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Successes and Failures in the Fight against Child Mortality in Sub-Saharan Africa: Lessons from Senegal

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Abstract

Child mortality has declined in Sub-Saharan Africa over the last 60 years but the decrease has not been regular: it has accelerated over some periods, as during the last decade, and slowed down in others. This is not solely attributable to HIV/AIDS. This paper examines in detail the trends observed in Senegal, an example of a country with low HIV prevalence but where trends in mortality have resembled those of the whole region. Both national and local level data are used, in particular the data on mortality and causes of deaths produced by the demographic surveillance systems (DSS) in the three rural areas of Bandafassi, Mlomp and Niakhar. Although Senegal experienced an appreciable fall in under-five mortality from the end of World War II, the country experienced a fifteen year stagnation in child mortality in the late 1980s and 1990s. This halt was due to a slowdown in vaccination efforts and a resurgence of malaria mortality linked to the spread of chloroquine resistance. The decrease in malaria and other infectious diseases thanks to renewed vaccination efforts and investment in anti-malaria programmes appears to be the main factor responsible for the return to a very rapid decline in under-five mortality observed during the 2000s.

Keywords: child mortality, causes of death, vaccination, malaria, demographic surveillance systems, Sub-Saharan Africa, Senegal

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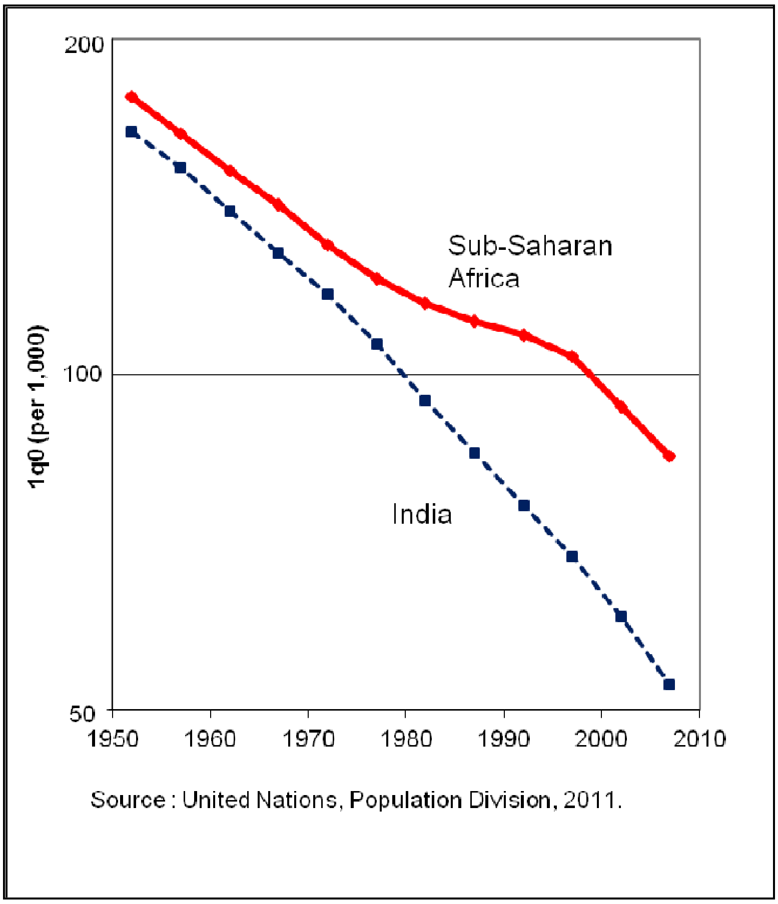
SUCCESSES AND FAILURES IN THE FIGHT AGAINST CHILD MORTALITY IN SUB-SAHARAN AFRICA: LESSONS FROM SENEGAL

INTRODUCTION

Life expectancy at birth worldwide has increased considerably over the last century, due mainly to a marked reduction in child mortality. This has also been the case in sub-Saharan Africa, although this region still has the highest mortality rates in the world.

According to the statistics of the United Nations Population Division (2011), infant mortality (1q0) has declined in sub-Saharan Africa over the last 60 years, falling from a level of roughly 180 per 1,000 in 1950-54 to 85 per 1,000 in 2005-2009. The decline occurred at a steady rate until the late 1980s, slowed down during the 1980s and the 1990s, and then resumed during the last decade (figure 1).

Figure 1. Infant mortality (1q0) trends in India and in the whole of sub-Saharan Africa between 1950 and 2010
(1q0: probability for a new-born child of dying before age 1)(log scale)



Note: trends in 1q0 are shown here instead of trends in 5q0 because UN statistics provide estimates back to 1950 for 1q0 but not for 5q0

Although the mortality decline in sub-Saharan Africa over these sixty years seems high in absolute terms, it has been slower than in Asia. If we compare, for example, sub-Saharan Africa with India, two regions with around 1 billion inhabitants each (respectively 0.9 and 1.3 billion in 2013), both had very similar levels of infant mortality in 1950-54 (177 and 165 per thousand, respectively, in sub-Saharan Africa and in India according to UN figures). By 2005-2009, however, the level was more than 50% higher in sub-Saharan Africa (85 per thousand, as against 53 per thousand in India). The rate of decline has been steady in India, with a slight acceleration over time, particularly during the 1970s and 1980s. Over the same two decades, the decline slowed down in sub-Saharan Africa. The gap with India has widened therefore, and continues to do so, despite a resumption of progress over the last decade in sub-Saharan Africa.

Can the fall in African child mortality be attributed to the same causes as in other parts of the world where mortality has declined from very high levels? At first sight, one might think that the slowdown in the mortality decline over the 1980s and 1990s seen in sub-Saharan Africa but not in Asia was due to a phenomenon unique to Africa, the AIDS epidemic being the first factor that comes to mind. AIDS is certainly highly prevalent in sub-Saharan Africa, with a major impact on mortality, although substantial efforts have been made over the last decade to fight the disease. Is the resumption of the child mortality decline at the beginning of the twenty-first century a consequence of this effort? Are other diseases or factors involved in the earlier slowdown and the recent resumption of progress in child mortality?

The debate on child mortality decline in sub-Saharan Africa has focused recently on two types of questions:

1 – Do the recent improvements in countries of sub-Saharan Africa represent the biggest falls in child mortality ever seen anywhere (Demombynes and Trommlerová, 2012)? If so, this would mean that, contrary to pessimistic views (Murray et al., 2007 ; Bhutta et al., 2010 ; Hill et al., 2012), many of them may reach the Millennium Development Goal (MDG 4) to reduce under-five mortality by two thirds between 1990 and 2015 (Masanja et al., 2008). From a more long-term perspective, are the recent improvements in child mortality in the African region just a correction for the epidemiological crises and health system failures that characterized much of the 1980s and 1990s? If so, the recent progress may not be a guarantee of long-term improvements in child health.

2 – Are the driving forces behind the mortality decline the same over time and from one population to the other? Which changes and programmes have contributed the most to the decline? Progress in health infrastructure and programmes? Socio-economic progress, especially in education, which enables all population groups to benefit from progress in health? What has been the contribution of specific intervention programmes to improve vaccination coverage and vitamin A supplementation, to control malaria or to combat HIV/AIDS?

To shed light on the reasons for the irregular pace of child mortality decline in sub-Saharan Africa since the mid-twentieth century, particularly the rapid fall in child mortality from the 1950s to 1980s, the subsequent ten- to twenty-year slowdown in progress, and the recent resumption of rapid decline, we shall examine in detail the case of Senegal. This country offers the following four advantages:

- child mortality has evolved there in a way that is typical of the whole region: a rapid fall followed by a ten- to fifteen-year stagnation and a subsequent return to rapid decline;

- up to the present, the country has not been severely affected by AIDS: the proportion of persons aged 15-49 infected by HIV is estimated at 0.7% and did not change much between 2005 and 2010 (Ndiaye et Ayad 2006 ; ANSD 2011). So HIV/AIDS cannot be held accountable for the stagnation in child mortality decline.

- sources of information there are relatively numerous and child mortality trends on a national scale can be tracked quite accurately;

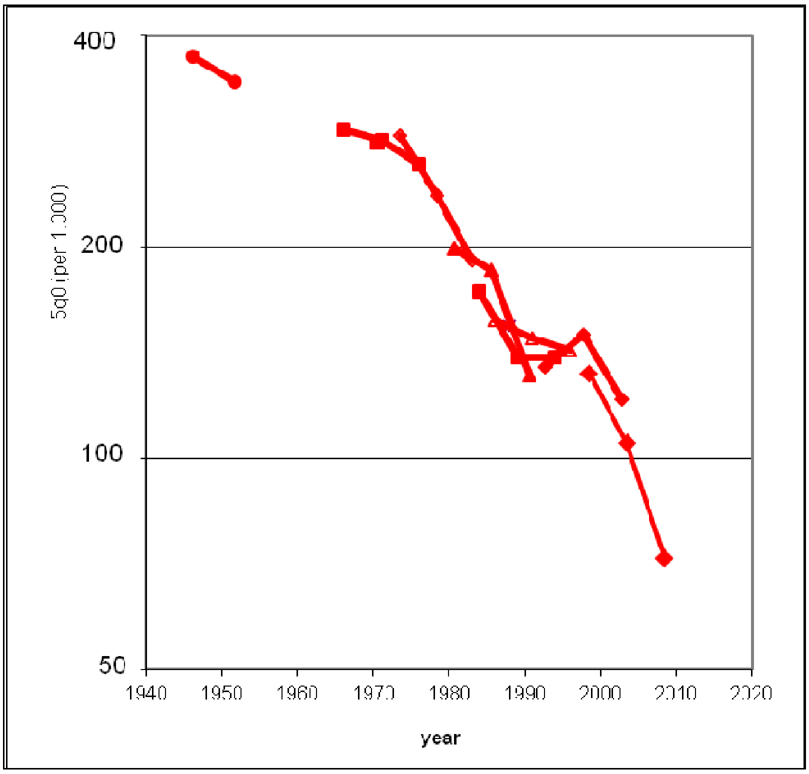
- the country also possesses three demographic surveillance sites in rural areas that have monitored child mortality and its causes in detail over a long period.

1. Child mortality decline and evolution of health conditions in Senegal

1.1. Child mortality decline in Senegal since 1945

Ten national surveys[1] supply data that can be used to estimate childhood mortality in Senegal. We use here as an indicator of child mortality the probability that a newborn will die before the age of 5 (5q0). Figure 2 shows 5q0 estimates for Senegal since 1946.

Figure 2. Under-five mortality (5q0) trends in Senegal between 1945 and 2006-2010
(5q0: probability for a new-born child of dying before age 5) (log scale)



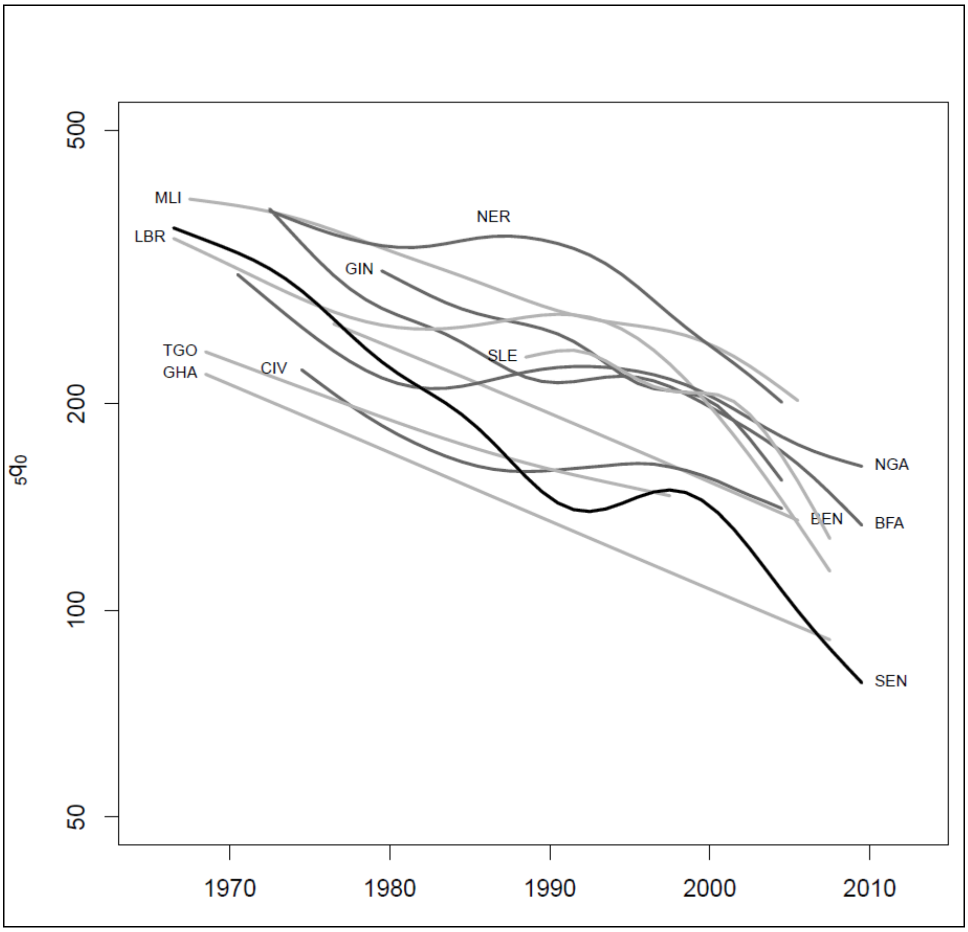
Note: indirect estimation for years 1946 and 1952; source: Hill, 1989
direct estimation for the other years; sources:

- Senegal, 1964 (Enquête démographique de 1960-61)
- Senegal, 1974 (Enquête démographique nationale de 1970-71)
- Rutstein, 1984 (Enquête sénégalaise sur la fécondité, 1978)
- Ndiaye et al., 1988 (Enquête démographique et de santé, 1986)
- Pison et al., 1995 (Recensement de 1988)
- Ndiaye et al.,1994 (Enquête démographique et de santé II, 1992-3)
- Ndiaye et al.,1997 (Enquête démographique et de santé III, 1997)
- Sow et al.,2000 (Enquête sénégalaise sur les indicateurs de santé, 1999)
- Ndiaye et al.,2006 (Enquête démographique et de santé IV, 2005)
- ANSD, 2011 (Enquête démographique et de santé à indicateurs multiples, 2010-2011)

[1] The list of surveys is provided in a note of figure 2.

According to these data, in the 60 years following the end of the Second World War, 5q0 decreased nearly six-fold. The decline appears to have occurred rather slowly until the early 1970s, with a 25% drop in 25 years (from 373 per 1,000 in 1946 to 280 per 1,000 in 1970), and to have accelerated thereafter, with 5q0 falling by 75% in 35-40 years (down to 70 per 1,000 in 2008). However, after this second period of rapid progress, the decline halted in the late 1980s and mortality stagnated at around 140 per thousand during the 1990s. At the end of the 1990s and the early 2000s, the decline resumed, with 5q0 falling rapidly by 50% in the following decade (to a level of 70 per 1,000 during the second half of the 2000s).

Figure 3. Trends in under-five mortality (5q0), 1966–2009. Comparison between Senegal and other West African countries
(5q0: probability for a new-born child of dying before age 5) (log scale)



Countries:
BEN (Benin), BFA (Burkina-Faso), CIV (Côte d'Ivoire), GHA (Ghana), GIN (Guinea), LBR (Liberia), MLI (Mali), NER (Niger), NGA (Nigeria), SEN (Senegal), SLE (Sierra-Leone), TGO (Togo).
Source: Masquelier et al. (forthcoming)
(estimates based on birth histories collected by DHS surveys)

Figure 3 shows the trends in Senegal in relation to those of other West African countries. The curves are taken from Masquelier et al. (forthcoming). Child mortality trends were estimated for each country on the basis of birth histories collected by the different DHS and applying the same method: estimates of 5q0 were obtained by pooling all DHS data and comparing mortality rates from successive surveys for a fixed reference period in an attempt to correct for potential biases such as omissions or displacement of births. Trends were also smoothed. Three features emerge from figure 3: first, child mortality declined substantially in all countries of the region from the 1970s to the 2000s; second, the decrease in Senegal appears to have been one of the largest in the region, exceeding that of its landlocked Sahelian neighbours (e.g., Mali and Niger), which have always had, and continue to have, some of the world's highest levels of child mortality; third, in most West African countries (with only a few exceptions, such as Benin and Ghana) there was a temporary slowdown or a reversal of the decline in the 1980s and 1990s, followed by a renewed acceleration in the 2000s, as in Senegal.

Let us return now to the case of Senegal. The trend shown in figures 2 and 3 for this country raises several questions:

– Are the trends real or artefacts? In particular, did mortality decline really level off during the 1990s? The type and quality of data gathered varies across the surveys, as do the methodologies employed. However we chose to focus on a simple, robust indicator of child mortality, 5q0. The different measurements shown in figure 2, which are original ones, unadjusted for potential biases, are fairly consistent. And a similar stagnation is also observed over the same period in the three demographic surveillance systems (DSS) in rural areas (see below).

– What are the factors behind the child mortality decline in Senegal since the mid 20th century? In this country, as in most other countries, it is probably related to economic development and the improvement in health conditions observed after the end of the Second World War. Can we be more precise ?

In this paper we address the first question by using the DSS data to examine whether the trends are real or simply reflect poor data quality. To answer the second one, we analyse more precisely the contribution of different factors in the decline: (1) changes in the epidemiological context, (2) the development of health infrastructures (number of hospitals, maternity clinics, health personnel, etc.) and their distribution across the country, (3) health programmes (vaccinations, programmes to control particular diseases – HIV infection, malaria, etc..). We examine in particular whether the changes in the pace of child mortality decline (acceleration, or slowdown, stagnation or reversal) are concomitant with changes in the epidemiological context or in health infrastructures and programmes. We also examine in detail the changes in causes of death. As there are no sufficiently reliable statistics on causes of death at the national level, we examine changes in three Senegalese rural areas: Bandafassi, Mlomp and Niakhar. The populations of these areas have been monitored for more than twenty-five years and changes in child mortality and causes of child death have been documented in detail.

1.2. Changes in health infrastructure and health programmes in Senegal since 1945

Until 1978, health infrastructure (hospitals, maternity clinics) in Senegal was concentrated in the cities. Public health programmes to improve sanitary conditions and control disease were developed primarily in the towns, building on these infrastructures. The poorly served rural areas received only periodic visits of mobile teams from the Major Endemic Diseases Department (Service des Grandes Endémies). In 1978, following the recommendations made at the World Health Conference in Alma Ata in 1977, Senegal introduced primary health care. Paralleling the effort towards decentralization of the major health facilities (hospitals and dispensaries), this policy led to the training of community health workers and the establishment of village health centres and maternity clinics. Using these new village-based infrastructures, several mother and child health care (MCH) programmes were initiated to provide services such as vaccinations, malaria prevention, rehydration of children suffering from diarrhoea, pregnancy monitoring and assistance in delivery, and food supplements for young children.

1.2.1. Health infrastructures

The number of hospitals increased three-fold between 1960 and 1988, reflecting the policy to equip each region with a hospital and to divide some hospitals in the cities into two separate entities (Pison et al., 1995). The number of hospitals increased only slightly thereafter, by 25% from 1988 to 2008 (from 16 to 20). The number of hospital beds has not grown proportionally however, and has not even kept pace with population growth. Thus, the supply of beds per inhabitant has halved since 1988.

The number of health centres has doubled over the last 50 years while the population has quadrupled. These health centres are normally run by a physician and are equipped with hospital beds. The number of dispensaries has been multiplied by five over the same period. Operated by nurses, they are found throughout the country, generally in district (arrondissement) capitals or rural communities (Senegal, 2009).

Maternity clinics were rare and, until 1977, concentrated in the towns. Beginning in 1978, the primary health care policy led to the construction of a large number of such clinics in rural areas. In 1988, there were almost as many rural maternity clinics as there were dispensaries.

The distribution of facilities between Dakar and the rest of the country is still unequal. It improved considerably in the 1960s and the 1970s, but progress has slowed since then. In 1960, the Dakar region, which accounted for 14% of the population, had three-fifths of the country's hospitals and the vast majority of its hospital beds. In 1988, it had 22% of the population, but only 6 out of 16 hospitals and half the hospital beds. Twenty years later, in 2008, the proportion had not changed much: it still had 22% of the population, 8 out of 20 hospitals and half of the hospital beds (Senegal, 2009). Health personnel remain very concentrated in Dakar, where two-thirds of the country's physicians, pharmacists and dentists and half of its nurses and midwives are to be found (Senegal, 2009).

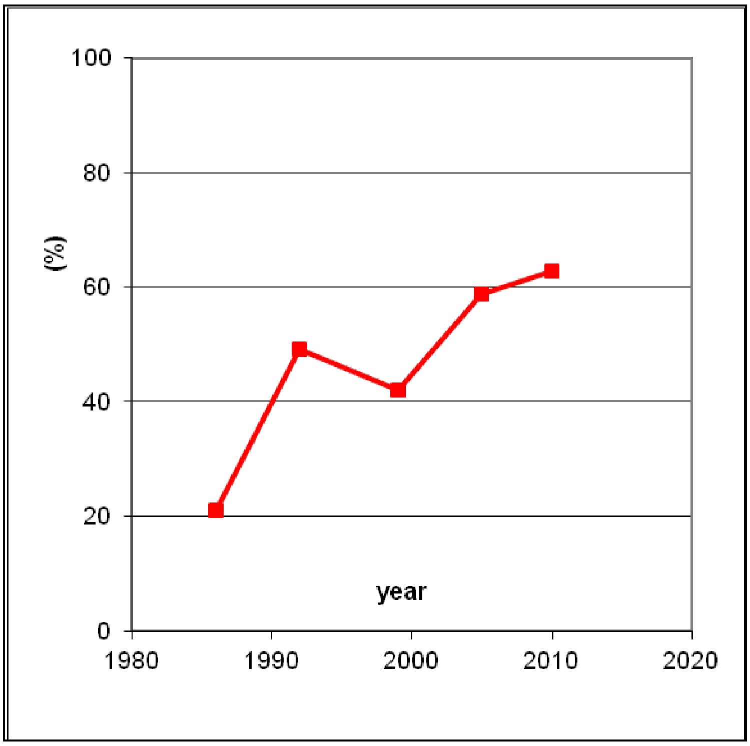
1.2.2. Health programmes

Numerous programmes were implemented before 1978, each one having a specific scope of action. They were carried out either by MCH centres in urban settings, or by mobile teams (in the cases of smallpox eradication and control of leprosy). After 1978, these programmes were integrated into the general primary health care programme carried out by the dispensaries and mobile vaccination teams. Two of these specific programmes, vaccinations and the anti-malaria campaign, are discussed in greater detail below.

— Vaccinations

Initiated in Senegal in 1981, the Expanded Programme for Immunization (EPI) was designed to extend vaccination coverage to poorly served rural areas and to improve coverage in urban areas. Its objective was to protect children against seven diseases: tuberculosis, diphtheria, tetanus, pertussis, polio, measles and yellow fever.

Figure 4. Change in the proportion of fully vaccinated* children aged 12-23 months in Senegal



Source: DHS surveys in Senegal

*Note: in 2010-2011 a child fully vaccinated received BCG, measles vaccine, three doses of Pentavac (conjugate vaccine against diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae type b) and three doses of polio vaccine (not including the polio dose received at birth). In 1992-1993, 1997, 2005, the conjugate vaccine was DTP (against diphtheria, tetanus and pertussis).

The programme targeted young children and also pregnant women, who were given tetanus vaccinations to protect their newborns against neonatal tetanus.

Since the EPI first began, its activities have varied in intensity, with periods of accelerated efforts followed by periods of lesser activity. Each acceleration involved the training and mobilization of administrative and health personnel, media information campaigns (especially by radio), and the supply of new equipment for dispensaries. There was a major acceleration effort, for example, in the first quarter of 1987, when it was decided to improve coverage in poorly served rural areas. Substantial efforts were also made at the end of the 1990s and in the 2000s, linked to the world effort to eradicate polio. In particular, polio vaccinations (with measles vaccine and vitamin A supplements) were given to children during "National immunization days".

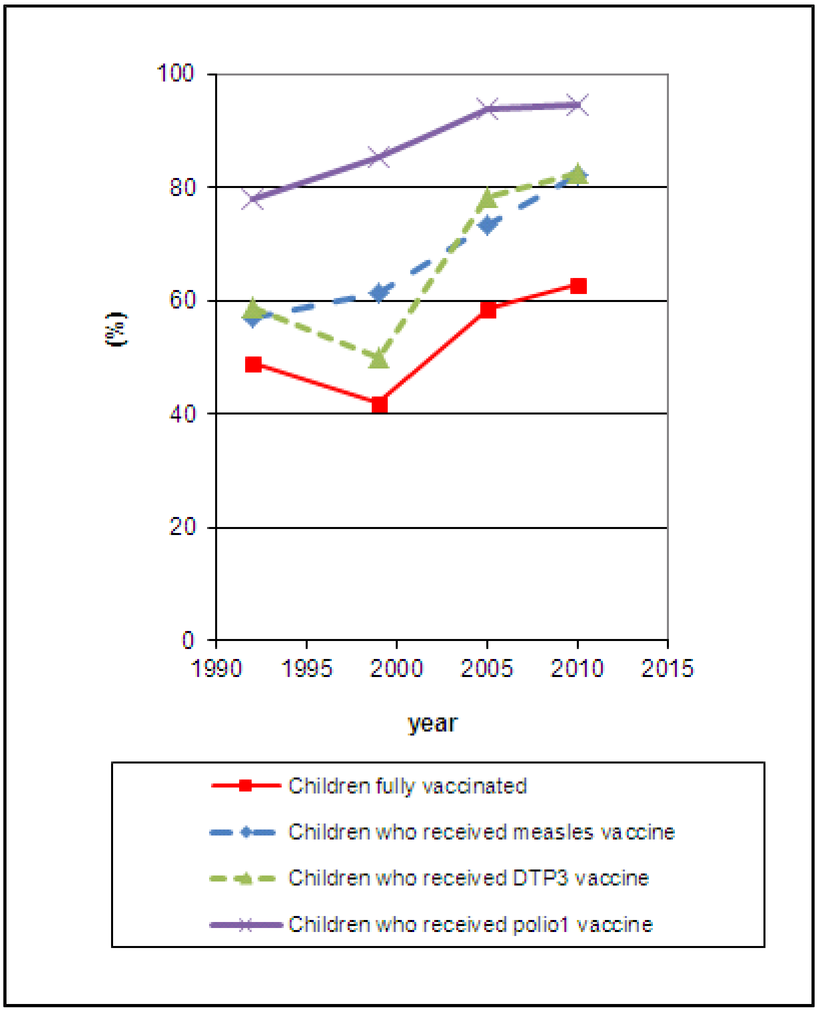
The fluctuation of vaccination efforts is reflected by the changing levels of vaccine coverage. The percentage of children aged 12-23 months who were fully vaccinated[2] increased considerably in the second half of the 1980s. Based on data from demographic and health surveys and multiple indicator surveys, it progressed from 21% in 1986 to 49% in 1992 (figure 4). Complete vaccination coverage increased 1.2-fold in the Region of Dakar between 1984 and 1987, and 1.5-fold in the other urban areas (Pison et al., 1995). The impact of the EPI acceleration in 1987 was therefore relatively small in the towns. In rural areas, on the other hand, where coverage was particularly low in 1984, there was a three-fold increase in 1987, so that the urban-rural gap in coverage levels was almost closed in one go.

Vaccination coverage declined rather than continuing to increase in the 1990s. The proportion of fully vaccinated children aged 12-23 months decreased from 49% in 1992 to 42% in 1999 (figure 5). After renewed vaccination efforts that year and in the 2000s, vaccination coverage rose again, with respectively 59% and 63% of fully vaccinated children aged 12-23 months in 2005 and 2010 (Ndiaye et Ayad 2006 ; ANSD 2011).

Figure 5 shows the changes in the proportions of children aged 12-23 months who received specific vaccines (polio 1, measles vaccine, DTP3) during the 1990s and the 2000s. Vaccination coverage for polio and measles remained stable in the 1990s. The point at the end of the 1990s corresponds to the estimate provided by the 1999 DHS survey which took place just after efforts began in 1999 to increase polio vaccine coverage as part of the world effort to eradicate polio. During the preceding years, measles and polio vaccine coverage had declined, however (UNICEF/WHO 2012). Thanks to the campaign initiated in 1999, nearly 95% of children had received the polio1 vaccine in 2005 and 2010. As measles vaccination and vitamin A supplements were increasingly offered alongside polio vaccines during national immunization days ("polio days") and, after 2005, during the "Journées de la survie de l'enfant" (Child survival days), measles vaccine coverage also increased in 1999 and the following years. This increase was also due to the resumption of routine vaccination activities through the EPI, as revealed by the large rise in DTP3 vaccine coverage during the 2000s (figure 5).

[2] the definition is provided in a note of Figure 4.

Figure 5. Changes in the proportion of children aged 12-23 months who received specific vaccines (polio 1, measles vaccine, Penta3) during the 1990s and the 2000s in Senegal



Source: DHS surveys in Senegal

Note: the definition of a child fully vaccinated is provided in a footnote of figure 4

Anti-tetanus vaccination of pregnant women increased considerably in the 1980s and 1990s. The proportion of women having received at least one anti-tetanus injection during their pregnancy increased from 31% for those giving birth during the period 1981-86, to 71%, 84% and 90%, respectively, for those who delivered in 1987-1992, 1992-1997 and 2000-2005. The vaccines received during a pregnancy ensure protection over several years, and subsequent children are also protected, even if the mother has not been revaccinated. Consequently, immunity to neo-natal tetanus resulting from the anti-tetanus vaccinations of pregnant women progressed even more than the figures indicate.

— Malaria control programmes

Malaria is endemic in Senegal and one of the major causes of child mortality. From the 1950s to the 1990s, anti-malaria programmes were based on prevention, using chloroquine-based chemoprophylaxis (called 'chloroquinization'), and on treatment, also based on chloroquine, the cheapest antimalarial drug. However, in most areas of the country, it was not until the 1970s and 1980s that chloroquine progressively became accessible to a significant proportion of the population. This policy was brought into question following the emergence of chloroquine-resistant strains of the parasite at the end of the 1980s and their rapid spread across the country in subsequent years (Sokhna et al., 1997; Trape et al., 1998 ; Trape et al., 2002). It was not until the end of 2003 that a new treatment combining amodiaquine + sulfadoxine/pyrimetamine (AQ+SP) was introduced to replace chloroquine for the first-line treatment of malaria in all health facilities in Senegal. In 2006, this treatment was replaced by a combination of artesunate + amodiaquine, known as ACT (Artemisinin-based Combination Therapy). Malaria rapid diagnostic tests were also introduced in 2007 in all health facilities to ensure rapid and effective treatment. A programme of mass distribution of insecticide-treated nets (ITN) was also launched in 2008 throughout Senegal (Senegal, 2010 ; Trape et al., 2011), in some cases coupled with distribution of mebendazole - to treat infestations by worms - and vitamin A supplements to all under-5s, (during the Journées locales de supplémentation en vitamine A couplées au déparasitage (JLS) in 2009, for example).

Trends in the proportion of children benefiting from these new malaria control methods can be tracked using the national surveys conducted since 2005. The proportion of households who reported having at least one mosquito net increased from 38% to 72% from 2005 to 2010-2011, and the proportion with at least one insecticide-treated net (ITN), from 27% to 63% (Ndiaye et Ayad 2006 ; Ndiaye et Ayad 2007 ; Ndiaye et Ayad 2009 ; ANSD 2011). The proportion of children under age 5 who slept under an ITN during the night preceding the survey increased from 10% in 2005 to 35% in 2010-2011.

The treatments received by children under age 5 have also changed. Among those who had a fever during the two weeks preceding the survey (30% in 2005, 23% in 2010-2011), 12% took antimalarial drugs rapidly, the same day or the next day in 2005, versus 6% in 2010-2011. The proportion was lower in 2010-2011 possibly because some of the children with fever had a rapid malaria test, which in general turned out to be negative, ruling out malaria as a cause of the fever[3]; this test could not be done in 2005 since it was not yet available in health facilities. The proportion of parents who reported having use chloroquine to treat their child was still high in 2005 (two-thirds of treatments the same day or next day) although since 2003 the official recommendation has been to no longer use it and only amodiaquine and sulfadoxine-pyrimethamine has been available for oral treatment of malaria in public health

[3] Malaria transmission is seasonal in Senegal with a peak of transmission from August to November (this period is an average: the transmission period is in general shorter in the north of the country, and longer in the south, and also varies locally depending on the presence or not of stagnant water) (Trape et al., 2012). The 2005 DHS survey took place between February and June, a period when malaria transmission was low, and the majority of fever episodes among children were not malarial. The 2010-2011 DHS survey took place between October 2010 and May 2011, a period when malaria transmission was also generally quite low, with the exception of the regions which were the first to be surveyed, in October and November.

posts and in hospitals. However, after 50 years of use, any oral malaria treatment was still called “chloroquine” treatment by the population, so this may explain the apparently high level of usage. In 2010-2011, it was much less frequently reported, in less than one-sixth of cases; half of the children benefiting from rapid administration of antimalarial drugs received ACT.

1.2.3. The impact of changes in health infrastructure and health programmes on child mortality

Child mortality, as we have seen above, declined continuously in Senegal between World War II and the late 1980s. In 45 years, from 1945 to 1990, the probability of dying before age 5 was reduced by two-thirds, from approximately 400 per 1,000 to 140 per 1,000. The decline accelerated in the late 1970s and early 1980s, when a new health policy focusing on primary health care was initiated. The ensuing development of health infrastructures in the various regions, and the implementation of the Expanded Programme for Immunization (EPI) probably contributed significantly to the acceleration of decline (Pison et al., 1995).

The stagnation of child mortality in the late 1980s and early 1990s coincided with a slowdown of improvements in health infrastructures and programmes. In particular, the EPI, which had proved highly successful during the 1980s, marked time over this period, with a decrease in vaccination coverage during the 1990s. This decrease is probably one factor behind the absence of progress in child mortality in the 1990s, while the resumption of vaccination efforts in the late 1990s and early 2000s is one of the reasons for the renewed mortality decline thereafter.

The stagnation of child mortality in the 1990s also corresponds to the spread of chloroquine resistance in Senegal, which probably resulted in an increase in malaria deaths among children. However, the new malaria control policy developed in the 2000s has progressively changed behaviours and treatments and this has probably contributed to the renewed decline in child mortality, alongside the resumption of vaccination efforts.

The changes in socioeconomic conditions may also have had an influence. The average level of education is still quite low, particularly for women: in 2010, only 3% of women aged 15-49 had completed secondary education or higher (ANSD, 2011). However, the proportion of Senegalese women aged 15-49 with no formal education has decreased regularly over the last decades, from 85% in 1978 to 58% in 2010. Economic growth was slow in Senegal over the 1980s and the 1990s. Gross domestic product (GDP) per capita expressed in current prices remained at around 550 US$ throughout this period with no overall increase (International Monetary Fund, 2011). The trend has since changed, however, and GDP per capita nearly doubled over the 2000s. If GDP per capita is expressed in international dollars using a purchasing power parity, it has increased continuously since 1980 with an acceleration at the end of the 1990s and in the 2000s. Although there is some correlation between GDP and mortality trends, it is difficult to estimate the precise contribution of economic growth to short term fluctuations in child mortality.

For a better understanding of child mortality trends in Senegal, we shall now examine changes in the causes of death. Unfortunately, as mentioned above, reliable information is not available for causes of death on a national scale, but the observations made in the three rural demographic surveillance sites give an idea of the changes that have taken place in this country.

2. Changes in child mortality and causes of death recorded in the three rural demographic surveillance sites of Senegal

The populations of three Senegalese rural areas, Bandafassi, Mlomp and Niakhar, have been monitored for more than twenty-five years (Pison et al, 1993 ; Pison et al., 1997, Delaunay et al., 2001). Changes in child mortality and causes of child death in these populations have been documented precisely. As these demographic surveillance sites are located in very diverse regions, the mortality differences between them give a certain sense of overall geographic variations across the country.

2.1. The Bandafassi, Mlomp and Niakhar surveillance sites

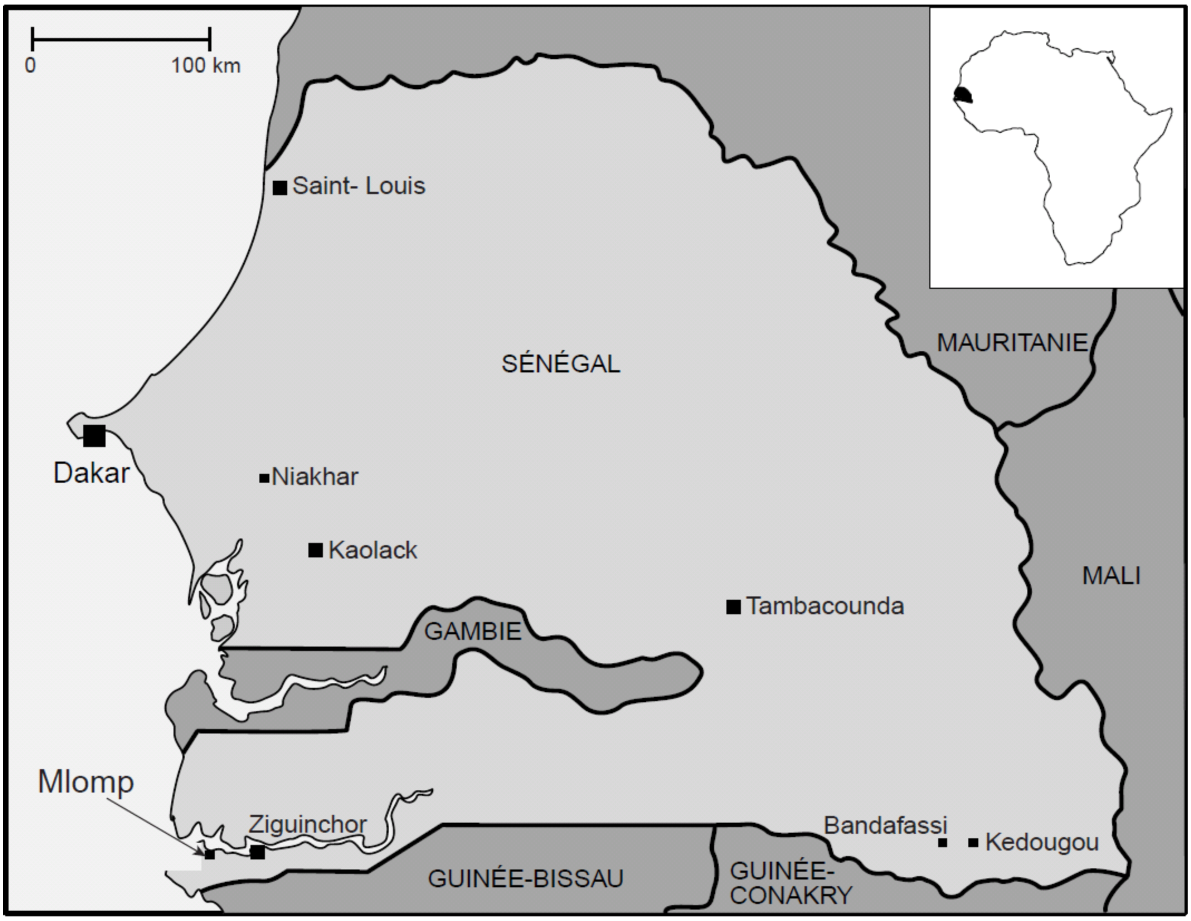
2.1.1. Locations and characteristics

The Bandafassi site is situated in south-east Senegal. It is the site farthest from Dakar, the capital city, located 750 km away (figure 6). Mlomp, located in the south-west, is at a distance of 500 km, and Niakhar, in the western and most populated area of the country, is the closest to the capital (150 km from Dakar).

In 2010, the three sites had populations of about 13,000 (Bandafassi), 43,000 (Niakhar), and 8,000 (Mlomp). Population density differed greatly from one site to the other, with the highest density in Niakhar (177 inhabitants per square km), the lowest in Bandafassi (19) and intermediate levels in Mlomp (63). The ethnic composition also varies. In Niakhar, it is homogenous, with 96% of the population belonging to the Serer ethnic group, and in Mlomp likewise, one ethnic group, the Diolas, represent 99% of the inhabitants. The population of Bandafassi is more diverse, however, and divided into three ethnic groups: the Fula (57% of the population), the Bedik (28%) and the Mandinka (16%)[4]. Detailed descriptions of these three sites are given elsewhere (Pison et al, 1993; Pison et al., 1997; Delaunay et al., 2001).

The populations of the three sites have access to health centres operated by nurses: one in Bandafassi, one in Mlomp, and three in Niakhar. Their level of activity varies. The Mlomp dispensary is the busiest; in addition to an outpatient clinic it has 12 hospital beds and a small laboratory. Nearly all pregnant women in Mlomp attend prenatal visits and deliver in a maternity clinic, most frequently the one located close to the health centre, which has 10 beds. When it is anticipated that delivery may be difficult, the pregnant woman is systematically taken to Ziguinchor hospital (at a distance of 50 km) some time before delivery. Deliveries in the Mlomp maternity clinic are assisted by two matrons supervised by the nurse from the health centre (Pison et al., 1993).

Figure 6. Location of Bandafassi, Mlomp and Niakhar sites in Senegal



4 Fertility is high in all three sites, but with appreciable differences between them. In 1990, it was highest in Niakhar, where the total fertility rate was, on average, 7.7 children per woman, lowest in Mlomp (5.0) and intermediate in Bandafassi (6.3).

The health centres of the other two sites are less active, and the proportion of women delivering in a maternity clinic is low: 15% in Niakhar during the 1988-1997 period, and 3% in Bandafassi (Pison et al., 2000). Throughout Senegal, about one woman in two delivered in a maternity clinic during the 1988-1997 period, the proportion increasing to 62% during the 2000-2004 period and 73% in 2006-2010 (Ndiaye et Ayad 2006 ; ANSD 2011). The proportion is higher in towns than in rural areas: respectively 80% and 30% during the 1988-1997 period, 88% and 47% in 2000-2004, and 93% and 60% in 2006-2010 (Ndiaye et al., 1994 ; Ndiaye et al., 1997). The proportions observed in Niakhar and Bandafassi are therefore well below the average for rural areas of the country. The exceptional situation in Mlomp, where the level is very high and well above the urban average, results from the efforts of health personnel in the area, and the delivery traditions of the Diola ethnic group, who do not favour home delivery (Enel et al., 1993).

Mlomp also preceded the other sites with vaccinations. At the outset, in 1971, the vaccination programme only involved a few of the children, but by the late 1970s it had gradually increased in influence until practically all children were fully vaccinated. Vaccination coverage has been maintained at this very high level up to the present day. In Bandafassi, apart from vaccinations received during national campaigns, practically no children were vaccinated until 1987. It was only then, following the acceleration of the EPI organised at the beginning of that year, that child vaccination began on a regular basis, resulting that year in a sudden increase in vaccination coverage. From a level of practically zero it rose to 48% of children aged 12-35 months in February 1987 (Desgrées du Loû and Pison, 1996). Over the following years, efforts waned and vaccination coverage tended to decrease, but with the resumption of the EPI in 1995 it peaked again, this time at a level even higher than in 1987, with 80% of the children fully vaccinated. Unfortunately, efforts waned once more in subsequent years and coverage rapidly fell to below 50% in 1999 (Guyavarch, 2003).

2.1.2. Population surveillance

The population of each site has been monitored for many years by means of multi-round survey techniques (Pison et al, 1993; Pison et al., 1997; Delaunay et al., 2001; Guyavarch, 2003; Duthé, 2006; Kante, 2009). Following an initial census, villages are repeatedly visited on a regular basis. The list of those present on the previous occasion is checked during each visit, and information is collected concerning the births, marriages, migrations and deaths (including cause of death) that have taken place in the meantime. Surveillance did not start in the same year in the various sites, and the frequency of visits is different. In Bandafassi and Mlomp, where surveillance started in 1970 and 1985, respectively, visits are carried out on an annual basis, whereas in Niakhar, where surveillance started in 1984, the frequency of visits has changed. It was annual from 1984 to 1986, weekly from 1987 to 1997, three-monthly from 1997 to 2005, and subsequently four-monthly.

As in many rural African areas, most deaths occur without the presence of a doctor to certify the event or diagnose the cause. The cause of death is determined by the 'verbal autopsy' method, which involves collecting information on the circumstances of the death and the symptoms of the disease that preceded it from the family of the deceased person. The same questionnaire is employed for these interviews at the three sites (Garenne and Fontaine, 1988 ; Desgrées du Loû et al., 1996b).

Information collected directly from the family is collated with clinical information from the health centre or hospital registers for those patients who died or had a clinical examination there before their death. In the case of Mlomp, most people who died had visited the health centre during their final illness, and information is consequently available from the register kept by the nurses from the beginning of the follow-up. The completed verbal autopsy questionnaire is submitted to two doctors who each make an independent diagnosis. If they disagree, a third doctor rereads it and acts as an arbiter.

The accuracy and reliability of diagnoses based on this method is variable, depending on the cause of death (Snow et al., 1992 ; Soleman et al., 2006). Neonatal tetanus, for example, is quite easily identified by this means, as is measles. There is a specific word for measles in every language in those three populations as in the other sub-Saharan African languages, and everyone can identify it when an epidemic breaks out. When a mother who has lost her child is asked whether the cause of death was ‘measles’ (using the name employed in her own language), she is seldom mistaken, and her personal diagnosis can generally be considered reliable[5]. For many other diseases, however, diagnosis through the verbal autopsy method is not very reliable. Malaria, for example, is easily mistaken for other diseases that also involve fever (Snow et al., 1992 ; Desgrées du Loû et al., 1996 ; Duthé, 2008) (see also discussion below).

Information gathered by the population surveillance systems at the three sites is of high quality for African rural populations. In particular, coverage of events is practically exhaustive and their dating is precise, so reliability of the resulting demographic measures is good, in particular those relating to mortality level and trends.

2.2. Child mortality trends in the three Senegalese demographic surveillance sites

The mortality trends of children under five (5q0) in the three Senegalese demographic surveillance sites are shown in figure 7.

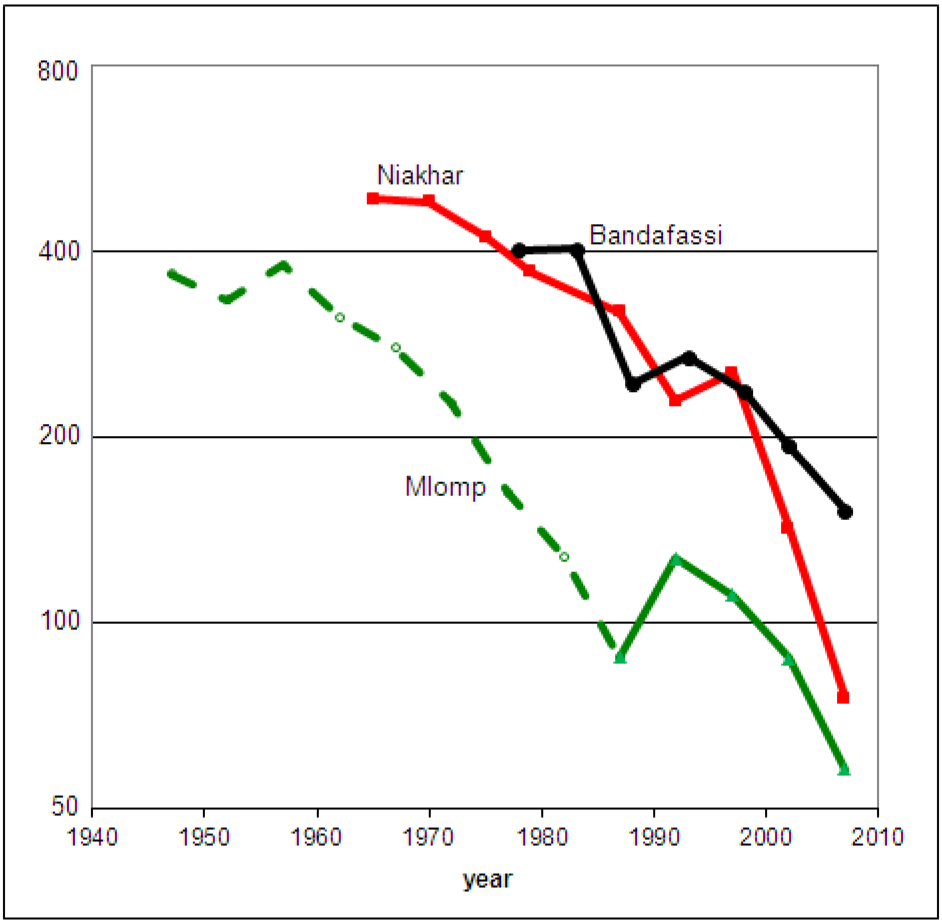
Similar patterns are found in the three areas studied: a first period with a plateau and a second period with a fall. The fall was interrupted in a similar fashion in the late 1980s on the three sites, and child mortality subsequently levelled off or even rose slightly during the 1990s. Mortality then started to decline again rapidly. The simultaneous stagnation observed on the three sites is concomitant with the trend observed at national level based on national survey

[5] However, due to the spread of immunization since the 1980s and the resulting decline in epidemics, self-diagnosis of measles is not as reliable as in the past.

estimates; this shows that this stagnation was real and is not an artefact related to measurement problems.

Figure 7. Child mortality (5q0, per 1,000) by five-year period years in the three rural sites of Senegal: Bandafassi, Mlomp and Niakhar

(5q0: probability for a new-born child of dying before age 5) (log scale)



Sources : Bandafassi, Mlomp and Niakhar demographic surveillance sites

Note: for the Mlomp site, estimates for the period 1945-1984 are derived from maternity histories collected retrospectively in 1985, and for subsequent years, from the surveillance data. For the Niakhar site, estimates for the period 1963-1983 are derived from surveillance data collected on a fraction of the present DSS (about one third).

The differences between the mortality trends on the three sites concern timing and levels. Bandafassi, the site farthest from Dakar, was the last site to witness a rapid decline in child mortality (after 1986), and this decline coincides with the acceleration of the Expanded Programme of Vaccination in 1987 (Desgrées du Loû and Pison, 1996a). As mentioned above, the proportion of vaccinated children was very low until that year. The vaccine coverage then increased sharply in the area as a result of the vaccination campaign of 1987, with nearly half of all children fully vaccinated just afterwards. Child mortality (5q0) then decreased rapidly: it was 40% lower during the six years after the acceleration of the EPI than during the six years before (Desgrées du Loû and Pison, 1996a).

In Niakhar, 150 km from Dakar, the fall began earlier, starting in the early 1970s. This was attributed primarily to a reduction in malaria due to lower rainfall (Cantrelle et al., 1986), but the decline continued at the same rate after the dry years had passed. The measles immunization campaign from 1978 to 1982, the introduction of EPI in the early-mid 1980s, more progressively than in Bandafassi, and campaigns for promoting malaria chemoprophylaxis and presumptive treatment of fever with chloroquine, are probably the main reasons for the initial mortality decrease observed from the mid 1970s up to the early 1990s (Delaunay et al., 2001 ; Trape et al., 2012).

The Mlomp zone was clearly different from the other two in that the fall started earlier (from the mid-1960s), and reached a much lower level – the risk of death before 5 years declined four-fold in 20 years. As mentioned above, this rural zone, very distant from Dakar, has been equipped since 1961 with a dispensary and a private maternity clinic providing quality health services to a large majority of the population in the area (Pison et al., 1993).

There is a correlation between mortality decline and the availability of health services in these three rural zones before the stagnation of the 1990s. The educational level of women and household incomes at the time were low in all these areas. The rapid fall in child mortality in rural areas of Senegal during the late 1970s may therefore be closely linked to the decentralization of infrastructures, and to the new public health policy which provided new services to populations with no previous access to health care.

The study of causes of death provides insights on the mechanisms of mortality decline.

2.3. Distribution of causes of death during the 1980s

Figures 8 and 9 compare child mortality and its causes in Bandafassi, Mlomp and Niakhar during the second half of the 1980s (1984-1989 period in Bandafassi and Niakhar, and 1985-1989 in Mlomp), distinguishing neonatal mortality (figure 8) from mortality between one month and five years (figure 9).

Neonatal mortality was lowest in Mlomp (36 per thousand) and highest, more than double, in Bandafassi (87 per thousand), with an intermediate level of 55 per thousand in Niakhar. The overall differential was due to differences in mortality for all the major causes of death. Neonatal tetanus, responsible at that time for one third of all neonatal deaths in Niakhar and one quarter in Bandafassi, and accounting on the two sites for the deaths of about 20 newborns per thousand, killed only 1 newborn per thousand in Mlomp. There were almost the same contrasts for deaths due to premature delivery and low birth weight (2 per thousand in Mlomp as against 15 and 21 per thousand in Niakhar and Bandafassi, respectively).

Figure 8 - Neonatal mortality by cause of death in the three demographic surveillance sites of Senegal (period 1984-1989)

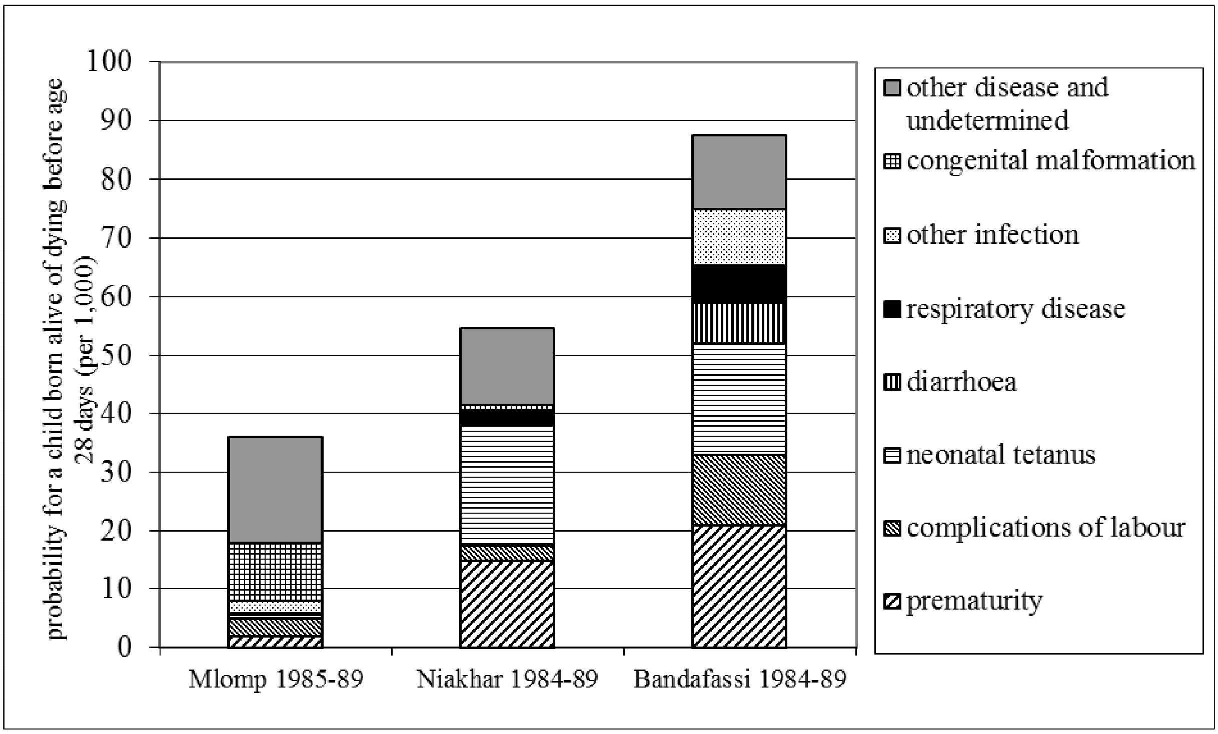
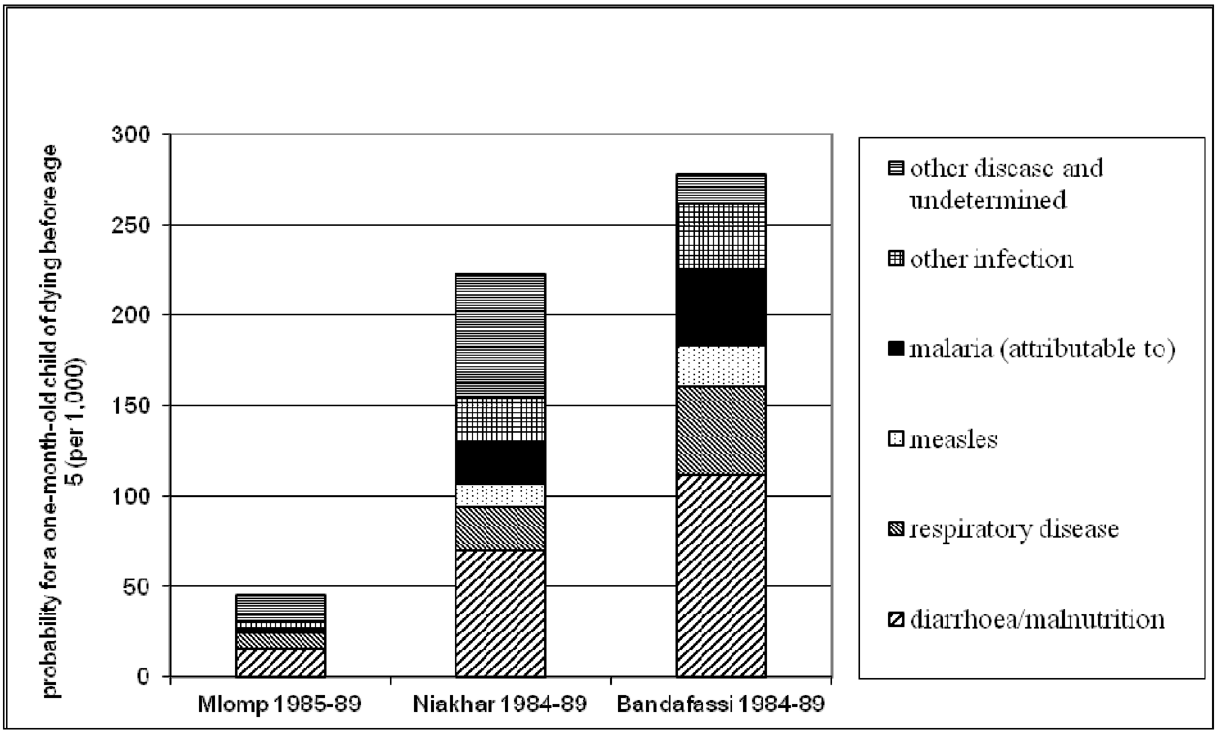


Figure 9 - Mortality of children from age 28 days to age 5 years by cause of death in the three demographic surveillance sites of Senegal (period 1984-1989)



Beyond the neonatal period and up to age 5 years (figure 9), the overall difference in mortality levels was even greater (45, 223 and 277 per thousand in Mlomp, Niakhar and Bandafassi, respectively), and was again linked to the differences in mortality for each of the major causes of death – diarrhoea and malnutrition, pneumonia, malaria etc. Measles, a major cause of death in Bandafassi and Niakhar at that time, was absent in Mlomp.

Unfortunately, we have no information on the causes of child mortality in Mlomp before the 1970s when it was still high there, but it is probable that the same causes as those observed in Bandafassi and Niakhar in the recent period were dominant at the time. If we assume that the causes of death in Bandafassi and Niakhar in the second half of the 1980s reflected those prevalent in Mlomp, twenty years earlier – at a time when death from all causes reached the same levels there – it is likely that there was a fall in each of the major causes of death.

We will now examine in more detail the evolution of two important causes of child mortality: measles, which regressed substantially in the 1970s and 1980s thanks to vaccination, and malaria, which increased in the 1990s before declining rapidly in the 2000s.

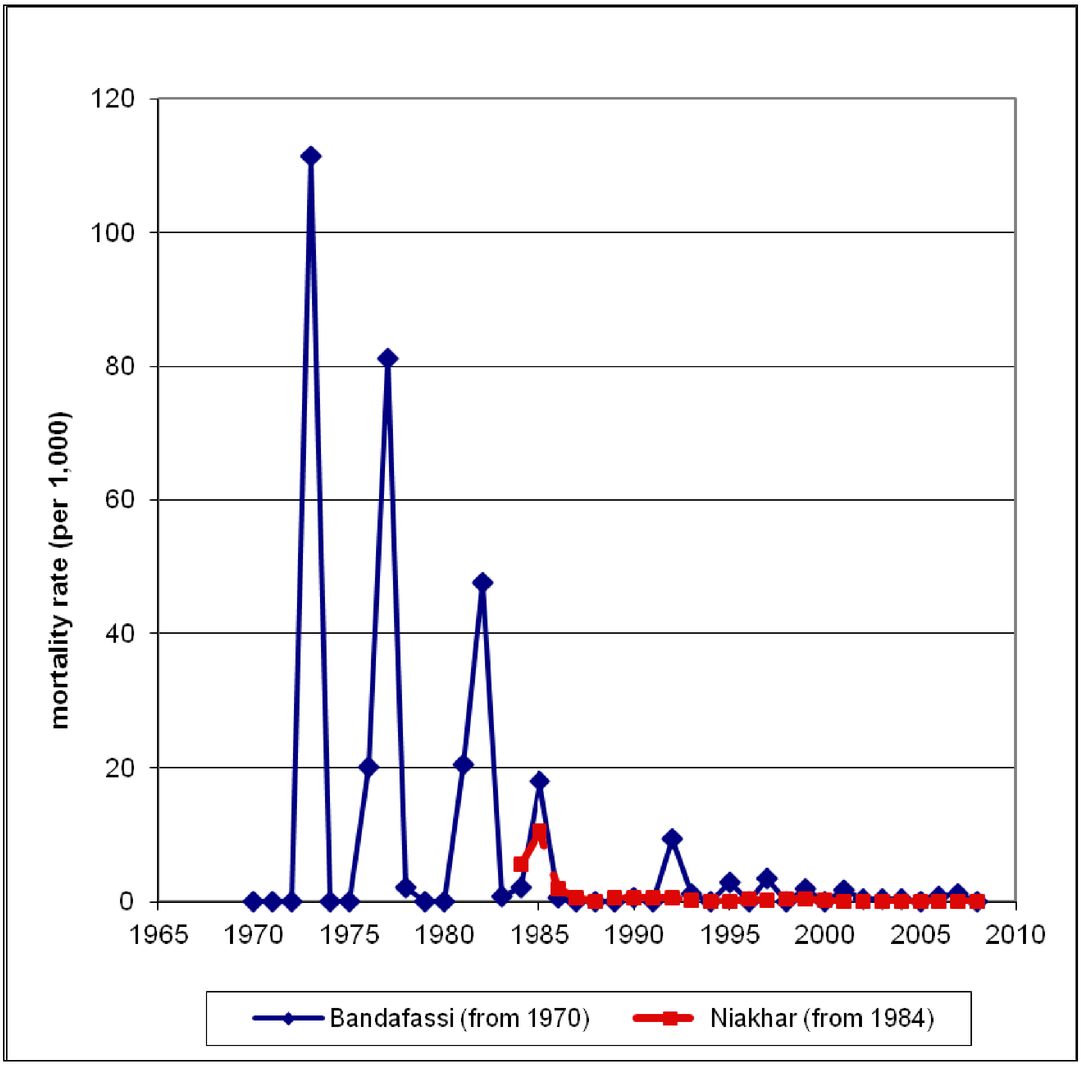
2.4. Measles, a fast regressing cause of death

As just noted, there are large differences between the three sites in deaths from measles. This cause of death disappeared earlier in Mlomp than in the two other sites, accounting for only two deaths of children under 5 in Mlomp during the twenty five years from 1985 to 2010, out of a total of around 430. However, it was still a major cause of death in Bandafassi and Niakhar during the second half of the 1980s.

As mentioned above, measles was a disease that villagers could easily identify until recent decades, so information is available on cases of measles-related deaths occurring in Bandafassi since the start of demographic surveillance in 1970, well before the introduction of verbal autopsy questionnaires in 1984. This makes it possible to trace the evolution of measles-related mortality since 1970 on this site. A change occurred after immunization began in 1987. Before then, measles was responsible for a high proportion of deaths. Among children aged 1-20 months it accounted for about 1 in 7 deaths (14% in 1970-1986), and 1 in 3 deaths (33%) among children aged 21-59 months, thus making it the primary cause of death. From 1987, however, measles was responsible for only 3% and 5% of deaths at these ages during the six year-period 1987-1993 (Desgrées du Loû and Pison, 1996).

Figure 10 retraces the annual variations in measles mortality rates in Bandafassi among under-5s over the entire period, from 1970 to 2008. The annual variations in Niakhar are also shown from 1984. The figure shows that before 1987 measles occurred in the Bandafassi area only in widely-spaced epidemics. More than a decade often elapsed between two successive epidemics in the same village. Because of the long measles-free periods, whenever a village was affected by an epidemic, the impact was devastating – within the space of a few weeks, many children fell ill (practically all those who were born since the previous epidemic), and mortality rates were very high. At least 15% of all under-5s died in the 1976-77 and the 1981-1982 epidemics (Pison et Langaney, 1985).

Figure 10 - Annual fluctuations in under-5 measles mortality at Bandafassi and Niakhar



The epidemiology of measles in Bandafassi changed after the EPI was launched in 1987. Apart from an epidemic which occurred in 1992 and led to relatively fewer deaths than previously, deaths from measles were observed more frequently (every two years) but the numbers in each epidemic were ten to fifty times lower than in the 1970s and the early 1980s. Measles became increasingly endemic, and much less lethal.

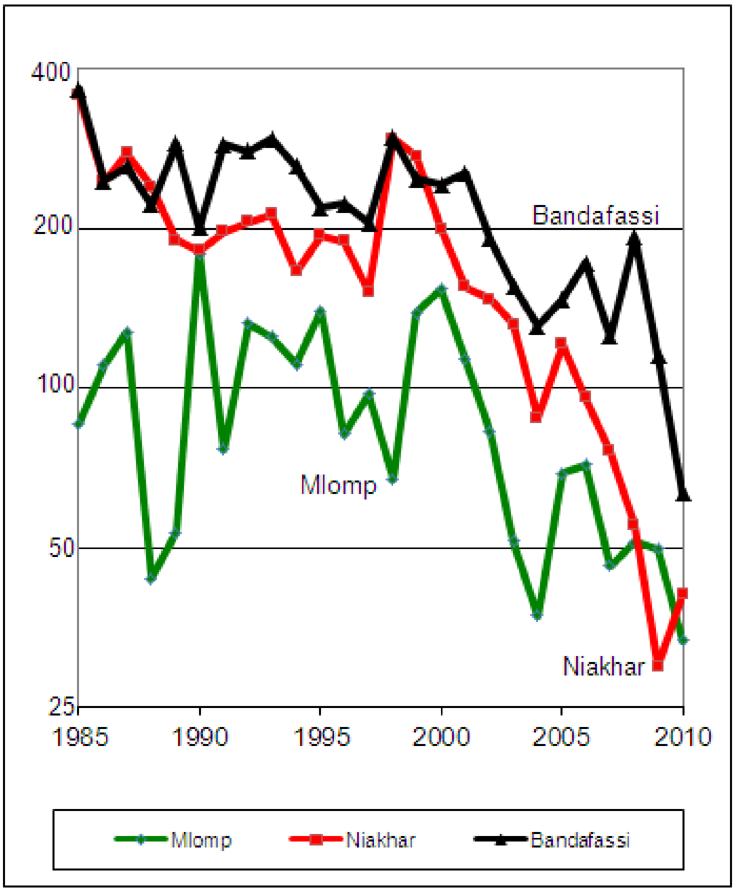
A similar change occurred in Niakhar, although observations shown in figure 10 start only in 1984. The last big measles epidemic, which was national and also affected Bandafassi, took palce in 1985 in Niakhar. Since then, measles has become a much less frequent cause of death.

Measles deaths in both Bandafassi and Niakhar declined considerably in the 1980s, and this marked regression of a leading cause of child mortality was the most spectacular consequence of introducing vaccination coverage in these two populations. The fall in vaccination coverage in the 1990s led to a slight rise in measles deaths in Bandafassi, but well below the extremely high pre-vaccination levels. In Niakhar, measles deaths remained at a relatively low level in the 1990s and the 2000s.

2.5. Temporary rise in deaths from malaria in the 1990s and subsequent rapid decline

The rapid decrease in overall child mortality over the 1970s and 1980s contrasts with the setback observed during the 1990s. Figure 11 shows the year-on-year evolution on the three sites since 1985. In Mlomp, under-five mortality varied considerably from one year to the next between 1985 and 2000, tending to increase slightly over this period. It stagnated during the 1990s in Bandafassi and decreased slightly in Niakhar, with the exception of the years 1998, 1999 and 2000 during which child mortality increased due to a meningitis outbreak (Trape et al., 2012).

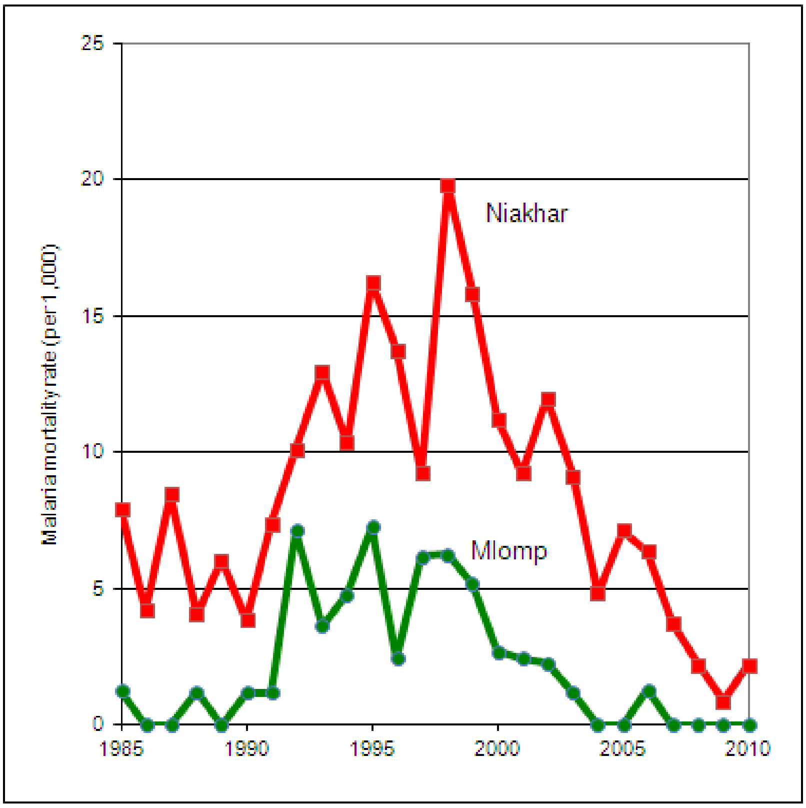
Figure 11 - Annual fluctuations of child mortality (5q0) since 1985 in the three DSS of Senegal (log scale)



In the following years, under-five mortality fell rapidly in the three sites, decreasing nearly four-fold in nine years in Mlomp and Niakhar (if we compare the estimate for the most recent year, 2010, with that for 2001).

Figure 12 shows the evolution of malaria-related mortality in Mlomp and Niakhar since 1985. In Mlomp, it was relatively low until 1991 (eight times lower than Niakhar); a sign that the anti-malaria campaigns organized by the health centre in the 1970s and 1980s were successful (almost all children received chloroquine prophylaxis during the malaria season and all fever cases treated at the dispensary received malaria presumptive treatment). Malaria-related mortality rose sharply between 1990 and 1993, and has subsequently remained at higher levels. During the period 1990-2000, malaria-related mortality increased 7-fold in Mlomp and 3-fold in Niakhar. This rise was attributable to the phenomenon described above: the appearance and spread in the early 1990s of malaria strains that were resistant to chloroquine, the anti-malarial widely used in Senegal both preventively and curatively up to 2003, and which dramatically reduced malaria mortality in Mlomp from 1975 up to the emergence of chloroquine resistance (Trape et al. 1998). This unfavourable trend in malaria deaths is one of the reasons why overall child mortality rose again in Mlomp in the 1990s and stagnated in Niakhar (and in Bandafassi).

Figure 12 - Annual fluctuations in mortality attributable to malaria (5q0) since 1985 in Mlomp and Niakhar

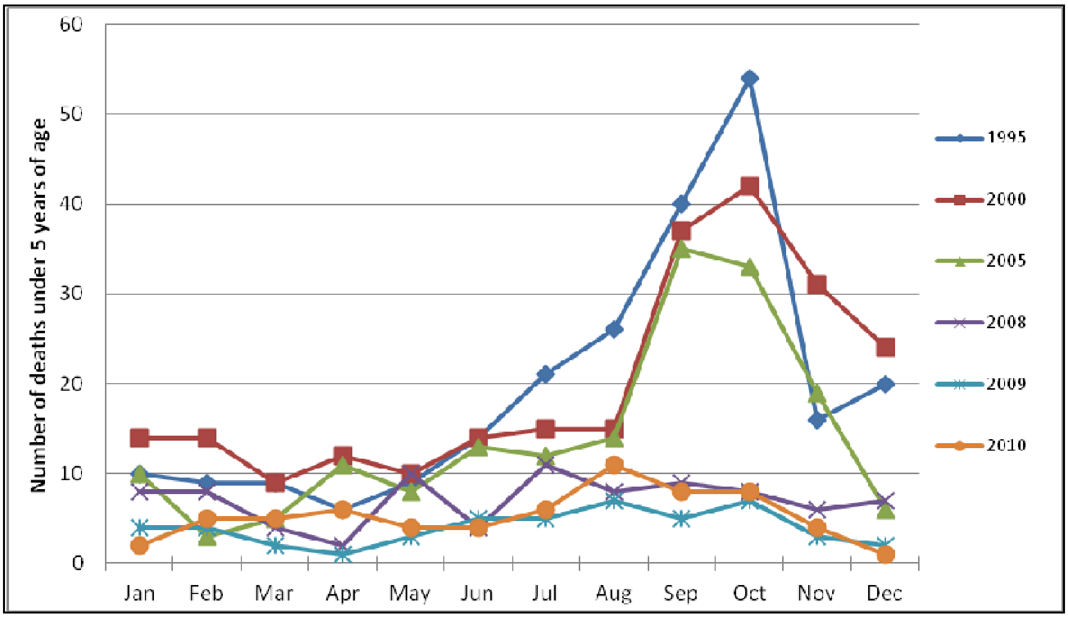


Note : the trends in Bandafassi are not shown because estimation of mortality attributable to malaria is still under review for the most recent period for this site (see explanations in the text)

Following the rise in malaria mortality observed during the 1990s, a striking new phenomenon has been the dramatic decline over the last decade, marked by a rapid decrease in malaria mortality in Niakhar and Mlomp from 2000 onwards. In Niakhar, annual under-five malaria mortality rates were 10.5, 6.1, 5.0 and 2.0 per thousand during the periods 2000-2003, 2004-2005, 2006-2007 and 2008-2010, respectively (Trape et al., 2012). In Mlomp, practically no malaria deaths were recorded after 2003.

How reliable are our estimates of malaria mortality? Deaths from malaria are more difficult to diagnose than those from measles. As mentioned above, both the sensitivity and the specificity of the verbal autopsy technique vary considerably across causes of deaths and by epidemiological context (Snow et al., 1992). Malaria cannot be identified with certainty through the verbal autopsy method, because of the difficulty in distinguishing it from other diseases that also cause fever. So here, “malaria” is a broad category that includes “confirmed malaria” but also “death probably attributable to malaria”. In Mlomp, however, malaria mortality could be retraced with much greater accuracy because most of the children who died following bouts of fever had been examined at the local health centre, where biological tests (using thick blood films with parasite density measurement) were made to verify the malaria diagnosis (Trape et al., 1998). In Niakhar, biological tests were rarely available. However, in the Sahel and sub-Sahel, rains only occur during a short period of the year, and the seasonal peak in child deaths associated with symptoms of high fever, seizure and/or coma occurring a few weeks after the massive increase in malaria vectors allows malaria to be diagnosed with much better sensitivity and specificity than in areas where rains occur all year round (Trape et al., 2012).

Figure 13 - Seasonal pattern of all-cause deaths among children under 5 years of age in 1995, 2000, 2005 and each year since 2008 in Niakhar



Source: Trape et al., 2012

Figure 13, which concerns the Niakhar site, shows large monthly variations in all-cause child mortality until recent years, with a peak during the second part of the rainy season and the beginning of the dry season when malaria vectors are most numerous. The seasonal mortality peak in Niakhar has almost totally disappeared in recent years (2008-2010), and this correlates with the drop in mortality attributable to malaria during this period and the simultaneous drop in prevalence of malaria parasites both in children and adults in this population (Trape et al., 2012). In Bandafassi, where no laboratory tests were available, and where a detailed analysis of mortality data is still in progress, verbal autopsy data indicate trends similar to those of the Niakhar area up to the most recent period (2004-2012).

3. DISCUSSION: LESSONS FROM SENEGAL

Mortality has declined in sub-Saharan Africa over the last 60 years but the decrease has not been regular. It has accelerated over some periods, such as during the last decade, and slowed during others. This is not solely attributable to the HIV/AIDS epidemic. In order to determine other diseases or factors that have also played a role, our study focuses on Senegal – a country with very low HIV prevalence but where trends in child mortality have resembled those of the whole region. In addition, Senegal has the advantage of possessing relatively numerous information sources available for tracing child mortality trends on a national scale, as well as three demographic surveillance sites in rural areas where child mortality can be followed and the causes of deaths studied in detail over almost 25 years.

Senegal experienced an appreciable and steady fall in child mortality from the end of World War II until the late 1980s. In 45 years, from 1945 to 1990, the risk of a newborn child dying before the age of 5 years was divided by three, dropping from about 400 to 140 per thousand. This progress accelerated towards the end of the 1970s and early 1980s, at a time when a new public health policy focusing on primary health care was introduced which led to an increase in primary health care infrastructures in the regions (they had previously been highly concentrated in Dakar), and the launch of the Expanded Programme for Immunization (EPI).

In the three Senegalese demographic surveillance sites, child mortality has declined over the last 30 to 50 years, decreasing six-fold in Bandafassi, seven-fold in Mlomp and ten-fold in Niakhar. In all of them, the fall was interrupted in a similar fashion in the late 1980s, as was the case in the country as a whole, and child mortality then stagnated during the 1990s at Bandafassi and Niakhar, and even rose slightly in Mlomp. Mortality declined again afterwards, at an even more rapid pace than before the stagnation period.

On the three sites, the child mortality decline in the 1970s and 1980s was linked to the reduction in deaths from infectious diseases, thanks largely to vaccinations, which produced for example a spectacular decline in deaths from measles, previously one of the primary causes of child mortality. But in the 1990s, just as in the whole country, vaccination coverage levelled off in Bandafassi and Niakhar, and deaths from measles, while not returning to the previously very high levels, stopped their downward trend. Deaths from malaria, on the other hand, increased sharply following the spread of chloroquine resistance across the country. Stagnation of vaccination efforts and the resurgence of malaria mortality allied to chloroquine resistance explain the halt in the decline of under-5 mortality in Bandafassi and Niakhar. In Mlomp, where nearly all the children had been vaccinated for at least 20 years, it was the rise in malaria mortality that explained the resurgence of child mortality in the 1990s.

These observations are probably valid for the whole country, and malaria deaths must have increased appreciably. The slowdown in the vaccination drive must also have held back the progress in fighting infectious diseases. These two phenomena were the main reasons for the fifteen year stagnation in under-5 mortality in Senegal, a country that, despite having escaped a severe AIDS epidemic and its consequences on mortality, still experienced a health crisis leading to a halt in the decline of child mortality. This crisis was due to a combination of several factors, in particular: a new epidemiological situation created by resistance to chloroquine; an inefficient healthcare system; an inability to ensure basic health services (such as vaccinations); and an unfavourable economic situation.

Mortality decline resumed rapidly in the 2000s, again due to a combination of factors, among which renewed vaccination efforts and investment in anti-malaria programmes played an important role. The decrease in mortality observed on the three sites during the 2000s is the consequence of progress in all the main causes of childhood death, including diarrhoeal diseases and acute respiratory infections. Both programmes probably had a much larger impact than would be expected from a mere reduction or eradication of deaths from malaria or vaccine-preventable infections, and they may have had synergic effects.

When measles vaccine was introduced in Africa in the late 1970s and early 1980s, several studies showed that it coincided with a major reduction in child mortality (Aaby et al., 1995). Since this could not be explained by measles prevention alone, the concept that vaccines have non-specific effects emerged, suggesting that health interventions affect general immunity and that these non-specific effects are broader than specific preventive effects (Kristensen et al., 2000). Vitamin-A supplementation is usually considered the most cost-effective intervention to reduce child mortality, the assumption being that it saves lives by preventing vitamin A deficiency. Its effect is more probably due to an amplification of the non-specific effects of vaccines (Benn et al., 2009).

Hence, vaccination campaigns and vitamin-A supplementation programmes have had a much stronger effect on child mortality than usually assumed. The so-called vaccine-preventable infections including measles, TB, whooping cough, diphtheria, tetanus, and polio, probably do not account for more than 10-25% of the childhood deaths in Africa – the death toll from malaria, diarrhoea, sepsis and respiratory infection being far greater (Benn et al., 2009).

Studies have shown that programmes to control malaria reduced overall child mortality more than would be expected from a mere reduction or even an eradication of malaria deaths. In the 1980s, control of malaria with either seasonal chemoprophylaxis or insecticide-treated nets in The Gambia reduced overall child mortality by nearly 50%, much more than was anticipated, lowering the number of deaths attributed to pneumonia and diarrhoea as well as those attributed to malaria (Alonso et al., 1991). More recently, a malaria control programme on the island of Bioko, which employed both insecticide-treated nets and indoor residual spraying, reduced under-5 child mortality from 152 per 1000 to 55 per 1000 over a 4-year period (Kleinschmidt et al., 2009). How a reduction in the incidence of malaria could have such a marked effect on overall mortality is uncertain, but there is evidence that malaria impairs the immune response, increasing susceptibility to other infections (Mackenzie et al., 2010), and that continuous exposure to malaria slows down weight gain during the malaria transmission season (Shiff et al., 1996).

What lessons can be drawn from the experience of Senegal? With its stable government, strong external support and low prevalence of HIV/AIDS – not many West African countries share these characteristics – Senegal may, at first glance, appear to be a special case. This probably explains why the child mortality decrease in this country over the last forty years was one of the highest in the region (Masquelier et al., forthcoming). It does not explain, however, why the trends have been irregular and why they resemble those in other West African countries, including those affected by social and political instability, war and moderate prevalence of HIV/AIDS (e.g., Côte d'Ivoire).

The changes in health conditions and programmes observed in this country are common to many countries in Sub-Saharan Africa and explain why many of them experienced the health crisis in the 1990s and the renewal of progress in the 2000s, irrespective of whether or not they were hit by the AIDS epidemic. Chloroquine resistance spread to most sub-Saharan African countries in the 1980s and 1990s, often pushing up childhood malaria mortality (Trape et al., 2001 ; Korenromp et al., 2003). Vaccination efforts were erratic in the 1990s, with decreasing coverage in many countries, followed by a renewal of activities in the 2000s. As a result, measles vaccination coverage in Sub-Saharan Africa as a whole declined from 56% in 1990 to 51% in 1999 before increasing to 75% in 2010 (UNICEF/WHO, 2012).

Will the rapid improvement in child mortality in the 2000s continue in the years ahead or will there be another slowdown, as in the past? The decline in child mortality observed up to now has been achieved mainly by preventing deaths after one month of age. The remaining deaths have become more concentrated in the neonatal period, where mortality is partly due to causes other than those affecting the post-neonatal period, and which call for a different set of prevention methods. While efforts to control infectious diseases will be continued, the conditions responsible for early deaths, in particular those in the neonatal period, should receive more attention.

Acknowledgments

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