NUTRITIONAL STATUS AND IRRIGATED RICE CULTIVATION IN NORTHERN SENEGAL: A FIVE-YEAR FOLLOW-UP

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(Received January 16, 1996; in final form January 7, 2000)

Nutritional status was monitored in a random sample of inhabitants of three villages in Northern Senegal where irrigated rice cultivation started in July 1989. In early 1990, weight and height were measured in children and adults. From 1990–1995, 290 preschool children, 175 mothers of the children and 99 men aged 20–60 years were followed longitudinally. The prevalence of wasting in children fell from 11.4% (95% confidence interval: 7.4–15.4%) in 1990 to 3.8% (1.6–6.0) in 1995, while the prevalence of stunting initially declined and then increased. Prevalence of chronic energy deficiency (BMI < 18.5 kg/m²) in men fell from 22.5% (14.6–30.4%) in 1990 to 6.6% (1.4–11.8%) in 1991 and thereafter increased to 13.0% in 1995, while no significant variations were found among women. The prevalence of overweight (BMI > 25 kg/m²) increased significantly over time in both sexes. Individual annual weight gains of adults were significantly greater than zero from 1990 to 1991 (mean: 1.8 kg/yr) and from 1991 to 1992 (mean: 1.2 kg/yr), and close to zero thereafter. In conclusion, the onset of irrigated rice cultivation was followed by a decrease in the prevalences of wasting and chronic energy deficiency, but a causal relationship between the agricultural project and nutrition changes cannot be ascertained.

KEY WORDS: Agricultural development, nutritional status, irrigation scheme, preschool children, developing countries, malnutrition, obesity, Senegal

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INTRODUCTION

Agricultural development programs are of critical importance in Subsahelian Africa, where the population is increasing at an accelerated rate. However, few development programs have been evaluated systematically in terms of their influence on the populations affected. In Kenya, an irrigated rice production program was evaluated by a cross-sectional survey (Niemeijer et al., 1988). Among farmers working on large-scale schemes, those who maintained traditional farming outside the scheme had high energy intake and their preschool children had good nutritional status, while those who depended entirely on rice production on the scheme had low energy intake and high prevalence of stunting among preschool children. Therefore, the diversity of production (subsistence crops in addition to cash crops) seemed important in maintaining satisfactory food consumption and nutrition. In another rice irrigation scheme in Kenya, the prevalence of preschool stunting in the scheme villages was considerably higher than among children living in a control area with traditional agriculture, located 5–10 km from the scheme (Mwadime et al., 1996). In the North Arcot district of India, technical improvement in rice production was followed by significant improvement in household food consumption of farmers over a ten-year period, from 1973 to 1983 (Pinstrup-Andersen and Jaramillo, 1989). In a sugar-cane producing area of Kenya, sugar producers had higher energy intakes than control groups, but the nutritional status of preschool children was no better than in control groups, perhaps because of elevated morbidity (Kennedy and Cogill, 1987). Thus, the few published studies that have evaluated the impact of agricultural development programs on nutritional status do not give consistent results. This may be due to the variability in ecological situations and study designs.

The present study, which was part of a multidisciplinary health evaluation project, utilized a longitudinal follow-up design in an area of West Africa where irrigation had just begun. In February 1990, the nutritional status of a sample of children and adults was assessed, and from February 1991 to February 1995 annual surveys estimated prevalences of wasting and stunting of
preschool children and of chronic energy deficiency and overweight of adults.

METHODS

Study Area

The study area comprised three villages inhabited by sedentary farmers of the Tokolor ethnic group and was located in the Middle Valley of the Senegal River, close to the border between Senegal and Mauritania. The climate is hot and scarce rainfalls occur during a short rainy season (from the end of July to October). From 1989 to 1994, annual rainfall was 324, 127, 97, 143, 287 and 221 mm, respectively. Since the severe droughts of the 1970s, traditional millet cultivation in the jeeri (non-flooded fields) has been marginal and most crops are grown near the river (flood recession cultures). However, these crops are also subject to climatic risks, since the area flooded depends on the level of floods. In order to control water supply for cultures, a dam was built upstream at Manantali in Mali in 1981, and an ambitious program of construction of irrigated schemes was initiated in the Middle Valley with the financial support of the European Fund for Development (EFD). One of the first of these irrigated areas, covering 528 ha (hectares), was chosen for the present study. Irrigation began in July 1989, and the first rice harvest took place in December 1989. Sorghum, the traditional flood recession cultigen grown from October to February, was largely replaced by irrigated rice grown from July to December. In addition to rice, tomatoes were grown as a cash crop from February to May and maize was grown from May to October, also in the irrigated area. Participation in the project was complete from the first year, since most of the fields formerly used for flood recession culture had been included in the irrigated area and could thus no longer be used for sorghum cultivation. The management of the project was done by the farmers themselves with technical assistance from the Senegalese Ministry of Agriculture, since rice is not a traditional crop in this area.
Extensive information on the agricultural system has been reported previously (Bénéfice and Simondon, 1993).

Sample Frame

A random sample of 110 compounds (foyrés), inhabited by one-third of the total population of 4,434 was selected using probabilities proportional to the number of members within the compounds based on a demographic census conducted in November–December 1989.

Field Work Methodology

In February 1990, at the onset of the study, all family members present in the compounds during the survey underwent anthropometric measurements: weight, height, left upper arm circumference (using a nonstretchable tape) and triceps skinfold (using a Holtain caliper). Thereafter, three target groups were selected for a yearly follow-up: preschool children, their mothers, and all men aged 20–60 years. Anthropometric surveys were conducted in February of each year, from 1990 to 1995. New subjects were included at each round, mainly infants born since the last round but also immigrants; children were excluded at the age of five years. The anthropometric measures taken were weight and height. Children were weighed naked on a Seca® baby scale (accuracy 10 g), which was tested daily against standard weights. Recumbent length was measured up to the age of 24 months and height was measured thereafter using a locally constructed wooden board (accuracy 0.1 cm). Adults were weighed on an electronic Tefal® scale (accuracy 200 g). Weights were not corrected for light clothing. Height was measured using a Harpenden® anthropometer (accuracy 0.1 cm). For adults, age was computed using the year of birth declared by the subject; for children, an interview with the mother was conducted, using Muslim calendars as well as calendars of local events. Mothers usually remembered the month of birth according to the Muslim calendar and for children aged less than one years, they often gave the precise Muslim date (for example, the 16th day of the month of Kor). No systematic birth registration system was operating in
this area. Women were also asked whether they were pregnant or lactating.

**Anthropometric Indices**

Dbase IV (Borland, Scotts Valley, California) was used for data handling. Anthropometric indices for children were weight-for-height, height-for-age and weight-for-age, computed by Anthro (Centers for Disease Control, Atlanta). Stunting was defined as a height-for-age of less than $-2$ z-scores of the National Center for Health Statistics (NCHS) reference medians, wasting as a weight-for-height less than $-2$ z-scores and underweight as a weight-for-age less than $-2$ z-scores (Waterlow et al., 1977). The body mass index (BMI, weight/height$^2$) was used to assess nutritional status in adults. Chronic energy deficiency was defined as a BMI of less than 18.5 kg/m$^2$ in both sexes (James, Ferro-Luzzi and Waterlow, 1988), and overweight as a BMI above 25 kg/m$^2$ (Garrow and Webster, 1985). Pregnant women were excluded from the analysis.

**Statistical Analysis**

Statistical analyses were done using Bio Medical Data Processing (BMDP) statistical software (University of California, USA): ANOVA, chi-square and chi-square for trend tests were employed for analysis. The first year of survey (1990) was used as level 1 and the following years were used as levels 2–6. For all men and nonpregnant women present during two consecutive years, yearly individual weight changes were computed as the difference between weight of one year and weight of the preceding year, standardized to exact early intervals. Means of annual individual weight change were compared to zero by $t$-tests.

**RESULTS**

During the baseline survey in 1990, the prevalences of stunting and wasting among children under the age of 5 were 21.5% (95% confidence interval (CI): 16.2–26.8) and 11.4% (95% CI: 7.4–15.4%), respectively. Mean height of adults was 173.8 cm for
men (standard deviation (SD): 7.6) and 163.7 cm for women (SD: 8.5). Younger adults (aged 20–39 years) were taller than older adults (aged 40–59 years) in both sexes \( (p < 0.05) \). Mean mid upper arm circumferences were 27.0 and 25.3 cm, respectively, and mean triceps skinfold thicknesses were 6.6 and 13.1 mm, respectively, for men and women. The prevalence of chronic energy deficiency was 21.8% \( (95\% \text{ CI: } 15.8–27.8) \) among women aged 18–50 years and 22.5% \( (95\% \text{ CI: } 14.6–30.4) \) among men aged 20–60 years.

For the follow-up surveys, the mean number of subjects measured was: 290 children, 201 women and 99 men. Several children were excluded due to inconsistent measurements or missing weight-for-height indices in very short neonates (insufficient reference data). The analysis was done on an average of 288 children, 175 nonpregnant women and 99 men over the five-year period.

The age distribution remained constant during the years of follow-up for children under 5 years. The prevalence of wasting differed significantly between the five years from 1990 to 1994 \( (Figure 1, p < 0.001) \). The linear trend towards lower values which
was observed graphically was statistically significant ($p < 0.001$). The decrease in prevalence was also significant when only the first year and last year of follow-up were compared: from 11.4% (CI: 7.4–15.4) in 1990 to 3.8% (CI: 1.6–6.0) in 1995 ($p < 0.001$). Age-specific analyses showed that the changes occurred mainly in the 12–23 month age group, which is the age of peak prevalence of wasting.

The prevalence of stunting declined slightly and non significantly during the first two years of follow-up (Figure 2) and then increased again. Over-all, the prevalence of stunting varied during the study period ($p < 0.05$), but the prevalence in 1995 did not differ significantly from that in 1990 (23.5 vs. 21.5%). The prevalence of underweight also showed a linear negative trend from 1990 to 1995 ($p < 0.05$), although the decrease was less than for weight-for-height (Figure 2).

Mean weight-for-height varied significantly during the five-year follow-up period ($p < 0.0001$, Table I), but the decrease in the mean, which suggests a variation in the total distribution and not simply in the lower values, occurred later (1993–1994) than the decrease in prevalence (1990–1994). Mean height-for-age did not vary significantly during the follow-up (Table I), while mean weight-for-age tended to be greater during the last two years of follow-up.

Results for adults are described separately for each sex. Mean age was 30.2 years for women and 36.6 years for men in 1990, and

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>Weight-for-height</th>
<th>Height-for-age</th>
<th>Weight-for-age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>1990</td>
<td>237</td>
<td>-0.79 ± 1.04</td>
<td>-1.01 ± 1.14</td>
<td>-1.23 ± 1.05</td>
</tr>
<tr>
<td>1991</td>
<td>309</td>
<td>-0.75 ± 0.94</td>
<td>-1.16 ± 1.07</td>
<td>-1.31 ± 1.01</td>
</tr>
<tr>
<td>1992</td>
<td>294</td>
<td>-0.73 ± 0.94</td>
<td>-1.09 ± 0.90</td>
<td>-1.27 ± 0.99</td>
</tr>
<tr>
<td>1993</td>
<td>295</td>
<td>-0.80 ± 0.97</td>
<td>-1.20 ± 0.95</td>
<td>-1.39 ± 0.96</td>
</tr>
<tr>
<td>1994</td>
<td>302</td>
<td>-0.51 ± 0.96</td>
<td>-1.23 ± 1.03</td>
<td>-1.21 ± 0.98</td>
</tr>
<tr>
<td>1995</td>
<td>290</td>
<td>-0.41 ± 0.98</td>
<td>-1.22 ± 1.14</td>
<td>-1.15 ± 1.05</td>
</tr>
</tbody>
</table>

***$p < 0.001$ for differences among the six years by ANOVA.
FIGURE 2 Prevalence of stunting (left) and underweight (right) with 95% confidence intervals in preschool children from 1990 to 1995, Senegal.
did not differ over the years. Neither did the distribution of age. From 1990 to 1995, the prevalence of chronic energy deficiency in women decreased slightly (Figure 3), but the difference was not significant. The prevalence of chronic energy deficiency in men decreased sharply during the first year of follow-up, from 22.5% in 1990 to 6.6% in 1991 and then rose again (Figure 3). The differences between the five years of follow-up were globally significant \( (p < 0.05) \), like the difference between the first and last year of follow-up \( (p < 0.05) \). Younger men (aged 20–34 years) had much higher prevalences than those aged 35–60 years \( (p < 0.001) \).

The prevalence of overweight in women (Figure 4) increased from 1990 to 1995 and differences among prevalences over the total study period were significant \( (p < 0.05) \), as was the difference between prevalences in 1990 and 1995 \( (p < 0.05) \). The prevalence of overweight in men (Figure 4) increased sharply from 1990 to 1992 (from 3.5 to 17.3%, \( p < 0.001 \)), and declined thereafter. The difference among the six years was significant \( (p < 0.05) \), while the increase between 1990 and 1995 was not. For both men and women, the younger subjects were significantly less often overweight compared to the older \( (p < 0.01) \). Mean nutritional status of both men and women increased from 1990 to 1992, in terms of weight and body mass index, and thereafter decreased slightly again, so that the 1995 means were similar to the 1991 means (Table II).

**TABLE II**

Nutritional status of adults by year of survey from 1990 to 1995, Senegal (mean±SD)

<table>
<thead>
<tr>
<th>Year</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N )</td>
<td>Weight</td>
<td>BMI(^{a})</td>
<td>( N )</td>
</tr>
<tr>
<td>1990</td>
<td>115</td>
<td>62.0±9.7</td>
<td>20.5±2.9</td>
<td>193</td>
</tr>
<tr>
<td>1991</td>
<td>92</td>
<td>65.5±9.0</td>
<td>21.5±2.7</td>
<td>163</td>
</tr>
<tr>
<td>1992</td>
<td>104</td>
<td>67.6±9.9</td>
<td>22.2±3.1</td>
<td>178</td>
</tr>
<tr>
<td>1993</td>
<td>108</td>
<td>65.3±10.3</td>
<td>21.4±3.3</td>
<td>169</td>
</tr>
<tr>
<td>1994</td>
<td>100</td>
<td>66.0±9.9</td>
<td>21.6±3.0</td>
<td>189</td>
</tr>
<tr>
<td>1995</td>
<td>77</td>
<td>65.3±9.7</td>
<td>21.3±2.9</td>
<td>158</td>
</tr>
</tbody>
</table>

\(^{a}\)BMI: body mass index.

\(^{b}\) \( p\) for differences among years: * \( p < 0.05 \); ** \( p < 0.01 \); NS: not significant.
FIGURE 3  Prevalence of chronic energy deficiency in women (left) and men (right) with 95% confidence intervals from 1990 to 1995, Senegal.
FIGURE 4. Prevalence of overweight in women (left) and men (right) with 95% confidence intervals from 1990 to 1995, Senegal.
TABLE III
Yearly individual weight changes of adults from 1990 to 1995, Senegal

<table>
<thead>
<tr>
<th>Years</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SDa</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>1990-91</td>
<td>+1.58**b</td>
<td>3.20</td>
<td>45</td>
<td>+1.91***b</td>
</tr>
<tr>
<td>1991-92</td>
<td>+1.90***b</td>
<td>2.89</td>
<td>54</td>
<td>+0.80*ab</td>
</tr>
<tr>
<td>1992-93</td>
<td>-0.12</td>
<td>2.93</td>
<td>62</td>
<td>+0.20</td>
</tr>
<tr>
<td>1993-94</td>
<td>-0.12</td>
<td>2.97</td>
<td>59</td>
<td>+0.27</td>
</tr>
<tr>
<td>1994-95</td>
<td>+0.70</td>
<td>3.16</td>
<td>45</td>
<td>-0.28</td>
</tr>
</tbody>
</table>

*SD: standard deviation.

p for difference of mean to zero: * < 0.05; ** < 0.01; *** < 0.001.

In addition to cross-sectional analyses, the longitudinal design of the study, using precise identification of subjects, enabled analysis of individual increments in weight from one survey to the next. Individual annual weight increments were computed on a mean of 55 men and 107 women per interval. The mean increments were positive, and significantly greater than zero for both men and women, from 1990 to 1991 and from 1991 to 1992 (Table III). During the last three years of follow-up, mean increments were near zero. These results thus suggest that men gained about 3.5 kg and women about 2.7 kg during the first two years following initiation of the agricultural project, and that they maintained their weight during the following years.

DISCUSSION

In this recently irrigated cultivation area, the prevalence of preschool wasting was above 10% at the onset of the project, which is rather high compared to other rural regions of Senegal, but equivalent to that of the rest of the Northeastern region (11.5%; Ayad, 1993). The prevalence of preschool stunting (21.5%) was slightly lower than in the region in 1992–93 (25.9%; Ayad, locacito). Significant changes in nutritional status of both adults and preschool children occurred during the second and third
years after the onset of the agricultural project. Among adults, mean weight, body mass index and arm circumference increased from 1990 to 1992, together with the prevalence of overweight, while the prevalence of chronic energy deficiency decreased significantly among men only. Among preschool children, the prevalence of wasting decreased dramatically from 1990 to 1992. The changes of prevalence in wasting among preschool children and in chronic energy deficiency of men were thus consistent, while no significant decrease was found among women. It is not known why the increase in mean weight-for-height started later than the decrease in the prevalence of wasting (1993–94 vs. 1990–91).

From year to year, there was a change in population due to out-migration and absence of some participants during the surveys. Migration for labor is very common in the area at present, and one of the aims of the agricultural project was to give young, able men the possibility to feed their families whilst remaining in the village. Therefore, changes in prevalence of malnutrition and overweight, and in mean nutritional status may reflect a progressive change in population, rather than true nutritional improvements. However, analyses of mean individual weight changes confirmed that adults of both sexes gained weight during the second and third years of the project. This shows the importance of longitudinal analyses of weight changes in adults, especially when massive migrations are anticipated. However, only 53% of men were present over two consecutive years and thus available for longitudinal analysis. Women were less often away because of migration or field work, but since median birth interval is only 31 months in this part of Senegal (Ndiaye, 1993), many had to be excluded because of pregnancy during one out of two consecutive rounds. For these reasons, cross-sectional and longitudinal analyses of changes in nutritional status provide valuable complementary information in follow-up studies.

There is thus clear evidence that the nutritional situation has improved during the study period, especially during the two first years of the follow-up (that is, the second and third years of the project), but several problems hamper interpretation of the causes of this improvement. First, no data are available for the years prior to initiation of the project in the study area, so neither the
baseline nutritional status nor the usual annual variations in nutritional status are known. Second, changes may be explained by improvements in nutrition and hygiene within the study area, which are not directly linked to the agricultural project. The water supply, for instance, was recently improved; outdoor piped water became available in one of the villages during the follow-up. However, these improvements in the accessibility to clean water were first effective in late 1993, that is, much later than changes in nutritional status. Furthermore, several studies found no relationship between outdoor piped water and weight-for-height of preschool children (Lindskog, Lindskog and Gebre-Medhin, 1987; Hassan et al., 1989). Health services have not been improved. The three villages shared a dispensary with one nurse, but attendance was low. Third, at the onset of the study, no adequate control area could be identified, since the few neighbor villages with similar characteristics (easy access from main road, position near the Senegal River) were all involved in more or less recent development projects or were scheduled to be involved in such projects. Therefore, the nutritional changes described might theoretically be a general feature of the River Valley. Several regional nutritional surveys, conducted during the follow-up period in the Senegal River Valley, may be used for comparisons. The prevalence of wasting in the Senegal River Valley was found to be 9.3% in December 1990 (95% CI: 7.5–11.1; UNICEF, 1991), 9.3% in February–March 1991 (95% CI: 7.1–11.5; Ly and Ndiaye, 1992) and 11.5% in December 1992–February 1993 (95% CI: 8.9–14.1; Ayad, 1993), respectively. The prevalence of wasting in the study area in 1990 was thus similar to or slightly better than the rest of the department, while the prevalences in 1994 and 1995 were much lower. Among mothers of preschool children, the prevalence of chronic energy deficiency was 22.5% (95% CI: 18.7–26.3) in the Senegal River Valley in early 1993 (Ayad, 1993). This prevalence was significantly higher than that found in the study area in February 1993 (15.4%, \( p < 0.05 \)).

The improvements were observed during the cold, dry season at the beginning of the year, and seasonal variations in nutritional status are important in this area (Simondon et al., 1993). Based on results obtained in February, April, June, October and
December, 1991 and in February, 1992, the month of February appeared to be a month of good nutritional status for adults and a better-than-average month for preschool children, probably because it followed the rice harvest by only two months. Men's weight gain from 1991 to 1992 occurred principally between December 1991 and February 1992 (mean: +0.65 kg/mo vs. +0.06 kg/mo from February to December 1991, Simondon et al., 1993). Since data for different seasons are only available for 1991, it is not clear whether improvements in nutritional status described in this report occurred only during the particular season under study, or year round. The project may have reduced seasonal variations some, since irrigation permits cultivation during the major part of the year. However, the continuing high prevalence of stunting might indicate a less favorable nutritional situation for preschool children during other seasons, since the prevalence of stunting is not sensitive to short-term variations in nutritional status (Brown et al., 1982; Bairagi, 1987). Alternatively, the persistence of stunting might be explained by the persistence of deficiencies in nutrients required for linear growth (Allen, 1994).

The increasing prevalence of overweight (body mass index above 25 kg/m²) in the study area is a cause for concern, especially since, among women, the prevalence of overweight increased without any significant decrease in the prevalence of chronic energy deficiency. This discrepancy may suggest that well-to-do women benefit more from the project than nutritionally at-risk women. It was previously reported that the benefit from agricultural projects was not equally distributed within the community (Niemeijer et al., 1988). However, the prevalence of overweight in the present study remained lower than in low-income areas in the capital city of Dakar, where 22.4% of mothers of preschool children had a BMI above 25 kg/m² in the 1980s (Maire et al., 1992).

The observed weight gain among adults from 1990 to 1992 might be explained by an increase in food intake, a decrease in physical activity, or both. Food consumption in the study area in 1990–91 is known from a household consumption survey, based on the precise weighing technique. The mean energy intake per day and per capita was 10,16 kJ (2,459 kcal, Bénéfice and Simondon, 1993). This mean was rather high compared to requirements
estimated by WHO/FAO for adults (9,14 kJ; 2,213 kcal), but masks great variation among families (more than one-third did not meet their energy requirements). Furthermore, nothing is known about the distribution among family members. It should be noted that, even in the post-harvest season, more than 50% of the energy intake was provided by purchased food.

It was expected that the project would increase the time spent at agricultural tasks for women, but the duration of field work among a group of younger women was moderate (68.2 min/day) during the rice harvest in December 1993 and even shorter in April and September of the same year. No significant seasonal variations were found in the mean score of activity because of the predominance of domestic tasks which did not vary over the year (Bénéfice, Simondon and Malina, 1996). Physical activity of men is probably subject to larger seasonal variations because their main tasks are agricultural. In 1991, mean total energy expenditure, estimated from observed activities over 4 days and published measurements of activity-specific energy costs, and expressed in multiples of basal metabolic rate (MBR), was higher for women than for men in both January and June (2.0 vs. 1.6 and 1.8 vs. 1.5, respectively, Simondon et al., 1993). That might explain the lesser improvement in the nutritional status of women compared to men. The difference between sexes was not due to the greater mean age of men in the sample, since younger adults tended to gain more weight than those aged 35 years or more (results not shown).

The improvements in nutritional status described in this area are in disagreement with the results of several studies on populations working on rice irrigation schemes in Kenya (Niemeijer et al., 1988, Mwadime et al., 1996), but the agricultural development projects differed between Senegal and Kenya. The Kenyan schemes were large-scaled with farmers recruited outside the scheme and settled in a new area. Fields were far away from the compounds, so that mothers often left their children at home with a surrogate caretaker, and hygiene was poor (water was taken from irrigation canals and the prevalence of diarrhea was high; Mwadime et al., 1996). In the Senegal River valley, the population remained in their villages and the irrigated fields, formerly cultivated during flood recession, were not far away from the
villages. Furthermore, at the onset of the project, irrigated land was distributed on the basis of the number of able adults in the compounds in an attempt to avoid social inequalities. Therefore, it is not surprising if the nutritional impact differed between these two agricultural development projects.

Provided that the prevalence of wasting in this area remains at the low level found in 1994–95, that is, 3–4%, and that the decrease in prevalence at this season is not counterbalanced by higher prevalences in other seasons, it will probably have positive implications in terms of public health because of the well-documented risk of mortality associated with wasting in African children (Yambi et al., 1991; Vella et al., 1992; Fawzi et al., 1997). However, the project also created new problems. Modern agricultural systems require investments (fertilizers, pesticides, fuel for the pump station), while a traditional system is freer of economic costs. Such expenses progressively result in accumulation of debt for producers (Lericollais, 1989). In addition to these problems, a negative impact on the health status of the population is anticipated, with a high risk of introduction of schistosomiasis in association with irrigation, as is the case elsewhere in the Senegal River Valley (Talla et al., 1990) and in Africa in general (Audibert et al., 1990).

The sustainability of the development project remains open to question, and further evaluation is needed. Ideally, evaluation of the impact on nutritional status and morbidity should be integrated into all agricultural development projects, as was recently recommended (International Conference on Nutrition, Rome, December 1992; Hoorweg et al., 1996). The design of the evaluation would be enhanced, enabling possibilities of pre-project data collection and better utilization of evaluation results in program implementation. In areas where seasonal variations in nutritional status are important, as is the case in Sahelian countries, this aspect should be accounted for in the evaluation design.

ACKNOWLEDGMENTS

The multidisciplinary health program Eau et Santé dans les Contextes du Développement was supported in part by the French Ministry of Research, grant 792.
We are indebted to Pape Niokhor Diouf and Oumar Sall for their field assistance and to the study population for their participation. Special thanks are due to Pascal Handschumacher for coordinating the demographic census used in this study. R.M. Malina and F. Simondon kindly reviewed the manuscript.

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