
Sybil Pinchinat,1 Catherine Enel,2 Gilles Pison,2 Géraldine Duthé,2 Emmanuel Lagarde,3 François Simondon1 and Kirsten B Simondon1

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Background Undernutrition is associated with an increased risk of death among young children in developing countries. Infant and child nutritional status and mortality were monitored in a rural area of Casamance, Senegal.


Results Between 1960–1964 and 1990–1994, under-5 and child (1–4 years) mortality rates decreased from 312 to 127 and from 201 to 68 per 1000, respectively. About 90% of resident children attended growth monitoring in 1985–1992. Mean weight-for-age was at a minimum at 15 months of age (−1.60 z-scores [SD: 0.95]); the prevalence of underweight was 33.2% (95% CI: 31.5, 34.9). The latter increased significantly over time, both when comparing all years of follow-up (P for trend <0.01) and over three pre-defined time periods (28.6, 34.6, and 35.0% in 1969–1974, 1975–1984, and 1985–1992, respectively, P for trend <0.05). Mean weight-for-age decreased over time in infancy and in the second year of life.

Conclusion No improvement in nutritional status was found among young children 1969–1992 despite a drastic decrease in mortality. Focused public health interventions such as vaccinations and malaria prevention probably did not enhance weight-for-age. Paradoxically, growth monitoring may have been more helpful in improving health than growth.

Keywords Growth, nutrition disorders, trends, infant, Africa, mortality

Childhood malnutrition remains a major problem in Africa. In 2000, 35.2% of preschool children were stunted and 9.6% wasted and, in contrast to Asia and Latin America, the prevalence of underweight has increased over the last 20 years in sub-Saharan Africa (from 30.1 to 36.5% in West Africa and from 24.9 to 35.9% in East Africa between 1980 and 2000).1

Underweight, defined as a low weight for the child’s age and sex (classically below −2 z-scores of the NCHS/WHO reference2) can originate from either low weight-for-height (wasting) or low height-for-age (stunting), or both. Many studies have provided evidence for increased risk of mortality among children with low weight-for-age,3 height-for-age,4,5 and weight-for-height in sub-Saharan Africa.6–9 Malnutrition is considered the underlying cause of more than half of all deaths among preschool

1 UR024, Institut de Recherche pour le Développement (IRD), 911, avenue Agropolis, BP 64501, 34394 Montpellier Cedex 5, France.
2 Institut National d’Études Démographiques (INED), 133 boulevard Davout, 75980 Paris Cedex 20, France.
3 U88, Institut National de la Santé et de la Recherche Médicale (INSERM), Hôpital National de Saint-Maurice, 14 rue du Val d’Osne, 94410 Saint-Maurice, France.
Correspondence: Kirsten Simondon, kirsten.simondon@mpl.ird.fr

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children in developing countries, strongly suggesting that a reduction in malnutrition could have a major impact on survival of these children.

Conversely, a reduction in mortality is not necessarily associated with a decrease in the prevalence of malnutrition. Some studies have reported a persistent high prevalence of malnutrition despite significant decreases in infant mortality and in the prevalence of infectious diseases. The objective of the present study was to analyse the trend in nutritional status of young children during a 24-year period (1969–1992) in a rural area of Senegal where drastic reductions in mortality and fertility rates were observed during this period of time.

Methods
Study design
An analysis of weight data recorded by Catholic nuns through a growth monitoring programme operating since 1969, compared with mortality data on children <5 years of age in a Senegalese population which has been under yearly demographic surveillance by the French National Institute of Demographic Studies (INED) since 1985.

Study area and population
The study was conducted in a rural community near Ziguinchor in Casamance, southern Senegal (7591 inhabitants on 1 January 2000). Characteristics of the study area have been published previously.

Since 1961, French Catholic nuns who are also professional nurses have been in charge of a private dispensary located in the village. This dispensary delivers permanent, high-quality service and is well-attended.

Demographic surveillance
Following a population census in 1984–1985, demographic events and causes of death have been monitored yearly. During the initial census, all women were interviewed concerning the birth and survival of their children. Since 1985, yearly censuses, usually conducted in January–February, have been recording demographic data, including all births, deaths, and migrations. The completeness and accuracy of dates of birth and death are cross-checked against those noted during demographic surveillance. The birth date, sex, and address reported in the register were confirmed by the mother. The first weighing sessions were stopped, but in this area the nuns continued weighing sessions. However, food was no longer provided.

During sessions, the nurses provided nutrition education messages (i.e., no complementary food prior to 3–4 months postpartum, preparation of high-energy and nutrient-dense infant gruels using local foods), and advice on illness management (oral rehydration during diarrhoea), and hygiene (well and water-jar disinfection, construction of pit-latrines). From 1975, they also distributed free chloroquine during the transmission season (May–November) for prevention and early presumptive treatment of malaria. From approximately 1985, chloroquine was no longer free, but was sold during sessions. Mothers who brought their ill child to the dispensary for diagnosis and treatment were expected to attend growth monitoring as usual.

Anthropometric data
During the sessions, children were weighed wearing light clothes on a Healthometer weighing scale with a precision to the nearest 10 g. The register also contained information concerning identity (name, sex, date of birth) and address, but not dates of weighing sessions. Only the calendar month and year of the first weighing session were noted for each child. All weights were plotted on growth charts kept by the mothers.

The children were not called in for growth monitoring. Villages and hamlets in the rural community were divided into eight groups, each of which was attributed a specific day during the month for sessions (group 1, the first Thursday of each month; group 2, the Tuesday of the second week, etc), so that each mother knew when to attend.

Data management
Data entry used the original registers of the programme. All weight measurements taken 1969–1994 were entered. Dates were estimated using monthly calendars of sessions, and were attributed to children on the basis of their address. The first Thursday of each month was considered the 4th day (from the 1st to the 7th), the Tuesday of the following week was the 9th day, etc. Dates were thus precise to ±3 days.

The birth date, sex, and address reported in the register were cross-checked against those noted during demographic surveillance. All weight gains or losses of >1 kg over a one-month period were investigated. Thereafter, weight-for-age was computed according to the NCHS/WHO reference using Anthro (CDC, Atlanta). Weight-for-age indices above +3 or below −6 z-scores were considered unreliable and excluded from the analyses.

Subjects
A total of 4636 children born 1967–1992 were weighed at least once from 1969 to 1994 between the ages of 3 and 24 months. Ninety-one had an unknown date of birth, 9 had unknown sex or address, 21 had an unknown date at first weighing: 578 had discordant information (on sex, birth date, or address) when comparing registers and demographic data files, and 25 had unreliable weight-for-age at some time point. Therefore, 3912 children (1983 boys and 1929 girls) were available for the analysis. Mean weights of children with discordant information did not differ from those of included children (data not shown).

Analysis
Nutrition data
Infants aged 0–2.9 months were not a target group for the programme and, from 1985, 3–5-year-olds were not a target either.
Since preliminary analyses showed that attendance of 24–36 month olds became poor from 1989 (data not shown), the analyses presented here are restricted to 3.0–23.9 month old children.

Coverage of the growth monitoring programme was computed as the number of children who had attended the programme during the month of February divided by the number of resident children who were not travelling or on migration during that year’s census. It was computed for 1985–1992 only, since the numbers of resident children were not known for earlier periods.

Frequency of participation in the growth monitoring programme was evaluated through the number of sessions attended per child, for children born in 1970 and later (n = 3642).

The change in nutritional status over time was estimated, first, through the trend over all years of follow-up, and second, through the trend over three cohorts of year of birth, determined prior to the analysis: 1969–1974, 1975–1984, and 1985–1992. Weight-for-age was examined at various ages: average of measures during second half of infancy (6–11 months) and during the second year of life (12–23 months), respectively, and at two target ages (i.e. 9 and 15 months). For children with missing weight at the target age, weights during the preceding or following month were used.

**Mortality data**

Mortality rates were computed for infancy (0–11 months, \(1q_0\)), childhood (12–59 months, \(1q_1\)) and under-5s (0–59 months, \(5q_0\)), together with rates for yearly age intervals beyond infancy (\(1q_1\), \(2q_1\), \(3q_1\), and \(5q_1\)). For an age interval \((x, x + n)\), \(xq_n\) is the probability for a child alive at age \(x\) of dying between age \(x\) and age \(x + n\), expressed per 1000 children alive at age \(x\). The probabilities were computed using maternal recall, conducted in 1984–1985, for 1960–1985, and yearly censuses since 1985.

The analyses used BMDP and SAS. Differences were considered significant for \(P\)-values < 0.05.

**Results**

**Participation in the growth monitoring programme**

From 1985 to 1992, the average coverage of the programme during the month of February was 88% for infants aged 3–11 months, and 90% for 12–23 month old children, respectively, (Table 1).

**Overall, 55 707 reliable measurements were available for the analysis. From 3 to 24 months of age, the mean number of sessions attended was 14.9 (i.e. 71%) and the median was 17. These figures, however, include children who had died or moved out of the area prior to 24 months. Children still participating in the programme at 13–15 months of age attended on average 82% of sessions during infancy, while those still in the programme at 22–24 months of age attended 87% of sessions from 12–21 months.**

**Nutritional status by age**

Mean weight-for-age z-score decreased with increasing age up to 15 months for all three cohorts/time periods (Figure 1). Mean z-scores were positive at 3 months of age, decreased sharply until age 10 months, and then decreased more gradually until a minimum of \(-1.60\) (SD: 0.95) z-scores.

The prevalence of underweight peaked at 15 months, at 33.2% (95% CI: 31.5, 34.9, \(n = 3086\)). From ages 8 to 17 months, boys had a significantly greater prevalence of underweight than girls (36.6% [95% CI: 34.2, 39.0] versus 29.8% [95% CI: 27.5, 32.1] at 15 months, \(P < 0.001\)).

**Table 1**

<table>
<thead>
<tr>
<th>Year</th>
<th>Infants aged 3–11 months</th>
<th>Children aged 12–23 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residents in February</td>
<td>Attended GM in February</td>
</tr>
<tr>
<td>1985</td>
<td>88</td>
<td>91 (103)&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>1986</td>
<td>106</td>
<td>96 (91)</td>
</tr>
<tr>
<td>1987</td>
<td>95</td>
<td>92 (97)</td>
</tr>
<tr>
<td>1988</td>
<td>110</td>
<td>86 (78)</td>
</tr>
<tr>
<td>1989</td>
<td>84</td>
<td>73 (87)</td>
</tr>
<tr>
<td>1990</td>
<td>117</td>
<td>80 (77)</td>
</tr>
<tr>
<td>1991</td>
<td>81</td>
<td>62 (77)</td>
</tr>
<tr>
<td>1992</td>
<td>82</td>
<td>77 (94)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Percentage in brackets.

<sup>b</sup> Coverage may exceed 100% if some children attending growth monitoring left the area just prior to census or returned from migration immediately after census.

**Figure 1** Mean weight-for-age by child’s age for three cohorts (1969–1974, 1975–1984, and 1985–1992, respectively) in a rural area of Casamance, Senegal
Change in nutritional status over time

Mean weight-for-age did not exhibit any clear linear trend over the 24 years of follow-up, whatever the age group considered (Figure 2). However, all means varied significantly over the three time periods (Table 2), with slightly higher levels during the first period.

The prevalence of underweight at 15 months was lower 1969–1974 than during the two following periods: 18.0% versus 22.2 and 22.7%, respectively, at 9 months of age ($P = 0.028$), and 28.6% versus 34.6 and 34.9%, respectively, at 15 months ($P < 0.01$).

At 15 months of age, a significant interaction between the time period and season was observed, that is, seasonal variations in mean weight-for-age were slight during the first period (i.e. 1969–1974) and became wider afterwards ($P$ for interaction <0.01, Table 3). From 1975 the children’s nutritional status was particularly poor from October to December.

Change in mortality over time

Mortality rates for preschool children and for yearly age groups are given in Table 4. Strong negative trends existed in all age groups. However, from 1990 to 1995 mortality rose slightly in most age groups.

The difference in trends between mortality rates and the prevalence of underweight is illustrated in Figure 3.

Discussion

The main finding of this study was a decrease in mean weight-for-age of young children in a rural population over a 20-year period (1969–1989), despite intense growth monitoring in a highly available, smoothly functioning health system, and an impressive decrease in 0–5-year mortality.

The nutritional status of young children in this community was not significantly different from that of 12–23 month old Senegalese children in the Demographic and Health Survey.

Table 2 Mean weight-for-age (compared to the WHO/NCHS reference$^2$) in three pre-defined time periods in a rural area of Casamance, Senegal, for various age groups (z-scores)

<table>
<thead>
<tr>
<th>Child age</th>
<th>6–12 months</th>
<th>9–11 months</th>
<th>15–17 months</th>
<th>Average 2nd year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969–1974</td>
<td>−0.86 (1.02, 906)$^a$</td>
<td>−1.10 (1.06, 786)</td>
<td>−1.49 (0.93, 766)</td>
<td>−1.43 (0.88, 926)</td>
</tr>
<tr>
<td>1975–1984</td>
<td>−1.03 (0.95, 1523)</td>
<td>−1.27 (1.00, 1454)</td>
<td>−1.62 (0.94, 1400)</td>
<td>−1.54 (0.88, 1504)</td>
</tr>
<tr>
<td>1985–1992</td>
<td>−0.93 (1.10, 1113)</td>
<td>−1.19 (1.12, 984)</td>
<td>−1.58 (1.12, 921)</td>
<td>−1.51 (1.03, 1041)</td>
</tr>
<tr>
<td>All years</td>
<td>−0.96 (1.02, 3542)</td>
<td>−1.20 (1.05, 3224)</td>
<td>−1.58 (0.99, 3087)</td>
<td>−1.50 (0.93, 3417)</td>
</tr>
</tbody>
</table>

$^a$ (SD, n).
First year: 3.0–11.9 months of age.
Second year: 12.0–23.9 months of age.

Table 3 Mean weight-for-age at 15 months of age by period and season (z-scores)

<table>
<thead>
<tr>
<th>Season</th>
<th>6–12 months</th>
<th>9–11 months</th>
<th>15–17 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan–March</td>
<td>−1.52 (0.90, 166)$^a$</td>
<td>−1.43 (0.83, 117)</td>
<td>−1.51 (1.03, 244)</td>
</tr>
<tr>
<td>April–June</td>
<td>−1.66 (0.96, 314)</td>
<td>−1.45 (0.91, 202)</td>
<td>−1.49 (0.92, 441)</td>
</tr>
<tr>
<td>July–Sept</td>
<td>−1.63 (1.22, 251)</td>
<td>−1.18 (1.01, 147)</td>
<td>−1.55 (1.06, 270)</td>
</tr>
<tr>
<td>Oct–Dec</td>
<td>−1.67 (1.05, 252)</td>
<td>−1.77 (1.05, 252)</td>
<td>−1.58 (1.05, 252)</td>
</tr>
<tr>
<td>All months</td>
<td>−1.49 (0.93, 766)</td>
<td>−1.54 (0.88, 1504)</td>
<td>−1.50 (0.93, 3417)</td>
</tr>
</tbody>
</table>

$^a$ (SD, n).
$^b$ The strong variation in sample size by season was due to seasonal variations in birth rates (data not shown).

Two-factor ANOVA: $P$ for differences among the three time periods = 0.04; $P$ for differences among the four seasons <0.001; $P$ for interaction between time period and season <0.01.
migrations of women take place from December to July.15

season (from July–September to October–December), since
decrease in weight-for-age during the malaria transmission
their children to the city is unlikely to explain the observed
phenomenon of seasonal migration of unmarried mothers and
the nurses began a malaria control programme in 1975. The

1960–1964
139 (129/929) 83 (63/756) 41 (28/684) 65 (42/650) 29 (16/561) 312 201
1965–1969
90 (85/941) 42 (38/907) 69 (59/853) 73 (53/728) 41 (27/664) 278 207
1970–1974
90 (79/882) 53 (45/846) 39 (32/816) 49 (40/814) 18 (14/760) 227 151
1975–1979
62 (51/827) 35 (27/763) 34 (25/742) 26 (19/719) 17 (12/720) 163 108
1980–1984
46 (35/756) 23 (17/734) 21 (15/724) 24 (17/715) 21 (15/703) 128 86
1985–1989
54 (43/798) 20 (16/801) 7 (6/818) 8 (7/848) 1 (1/913) 88 36
1990–1994
63 (51/806) 30 (26/855) 24 (21/859) 7 (6/857) 8 (7/855) 127 68

P for trend
<0.0001 <0.0001 <0.0001 <0.0001 <0.0001

For an age interval (x, x+n), the probability for a child alive at age x of dying between age x and age x+n, expressed per 1000 children alive at age x.

The probabilities were computed using maternal recall, conducted in 1984–1985, for 1960–1985, and yearly censuses since 1985.

Number of deaths/population at risk (in brackets).

A high level of coverage is a critical requirement for this purpose in order to avoid self-selection biases among attending children. Fortunately, the coverage of the programme was above 90% from 1985 to 1990 and, according to the nurse in charge, at least as high during earlier years.16
Another methodological issue is that the strong reduction in mortality among infants and young children probably preferentially benefitted malnourished children and may thus have led to a higher prevalence of underweight. This ‘survivor bias’ is usually small, but may be substantial in populations with a decrease in mortality rates >50–100 per 1000, as is the case here.22 However, this bias would mainly affect older children, and we found no improvement in weight-for-age, even during infancy.

Mortality of preschool children was estimated using two different methods, i.e. maternal recall up to 1985 and yearly census thereafter. The recall method is subject to bias because women who died cannot be included. If risks of death of children are correlated with those of their mothers, child mortality rates for the years 1960–1985 may have been underestimated, and thus secular trends are perhaps even more pronounced than those given here. Rates differ slightly from previously published estimates because we computed them by periods rather than by birth cohorts.14

The observed increase in mortality between 1985–1989 and 1990–1994 is probably explained by increased malaria mortality, due to plasmodium resistance to chloroquine.23 Indeed, the average annual mortality rate from malaria increased from only 0.4 per 1000 preschool children in 1985–1989 to 5.5 per 1000 in 1993–1995, using verbal autopsy.23

Growth monitoring programmes were considered an important component of primary health care in less-developed countries during the period under study, but became an object of severe criticism from the late 1980s due to reports of errors in weighing, charting weights and interpretation of growth curves,14–26 lack of action in case of insufficient weight or weight gain,27 and insufficient nutritional education of mothers during sessions, partly due to time constraints.25,27 For this programme, the high level of qualification and motivation of the nurses led us to hypothesize that the technical quality of sessions was high. But the intensity and quality of nutritional education performed during sessions were not assessed.
The nurses consider that the nutritional status of young children has improved since 1969. One possible explanation is that the prevalence of severe clinical malnutrition (marasmus, kwashiorkor) did indeed decrease, but the prevalence of stunting remained unchanged. Unfortunately, no height measurements were available to test this hypothesis.

However, the impressive reduction in mortality over this period of time may be at least partly due to the growth monitoring programme. Diarrhoea, respiratory infectious diseases and malaria are among the main child killers in developing countries, together with measles and neonatal tetanus. Nurses used the sessions to detect, investigate, and treat children suffering from diarrhoea, fever, cough, and helminthiasis and to educate mothers about the efficacy of early home-based presumptive chloroquine administration and about the importance of prompt health care seeking for ill children.

Thus, growth monitoring was perhaps more successful in promoting health than in favouring growth in this community. Although similar progress in health and survival may be achievable without growth monitoring, it would require another inducement for mothers to bring their young children to dispensaries each month.

The observations reported here seem to be in contradiction with those of a recent analysis of data from 59 developing countries. Indeed, national or sub-national decreases in the prevalence of underweight were significantly associated with decreases in child and under-5 mortality in all parts of the developing world. However, sub-Saharan African countries experienced a lower decline in mortality and, on an average, their prevalence of underweight increased slightly. Thus, there are several similarities between findings from our case study in a small West African population with unusually efficient health services and findings at the continental level.

In conclusion, the rapid transition towards lower levels of childhood mortality observed in this rural area of Casamance, Senegal was not concomitant with any improvement in young children's nutritional status. Other types of intervention are needed to significantly improve growth of infants and young children in this and similar African communities.

Acknowledgements

This study was financed by INED and IRD (formerly named ORSTOM). Sœur Jeanne-Marie Rousset set up and conducted the growth monitoring programme from 1969 until she retired in 1993. From 1977 on, she was assisted by Sœur Thérèse and later by Sœur Marie-Joëlle. Pape Niokhor Diouf, Noël Senghor, and Joseph Sambou were in charge of the tenuous work of data entry from growth monitoring registers.

KEY MESSAGES

- In a rural area of Casamance, Senegal, infant and child mortality rates have decreased drastically over the last 40 years.
- In the present study, the prevalence of underweight increased between 1969 and 1992 among children aged <2 years who were included in a growth monitoring programme.
- Targeted health interventions may improve childhood survival, but do not necessarily improve the nutritional status of young children if no specific nutritional interventions are undertaken.

References


