



No Improvement in Weight-for-age of Young Children in Southern Senegal, 1969-1992, Despite a Drastic Reduction in Mortality

Sybil Pinchinat, Catherine Enel, Gilles Pison, Géraldine Duthé, Emmanuel Lagarde, François Simondon, Kirsten B. Simondon

► To cite this version:

Sybil Pinchinat, Catherine Enel, Gilles Pison, Géraldine Duthé, Emmanuel Lagarde, et al.. No Improvement in Weight-for-age of Young Children in Southern Senegal, 1969-1992, Despite a Drastic Reduction in Mortality: Evidence from a Growth Monitoring Programme. *International Journal of Epidemiology*, 2004, 33 (6), pp.1202-1208. 10.1093/IJE/DYH174 . hal-04006372

HAL Id: hal-04006372

<https://hal.science/hal-04006372>

Submitted on 27 Feb 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

This is a pre-copyedited, author-produced version of an article accepted for publication in *International Journal of Epidemiology* following peer review. The version of record « Pinchinat, S., Enel, C., Pison, G., Duthé, G., Lagarde, E., Simondon, F., & Simondon, K.B. (2004). No improvement in Weight-for-age of Young Children in Southern Senegal, 1969-1992, Despite a Drastic Reduction in Mortality. *International Journal of Epidemiology*, 33(6), 1202-1208 » is available online at: <https://doi.org/10.1093/IJE/DYH174>

No improvement in weight-for-age of young children in southern Senegal, 1969-1992, despite a drastic reduction in mortality. Evidence from a growth monitoring programme

Sybil Pinchinat^a, Catherine Enel^b, Gilles Pison^b, Géraldine Duthé^b, Emmanuel Lagarde^c, François Simondon^a, Kirsten B Simondon^a

^a UR024, Institut de Recherche pour le Développement (IRD), 911, avenue Agropolis, BP 64501, 34394 Montpellier Cedex 5, France

^b Institut National d'Études Démographiques (INED), 133 boulevard Davout, 75980 Paris Cedex 20, France

^c 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

Abstract

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.

Methods: Analysis of weight measurements taken at 3-24 months of age during routine growth monitoring in the community's private dispensary from 1969 to 1992 (3912 children, 4642 child-years) and of mortality rates of children estimated from maternal recall for 1960-85 and yearly census from 1985-95.

Results: Between 1960-64 and 1990-94, under-five and child (1-4 y) mortality rates decreased from 312 to 127 and from 201 to 68 per thousand, respectively. About 90% of resident children attended growth monitoring in 1985-92. 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% (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 1969-74, 1975-84 and 1985-92, 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 from 1969 to 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

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.

Introduction

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 children in developing countries,¹⁰⁻¹² 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.¹³

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.¹⁴

Methods

Study design

An analysis of weight data recorded by Catholic nuns through a growth monitoring programme operating since 1969, compared to mortality data on children below 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 January 1, 2000). Characteristics of the study area have been published previously.¹⁴

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 1984-85, 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 of registers of the local maternity ward (>95% of all births) and dispensary (all deaths are recorded, including those occurring outside the area), respectively. The total fertility rate decreased from 5.9 live-born children per woman in 1985-89 to 3.7 in 1995-99.¹⁵

Growth monitoring programme

In April 1969, a growth monitoring programme was initiated in the village as part of the National Programme for Nutrition in Senegal (PPNS), supported by Cathwell, a North American non-governmental organisation. Children were followed up monthly from 3 months of age until 5 years (3 years since 1985). A financial contribution was requested at each session (50 FCFA until 1989, and thereafter 100 FCFA, i.e. 0.31 euros). The mothers received powdered milk, vegetable oil, sorghum and wheat flour. In 1989, the national growth monitoring programme was 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.¹⁶ 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 precise 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 from 1969 to 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 d.

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 more than 1 kg over a one-month period were investigated. Thereafter, weight-for-age was computed according to the NCHS/WHO reference² 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 from 1967 to 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 on travel or migration during that year's census. It was computed for 1985-92 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, ${}_4q_1$) and under-fives (0-59 months, ${}_5q_0$), together with rates for yearly age intervals beyond infancy (${}_1q_1$, ${}_1q_2$, ${}_1q_3$ and ${}_1q_4$). 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 1984-85, for 1960-85, and yearly censuses since 1985.

The analyses used BMDP and SAS. Differences were considered significant for P-values below 0.05.

Results

Participation in the growth monitoring programme

Table 1 Number of children attending growth monitoring sessions in a rural area of Casamance, Senegal, in February 1985 to 1992, compared to numbers of residents

Year	<u>Infants aged 3-11 months</u>			<u>Children aged 12-23 months</u>		
	Residents in February	Attended in February	GM ^a	Residents in February	Attended in February	GM ^a
1985	88	91	(103) ^{b c}	120	124	(103)
1986	106	96	(91)	128	108	(84)
1987	95	92	(97)	114	113	(99)
1988	110	86	(78)	90	95	(106)
1989	84	73	(87)	110	104	(95)
1990	117	80	(77)	79	80	(101)
1991	81	62	(77)	117	65	(56)
1992	82	77	(94)	75	59	(79)
1985-92 (average)			(88)			(90)

^a GM: growth monitoring

^b Percentage in brackets

^c Coverage may exceed 100% if some children attending growth monitoring left the area just prior to census or returned from migration immediately after census

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).

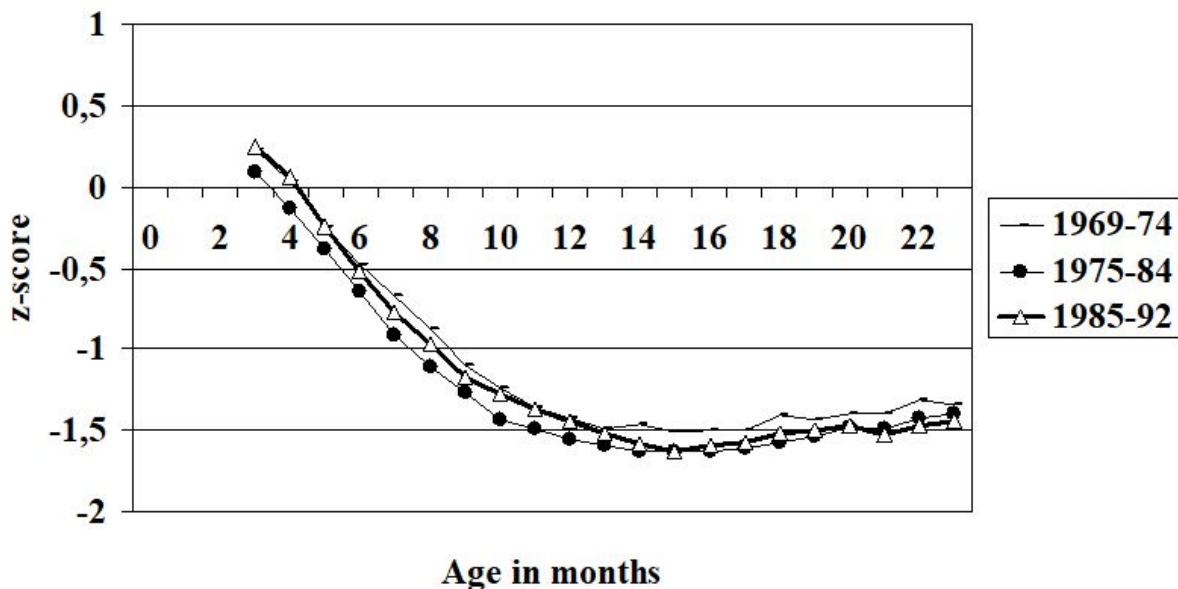
Overall, 55,707 reliable measurements were available for the analysis. From 3 to 24 months of age, the mean number of sessions attended was 14.9 (i.e. 71%) and the median was 17. These figures, however, include children who had died or moved out of the area prior to 24 months. Children still participating 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) vs. 29.8% (95% CI 27.5 – 32.1) at 15 months, $P < 0.001$).

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 from 1969-74 than during the two following periods: 18.0% vs. 22.2 and 22.7%, respectively at 9 months of age ($P=0.028$), and 28.6% vs. 34.6 and 34.9%, respectively, at 15 months ($P<0.01$).

Table 2 Mean weight-for-age (compared to the WHO/NCHS reference²) in three pre-defined time periods in a rural area of Casamance, Senegal, for various age groups (z-scores)

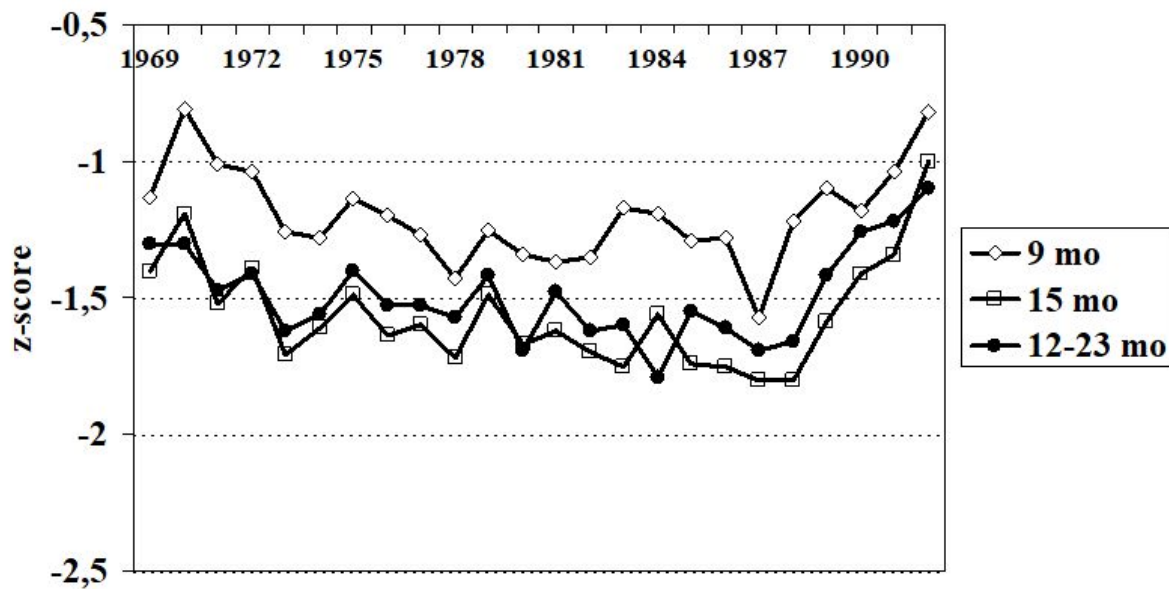
Time period	Child age			
	Average 6-12 mo	9-11 mo	15-17 mo	Average 2 nd y
1969-1974	-0.86 (1.02, 906) ^a	-1.10 (1.06, 786)	-1.49 (0.93, 766)	-1.43 (0.88, 926)
1975-1984	-1.03 (0.95, 1523)	-1.27 (1.00, 1454)	-1.62 (0.94, 1400)	-1.54 (0.88, 1504)
1985-1992	-0.93 (1.10, 1113)	-1.19 (1.12, 984)	-1.58 (1.12, 921)	-1.51 (1.03, 1041)
All years	-0.96 (1.02, 3542)	-1.20 (1.05, 3224)	-1.58 (0.99, 3087)	-1.50 (0.93, 3417)
P	<0.001	<0.001	0.015	0.014

^a (SD, n)

First year: 3.0-11.9 months of age

Second year: 12.0-23.9 months of age

Figure 2 Mean weight-for-age at various ages among children attending growth monitoring, 1969–1992 in a rural area of Casamance, Senegal



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. 1969-74) 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.

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

Time period	Season				All months
	Jan-March	April-June	July-Sep	Oct-Dec	
1969-1974	-1.52 (0.90, 166) ^a	-1.43 (0.83, 117)	-1.51 (1.03, 244)	-1.48 (0.90, 239) ^b	-1.49 (0.93, 766)
1975-1984	-1.66 (0.96, 314)	-1.45 (0.91, 202)	-1.49 (0.92, 441)	-1.79 (0.92, 443)	-1.62 (0.94, 1400)
1985-1992	-1.63 (1.22, 251)	-1.18 (1.01, 147)	-1.55 (1.06, 270)	-1.77 (1.05, 252)	-1.58 (1.12, 920)

^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 < 0.0

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 1990-95 mortality rose slightly in most age groups.

Table 4. Mortality rates^a among children below 5 years of age from 1960 to 1995 in a rural area of Casamance, Senegal

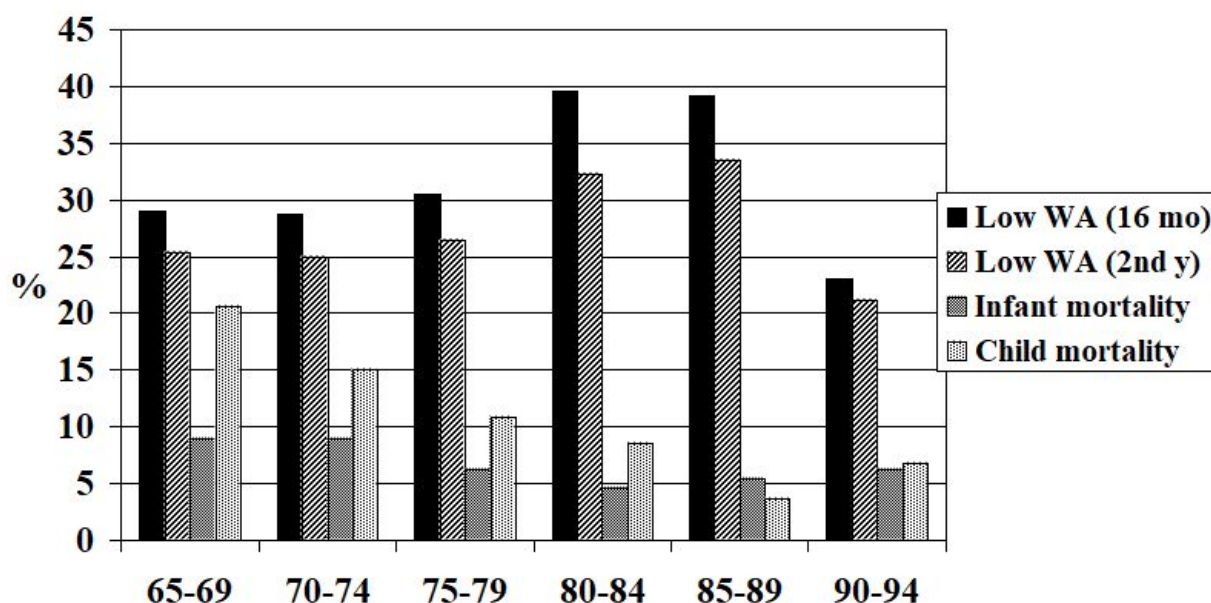
Period	Age interval (months)					0-59 (0q5)	12-59 (1q4)
	0-11 (0q1)	12-23 (1q1)	24-35 (2q1)	36-47 (3q1)	48-59 (4q1)		
1960-64	139 (129/929) ^b	83 (63/756)	41 (28/684)	65 (42/650)	29 (16/561)	312	201
1965-69	90 (85/941)	42 (38/907)	69 (59/853)	73 (53/728)	41 (27/664)	278	207
1970-74	90 (79/882)	53 (45/846)	39 (32/816)	49 (40/814)	18 (14/760)	227	151
1975-79	62 (51/827)	35 (27/763)	34 (25/742)	26 (19/719)	17 (12/720)	163	108
1980-84	46 (35/756)	23 (17/734)	21 (15/724)	24 (17/715)	21 (15/703)	128	86
1985-89	54 (43/798)	20 (16/801)	7 (6/818)	8 (7/848)	1 (1/913)	88	36
1990-94	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		

^aFor 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 1984-85, for 1960-85, and yearly censuses since 1985.

^bNumber of deaths / population at risk (in brackets)

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

Figure 3 Trends in underweight at 15 months of age 1969–1992 and in mortality from 0–1 and 1–4 years of life, 1965–1995, in a rural area of Casamance, Senegal



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, 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 from 1992–93 (prevalence of underweight : 27.2%, 95% CI 24.1–30.3).¹⁷ Furthermore, average weight-for-age from 3 to 24 months of age was remarkably similar to that of young children from 23 African countries, measured in 1987–97.¹⁸

The tendency towards better nutritional status during the last 3 years of follow-up was unexpected, because no major changes in the health system, socio-economic status of the community or otherwise were identified. However, since attendance at growth monitoring sessions decreased from 1990 among 12–24-month-old children, probably due to the arrest of food distribution, this apparent improvement may be due to a selection bias.

Seasonal differences in mean weight and the prevalence of underweight became significant starting in 1975. This finding was also unexpected, since malaria morbidity is thought to be at least partially responsible for seasonal variations in the nutritional status of young children in sub-Saharan Africa,^{19, 20} and the nurses began a malaria control programme in 1975. The phenomenon of seasonal migration of unmarried mothers and their children to the city is unlikely to explain the observed decrease in weight-for-age during the malaria transmission season (from July-September to October-December), since migrations of women take place from December to July.¹⁵

One possible limitation of the study was that it used growth monitoring data for the purpose of nutritional surveillance.²¹ 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 greater than 50-100 per thousand, 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 1960-85 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 1985-89 and 1990-94 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 thousand preschool children in 1985-89 to 5.5 per thousand in 1993-95, 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,²⁴⁻²⁶ 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 1969.¹⁶ 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.¹² 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.¹⁵

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 incitation 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.²⁸ Indeed, national or sub-national decreases in the prevalence of underweight were significantly associated with decreases in child and under-five 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.²⁸ 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.

Acknowledgments

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 et Joseph Sambou were in charge of the tenuous work of data entry from growth monitoring registers.

This study was financed by INED and IRD (formerly named ORSTOM).

References

1. ACC/SCN. Fourth report on the world nutrition situation: Nutrition throughout the life cycle. Geneva: ACC Sub Committee on Nutrition, 2000.
2. Hamill PVV, Drizd TA, Johnson CL, Reed RB, Roche AF, Moore WM. Physical growth: National Center for Health Statistics percentiles. *Am J Clin Nutr* 1979; **32**: 607-29.
3. Chen LC, Chowdhury AKMA, Huffman SL. Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among preschool aged children. *Am J Clin Nutr* 1980; **33**: 1836-45.
4. Katz J, West KP, Tarwotjo I, Sommer A. The importance of age in evaluating anthropometric indices for predicting mortality. *Am J Epidemiol* 1989; **130**: 1219-25.
5. Bairagi R, Chowdhury MK, Kim YJ, Curlin GT. Alternative anthropometric indicators of mortality. *Am J Clin Nutr* 1985; **42**: 296-306.
6. Yambi O, Latham MC, Habicht JP, Haas JD. Nutrition status and the risk of mortality in children 6-36 months old in Tanzania. *Food Nutr Bull* 1991; **13**: 271-6.
7. Pelletier DL, Low JW, Johnson FC, Msukwa LAH. Child anthropometry and mortality in Malawi: testing for effect modification by age and length of follow-up and confounding by socioeconomic factors. *J Nutr* 1994; **124**: 2082S-105S.
8. Fawzi WW, Herrera MG, Spiegelman DL, El Amin A, Nestel P, Mohamed KA. A prospective study of malnutrition in relation to child mortality in the Sudan. *Am J Clin Nutr* 1997; **65**: 1062-9.
9. Garenne M, Maire B, Fontaine O, Dieng K, Briend A. Risques de décès associés à différents états nutritionnels chez l'enfant d'âge préscolaire. Paris: CEPED; 2000.
10. Pelletier DL, Frongillo EA, Habicht J-P. Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. *Am J Public Health* 1993; **83**: 1130-3.
11. Pelletier DL. The potentiating effects of malnutrition on child mortality: epidemiologic evidence and policy implications. *Nutr Rev* 1994; **52**: 409-15.
12. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? *Lancet* 2003; **361**: 2226-34.
13. Rousham EK, Gracey M. Persistent growth faltering among Aboriginal infants and young children in north-west Australia: a retrospective study from 1969 to 1993. *Acta Paediatr* 1997; **86**: 46-50.
14. Pison G, Trape JF, Lefebvre M, Enel C. Rapid decline in child mortality in a rural area of Senegal. *Int J Epidemiol* 1993; **22**: 72-80.
15. Pison G, Gabadinho A, Enel C. Mlomp (Sénégal): Niveaux et tendances démographiques 1985-2000 [Mlomp (Senegal): Demographic levels and trends 1985-2000]. Paris: INED, 2001.
16. Enel C. Entretien avec soeur Jeanne-Marie Rousset [Conversations with Sister Jeanne-Marie Rousset]. Paris: INED, 2002.
17. Ndiaye S, Diouf PD, Ayad M. Enquête Démographique et de Santé au Sénégal (EDS-II) 1992/93 [Demographic and Health Survey in Senegal (DHS-II) 1992/93]. Dakar: Division de la Prévision et de la Statistique, 1994.
18. Shrimpton R, Victora CG, de Onis M, Lima RC, Blössner M, Clugston G. Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics* 2001; **107**(5): e75.

19. D'Alessandro U, Olaleye BO, McGuire W, et al. Mortality and morbidity from malaria in Gambian children after introduction of an impregnated bednet programme. *Lancet* 1995; **345**: 479-83.
20. ter Kuile FO, Terlouw DJ, Phillips-Howard PA, et al. Impact of permethrin-treated bed nets on malaria and all-cause morbidity in young children in an area of intense perennial malaria transmission in western Kenya: cross-sectional survey. *Am J Trop Med Hyg* 2003; **68(Suppl 4)**: 68-77.
21. Mason JB, Habicht J-P, Tabatabai H, Valverde V. Nutritional surveillance. Geneva: World Health Organization, 1984.
22. Boerma JT, Sommerfelt AE, Bicego GT. Child anthropometry in cross-sectional surveys in developing countries: an assessment of the survivor bias. *Am J Epidemiol* 1992; **135**: 438-49.
23. Trape JF, Pison G, Préziosi M-P, et al. Impact of chloroquine resistance on malaria mortality. *C R Acad Sci III* 1998; **321**.
24. Gopalan C, Chatterjee M. Use of growth charts for promoting child nutrition. A review of global experience. New Delhi: Nutrition Foundation of India, 1985.
25. Anonymous. Growth monitoring: intermediate technology or expensive luxury? *The Lancet* 1985; **ii**: 1337-8.
26. Brewster D. Growth monitoring. *Lancet* 1993; **342**: 750.
27. Gerein NM, Ross DA. Is growth monitoring worthwhile? An evaluation of its use in three child health programmes in Zaire. *Soc Sci Med* 1991; **32**: 667-75.
28. Pelletier DL, Frongillo EA. Changes in child survival are strongly associated with changes in malnutrition in developing countries. *J Nutr* 2003; **133**: 107-19.

