritional status for adult women and young children using data from the 1992 and the 1996 DHS survey (figure 6). For adult women, we focused on height by birth cohort, for women aged 18-49 years at time of surveys, that is for birth cohorts 1942 to 1978. Both surveys were combined. Results indicate that heights were increasing for women born between 1942 (1564 mm) and 1963 (1584 mm, slope = +9.2 mm per decade), and decreasing thereafter for women born between 1963 and 1984 (1564 mm, slope = -1.7 mm per decade). Both slopes were highly significant based on individual data ( $P= 0.001$  and  $P= 3.0 \text{ E-}12$  respectively). The cohorts that started to suffer from increasing stunting reached age 12 years at the time of the 1975 crisis. We therefore conclude that the crisis starting in 1975 had an effect on female adolescent growth spurt, not only stopping the earlier gains, but also reversing the trends, leading towards shorter women. The effect was still visible for women born in 1984 who reached puberty in 1996. It appears that the 1975-1992 crisis had visible effects on linear growth of adult women, which can be linked to the decrease in food availability over the period shown above.

For under-five children, nutritional status data were available for the two DHS surveys, covering cohorts born between 1987 and 2000. Because of the strong age component of stunting, we selected children aged 18-59 month at time of survey, for which stunting is virtually independent from age. Here again data show an increase in stunting by birth cohort. Average Z-score declined from  $-1.95$  for children born in 1987 to  $-2.24$  for children born in 2000 ( $P$  value of slope =  $1.1 \text{ E-}5$ ). Estimates of the prevalence of stunting (percent below -2 standard deviation of height for age) ranged from 47 to 56% for the same cohorts, again with a significant slope based on individual data ( $P= 4.3 \text{ E-}6$ ). There is therefore no doubt that the nutritional status of children continued to deteriorate, at least until year 2000. However, part of the negative trends in the 1990's could be due to HIV/AIDS, and cannot not be readily attributed to diminishing food availability, as opposed to trends among adult women in the 1970's and 1980's.

Figure 6: Trends in nutritional status of women and children, Zambia 1935-1994



## Malaria

Malaria is highly endemic in Zambia, and is the leading cause of visits to health centers and of hospital admissions. Malaria morbidity and case fatality seem to have increased in Zambia over the study period. For instance, according to published statistics, the number of reported cases of malaria increased by 2.82 fold, the number of reported malaria deaths by 4.0 fold, and therefore the malaria reported case fatality rate increased by 1.42 fold over the 1976-1992 period (see table 4). However, since 1993, malaria morbidity and mortality seem to have stabilized and even declined (Web site of Africa Fighting Malaria).

Table 4: Indicators of malaria morbidity and mortality in health facilities, Zambia

| Year | Index (base 100 in 1976) |           |               | % of children deaths |
|------|--------------------------|-----------|---------------|----------------------|
|      | Morbidity                | Mortality | Case fatality |                      |
| 1976 | 100                      | 100       | 100           | 4%                   |
| 1984 | 186                      | 230       | 124           | 8%                   |
| 1992 | 282                      | 400       | 142           | 15%                  |

Source : recalculated from various issues of CSO publications : Major Health Trends (1976-1986 and 1989-1992).

Malaria strains resistant to chloroquine treatment have been documented in Zambia since the late 1970's. A study conducted in 1995 found that 69% of children with malaria showed some resistance to chloroquine (RII or RIII level) and 41% experienced clinical failure to the treatment (Ettling et al., 1997). A more recent study showed that malaria strains became resistant to other treatments such as Sulfadoxine-Pyrimethamine in the late 1990's (Bijl et al. 2000).

The Ministry of Health of Zambia publishes causes of death statistics for selected causes among deaths notified in hospitals and health centers (Republic of Zambia, Bulletin of Health Statistics, 1994 and 1997). The only disease among children that shows an increasing trend, and faster than the trend in overall mortality, is malaria. Notified malaria deaths among children increased by 6 fold between 1976 and 1992, when population increased by 45% and mortality by 31%. The increase in malaria mortality per population is different from other causes, such as pneumonia and diarrhea which approximately follow the increase in all causes mortality, or from causes such as malnutrition and measles which became even lower in proportions. Given the increase in under-five mortality, malaria mortality seems to have increased by 3-fold over the period, and its share of the total number of deaths could have increased from some 4% to some 15%. This implies that the increase in malaria mortality could explain some 18% of the total increase in under-five mortality for all causes. The increase in malaria mortality may be attributed primarily to resistant malaria, and therefore is probably somehow independent from the economic and socio-political crisis, though its effect might have been enhanced by the crisis. When compounded to the net effect of HIV/AIDS, the effect of emerging and re-emerging diseases explains a significant part of the mortality increase (15% for HIV/AIDS in 1992 and 18% for malaria), and the net effect of the economic crisis appears therefore as about one third lower than predicted solely by the overall mortality increase. Following these assumptions, we estimated that notified malaria deaths for children in hospitals and health centers could account for some 40% of all children malaria deaths in the country, a remarkable result compared to other causes of death. This justifies a posteriori the use of these official statistics for our analysis, since coverage is relatively large compared to other African countries.

## Vaccination

There is no doubt that vaccination coverage increased during the 1980's and 1990's in Zambia (Fussum, 1994). Data from the Ministry of Health indicate a rise of full vaccination coverage from 37% in 1984 to 73% in 1991 and 78% in 1996. The three DHS surveys conducted in Zambia indicate similar values of vaccination coverage with high values throughout the 1990's. The proportion of 12-23 months old children who were fully vaccinated ranges from 66.6% in the 1992 DHS, to 78.3% in 1996 and 70.0% in 2000. The coverage for BCG ranged from 95%, to 97% and 94% over the same period, and the coverage for measles from 77% to 87% and 84%. Vaccination coverage was therefore medium for a long time in Zambia, increased considerably in the late 1980's as a result of the national EPI program, and stayed at high levels in the 1990's, with only a minor drop in the last years. Vaccinations certainly contributed to the mortality decline for causes other than HIV/AIDS in the 1990's.

## **6. Econometric analysis**

Several econometric models were tested to investigate the relationships between under-five mortality and economic indicators. First, a multiple linear regression model linking under-five mortality, after discounting for the net effect of HIV/AIDS, was tested on a set of 30 economic indicators. Four variables stayed significant after numerous runs and stepwise regressions: a linear trend, Gross Domestic Product per capita in parity purchasing power (GDP-PPP), the net value of public health expenditures converted in parity purchasing power (HEALTH-EXPEND), and the value of imports of medical products (MED-IMPORTS). If the last variable was dropped, the value of international aid (INT-AID) was also significant. GDP-PPP was taken from Maddison et al. (2001); Health expenditure were standardized for parity purchasing power by multiplying the share of the state budget spent on health by the ratio of the state budget to GDP (in Kwacha), and by the GDP-PPP (in constant USD); the value of medical imports per capita and of international AID per capita obtained from the CSO was converted in constant USD by applying the official exchange rate (kwacha into dollars) published by CSO and by the OECD deflator rate for constant 1999 USD. All variables had the expected signs: the time trend, describing the underlying health transition

was strongly negative; an increase in GDP-PPP, in health expenditures and in imports of medical products all had the effect of reducing mortality. The model could explain the fluctuations of mortality, ups and downs, after controlling for the underlying time trend (table 5). The faster mortality decline between 1960 and 1975 was associated with increasing income, increasing health expenditures and increasing imports of medicines, the changes in the three variables having roughly the same negative net effects: -19, -22 and -24 per 1000 respectively, out of a baseline value of 308 per 1000 and a trend effect of -83 per 1000. Economic indicators explained about half of the improvements in under-five mortality over this period. The rise in mortality between 1975 and 1988 was closely associated with decreasing income, decreasing health expenditures and decreasing imports of medicines, the changes in the three variables having roughly the same positive net effects: +38, +23 and +34 per 1000 respectively out of a baseline value of 150 per 1000 and a trend effect of -72 per 1000.

Table 5: Net effects of economic variables on under-five mortality, Zambia

| Variable            | Results from linear regression |                |          | Net effects on q(5) of changes in each independent variable, |           |           |
|---------------------|--------------------------------|----------------|----------|--|-----------|-----------|
|                     | B-coef-ficient                 | Standard error | P value  | Period   |           |           |
|                     |                                |                |          | 1960-1975  | 1975-1988 | 1988-2000 |
| Constant            | 11309.9                        | 601.7          | 1.55E-19 |  |           |           |
| Year                | -5.544                         | 0.295          | 1.48E-19 | -83  | -72       | -67       |
| GDP-PPP             | -0.117                         | 0.031          | 0.0006   | -19  | +38       | +17       |
| Health expenditures | -1.452                         | 0.438          | 0.0022   | -22  | +23       | +0        |
| Medical imports     | -4.806                         | 1.438          | 0.0020   | -24  | +34       | -8        |
| Total               |                                |                |          | -149   | +22       | -57       |

Note: R-square= 0.953. Units: All values for GDP-PPP, health expenditures and medical imports are in USD; Year ranges from 1960 to 2000; q(5) per 1000, after removing the effect of HIV/AIDS.

In the last period (1988-2000), the mortality decline was not associated with income, which continued to decline, or health expenditures which were quite stable, and was affected only mildly by imports of medicines, the net effect (-8 per 1000) of which being small compared to baseline value of 171 per 1000 and a trend effect of -67 per 1000. The changes

in mortality in 1960-1975 and 1975-1988 could therefore be associated with changes in the three economic variables; however the recent trend over the 1988-2000 period seems almost entirely due to the underlying trend, which can be interpreted as the general health transition, overall improvements in health services and technology, cumulative effect of education and other capital variables, but not as a product of income or related variables. The logit slope of the underlying trend, after discounting for the effect of economic factors, was estimated at -1.9%, a medium value by international standards, quite typical of the African situation. If the country had been through a regular health transition without HIV/AIDS, and a steady increase of 2% a year in GDP per capita and other economic indicators since 1964, the under-five mortality would have been 86 per 1000 in year 1990 and 48 per 1000 in year 2001. This gives a measure of the impact of the economical and epidemiological difficulties Zambia went through over the period.

Since there are obvious correlations between economic indicators, in particular the strong effect of copper price on GDP and the state budget, we developed a path analysis model, where the first equation relates GDP to copper price, the second equation relates health expenditures to GDP, and the third equation relates under-five mortality to health expenditures and a time trend. All variables were taken in logarithms. The effects were in the expected direction. Elasticity between GDP-PPP and copper price was +1.14; elasticity between health expenditure and GDP-PPP was +1.68, and the elasticities between under-five mortality and other variables were: -0.152 with health expenditure, -0.018 with international aid, and -0.022 with the time trend. The three regressions explained well the mortality decline between 1960 and 1975 (275 to 183 per 1000). However, the model was less suited to explain further mortality changes: it predicted steady levels of mortality between 1975 and 1984, then a fast decline between 1984 and 1990 (179 to 140), then steady levels again until 1998, therefore missing precise dates of changes. This is probably because this model puts too high a weight on copper prices, which seems to play no role in the recent period.

Last, we investigated time series analysis, to take into account possible co-integration of variables with time. We first discounted for the time trend, and regressed the residuals on GDP-PPP, health expenditures and medical imports, allowing for an autoregressive term with lag (t-1). Only the first variable came out significant, which suggest that the other two were structurally linked to income. In the final model linking the residuals of observed under-five mortality minus the time trend to GDP-PPP, we found a negative coefficient of GDP-PPP (b=-0.023, P= 0.037), meaning that an increase in income will lead to lower values of under-five mortality than expected from the underlying trend, and a strong autoregressive term (ar(1)=

0.91,  $P= 1.26E-26$ ). However, when used for forecasting, the model failed to fit the reversals in mortality trends, and led only to lower than expected values of  $q(5)$ .

## **7. Urban / Rural Differentials**

Several authors have noted the divergence of mortality trends between urban and rural areas. In our analysis, the overall trends were the same, with declining mortality in both areas in the first period, increases in the second period, and decrease in the third period. The turning points (1975 and 1992) were basically the same in the two areas, the data being not precise enough to make an assessment more accurate than 2-years. Mortality decline was faster (logit slopes of -8.3% and -5.0% respectively,  $P=0.047$ ) in urban areas during the first period (1958-1975); mortality increase was more pronounced (logit slopes of +3.2% and +0.9% respectively,  $P= 0.0001$ ) in urban areas during the second period (1975-1992); and mortality decline was faster (logit slopes of -4.3% and -0.1% respectively,  $P=0.020$ ) in rural areas during the third period (1992-2001), so that by the end of the period, mortality levels were similar in the two areas. The same was true even after discounting for HIV/AIDS. It is beyond the aim of this paper to conduct a full analysis of urban / rural differentials, not counting the fact that most data used for the national analysis are not available for the two areas separately. However, the gaps identified in the demographic analysis seem to match what is known about the main determinants of mortality changes. In the period before 1975, most investments were directed towards the urban areas, which also benefited from much higher income and government subsidies. During the crisis years, the urban poor seem to be have been the ones who suffered the most, and the urban population was probably more affected by the problems of the health sector. During the recovery period, the rural population seems to have benefited more from the structural adjustment programs, and rural poverty declined somewhat whereas urban poverty was still increasing in the 1990's. Many of the health programs in the 1990's, in particular vaccination programs and development of health infrastructure, are likely to have benefited more to the more deprived rural areas.

## Discussion

Zambia can be considered as a quasi-experimental case-study to evaluate the effects of rapid changes in income on the social sector, and in particular on under-five mortality. Our analysis shows that a serious shock such as a decline in income of about 30% in a period of 17 years (1975-1992) has serious consequences on most economic and social indicators, and lead to increasing under-five mortality, and to halting improvements in levels of education. This can be easily understood by the changes in real value of the state budget spent in health and education. However, the social system appears resilient in the long run, and coping mechanisms were obviously found in Zambia, since continuous decline in GDP in the 1990's did not produce a steady increase in under-five mortality or a steady decline in levels of education.

With respect to under-five mortality, the main focus of this study, the determinants of changes have to be analyzed in a health transition framework. Under-five mortality is primarily the product of public health policies, curative medicine and nutrition. Cases of fast mortality decline without increase in income are numerous in the world, although when income rises, usually enough money is put in public health, medicine and nutrition. In the case of Zambia, mortality increase during the 1975-1992 period appears primarily as the result of the change in income, which had effects on health services and on nutrition. Decline in income also lead to the departure of physicians and nurses, in particular in the public sector, who could find higher income in neighboring countries. In addition, this period was also affected by increases in malaria mortality, and by the emergence of HIV/AIDS, for independent epidemiological reasons.

The recovery period (1992-2001) is most interesting, since under-five mortality resumed its decline despite continuous depreciation of income. Many reasons could explain this trend. As far as health personnel is concerned, the 1992-2001 period was favorable, as the ratio of physicians and nurses per population increased in both the public and the private sectors. In terms of health policies, the program of decentralization probably led to better efficacy of the health system, and the program of cost recovery to better availability of medicines. In terms of health programs, the immunization program had probably a maximum effect after 1992, when vaccination coverage became high in the under-five population (it takes 4 years after systematic vaccinations of 12-months old babies until all under-five children are protected), and clearly measles mortality declined during this period. Note that

the mortality decline occurred despite continuous deterioration of the nutritional status, which implies that malnutrition is better treated, as can be seen in the decline in the proportion of notified deaths due to malnutrition, an indication of improvement in curative medicine or better access to health services. Furthermore, the education effort of the 1960's and 1970's could have had cumulative effects, since by the 1990's most women in their reproductive ages would have been educated (it takes some 30 years between the time educated women leave secondary school and the end of the reproductive period).

The regression equation linking under-five mortality to economic indicators confirms our findings. The main determinant of mortality trends seems to be the underlying trend, which is the health transition independent from income, resulting primarily from health policies and programs. The economic shock of 1975 and the subsequent recession do explain the rise in under-five mortality until 1990, but appear to not have had longer term effects.

The effects of the external economic shock, the decline of copper prices on the international market, shows the vulnerability of the state in a country like Zambia, which depended largely on a single export commodity (Bigsten and Kayiwwi-Mugerwa, 2000; Bigsten 2001; Fardi 1991; Bates and Collier, 1993; Guillaumont, 1999; Combes and Guillaumont, 2001). A strong shock had rapid effects, within a year or so, on health indicators, education, and nutritional status, and effects lasting for some 15 years. This large effect is due to the strong dependence on one single production good. This is the result of colonial policies, which aimed primarily at fast benefiting from extracting minerals, and from policies during the early years after independence, which failed to address the broader issue of economic development, and in particular agricultural and industrial development, and relied too much on earlier choices. By over-using revenues from mineral exports, the Zambian government put itself in a vulnerable situation. In this type of situation, any shock would be likely to have large effects, as was the case, for instance, of cotton in Egypt in the 19<sup>th</sup> century or uranium prices in Niger in the 1980's (Deaton, 1999; Collier, 1991; Collier and Gunning, 1999a,b). Reactions to the 1975 shock appeared also inappropriate, since the government expected later increases in prices, which never came, and borrowed money on international markets, adding to the national debt and to the vulnerability. Such reactions were not typical of Zambia, and even the World Bank made major errors in forecasting prices of commodities in the 1970's and 1980's (Deaton, 1999).

Resilience of the system and its capacity of recovery are more important, and more informative for future action. Despite declining income, the Zambian government found a way of coping with the difficulties. By implementing new policies, and by continuing its

effort in medical training and in medical infrastructure, it was able to continue the health transition. In particular, structural adjustment policies appeared to have had positive effects on health indicators. We found similar evidence in other African countries, such as Madagascar, Uganda, Ghana, and Mozambique, where under-five mortality resumed its decline after structural adjustment policies were put in place, when it was increasing before. Details of the mechanisms could be analyzed more in depth, but it is quite clear that access and use of health services and medicines consumption did improve in these cases after SAP were put in place, and despite negative effects such as increasing urban poverty.

Some authors have put a large emphasis on epidemiological factors in the case of Zambia. We found a large effect of HIV/AIDS, though not large enough to inhibit the mortality decline in the 1990's nationwide. Of course, the net effect of HIV/AIDS on mortality trends depends on the underlying level of mortality. When mortality gains due to the health transition become lower than the mortality losses due to HIV/AIDS, mortality increases, as it is the case in nearby Botswana. In Zambia, the underlying mortality level is still above this threshold, though probably not for long. The AIDS epidemics is raging, and its full effect is going to be seen in the coming years. Combined with declining mortality for other causes could well lead to another reversal in mortality in the near future, unless proper measures are taken to limit mother to child transmission of HIV and to treat infected mothers. Malaria did play a role in the mortality increase of the 1980's, though according to our calculations had only a minor effect. Proper prevention and treatment of resistant malaria is still not resolved in sub-Saharan Africa, and also could also lead to mortality increase in the future. Some other authors have pointed out the possible role of cholera. We found little evidence that cholera could have played a role here. According to cases notified to the World Health Organization, three major epidemics stroke Zambia in 1978-1983, 1990-1993 and 1996-2001. We found no correlation with our under-five mortality estimates, which can be easily understood, since cholera affects primarily adults, and rarely breastfeeding children, the prime age group for under-five mortality.

Our analysis tried to encompass a systematic analysis of mortality trends, discounting for independent epidemics such as HIV/AIDS or malaria, and a systematic analysis of various determinants: economic, social, public health and nutrition. This is probably why our conclusions differ from some of the other authors. Of course, much remains to be done to analyze in details the precise mechanisms, in particular morbidity and mortality by cause, use and access to health services, efficacy of prevention and treatments etc. Similarly, the economic analysis could be much improved by analyzing private consumption of health

services and medicines (Berman et al. 1995). Furthermore, more research could be conducted to analyze mortality determinants according to socioeconomic status and urban or rural residence. In particular, much work remains to be done on the situation of the urban poor, who seem to be the only ones to not have benefited from the overall improvements in the 1990's (Muuka and Kalyalya, 1997).

## **Acknowledgement**

The authors acknowledge the support of the “Health Consequences of Population Change Panel” of the Wellcome Trust, London, who provided a grant to conduct this study. Authors would like to thank very warmly all those who welcomed Dr. Eneas Gakusi in Lusaka, and provided time, information, documents and data necessary for the analysis, in particular: Ms. Efreda Chulu, acting director of the CSO, Mr. Chimfwembe, director of Planning and Development at MoH, Ms. Chivundu Leo, EPI officer at MoH, Ms. Jenny Meya Nyirenda, Child Health Specialist, Central Board of Health, Ms. Catherine Mwape, International Trade Division at CSO, Mr. Edgar Musonda at CSO, Mr. William Mayaka, Deputy Director at CSO, Mr. James Lungushi, Director of Planning at the Ministry of Finance, Dr. Edward Maganu, Director of WHO regional office in Lusaka, Dr. Eddie Limbambala at the WHO office in Lusaka, and Ms. Liseli Simasiku-Sikota at the World Bank office in Lusaka.

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