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Early Mortality and Health Intervention Strategies in the Sine-Saloum Region of Senegal

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INTRODUCTION

With little doubt Sub-Saharan Africa has the most severe and widespread health problems of any major area of the world. The incidence of severe infectious disease there is unsurpassed as are levels of infant and childhood mortality. Mean life expectancy at birth for all countries combined has yet to reach 50 years, well below that for any other region of the world. Not surprisingly, the availability and use of effective health care services is also probably the lowest in the world, particularly in rural areas. Ratios of trained medical personnel to population tend to be extremely low. Many people have no access to even the most basic medical facilities or services and those facilities which do exist are frequently inadequate.

In recent years a number of primary health care projects have been implemented in various areas of Sub-Saharan Africa and still others are planned, the major purpose of most being to provide inexpensive, effective means of reducing mortality and alleviating major health problems. One such project is the Sine-Saloum Family Health Project, begun in 1978 in much of the Sine-Saloum Region of the West African Nation of Senegal.

In the first phase of this project administered by the Ministry of Health and funded by USAID, 2-room "health huts" were set up in about 400 villages in the region. Villagers were trained as community health workers (CHW's) to provide project services. Users of the huts' services were to pay a modest fee for medicines received. These fees, in turn, were to be used to pay the CHW's and replenish the huts' supplies.

The second phase of the project, beginning in 1984, is to consist of expanding the health huts to more of the region and eventually expanding the services to include some or all of such important activities as oral rehydration therapy, growth monitoring, immunizations, and family planning services. Thus, by the nature of its latest interventions, the project is increasingly likely to contribute significantly to the reduction of rates of mortality and severe morbidity, especially among children.

In this paper we use population-based survey data to investigate mortality levels and causes of death among infants and young children in the rural sector of the Sine-Saloum Region. Then, given these estimates of mortality, we project the likely effects on mortality of certain project interventions under various assumptions. We will concentrate on two interventions which may be added and which would be likely to make a substantial impact on childhood mortality--oral rehydration solution and measles immunizations. The projections are a function of survey estimates of age-specific and cause-specific mortality and access, use, and effectiveness of the interventions examined.

DATA

The Sine-Saloum is a predominantly agricultural region of west-central Senegal covering about 9,000 square miles and containing an estimated 1.2 million inhabitants. The data for this analysis are taken from the 1982 Sine-Saloum Family Health Survey (SSFHS) performed jointly by the U.S. Centers for Disease Control's Division of Reproductive Health and the National Census Office of

Senegal. Funding for the survey was provided by the U.S. Agency for International Development, whose prime objectives were: (1) to assess the health status and health needs of the population of the Sine-Saloum in order to determine future directions for the Sine-Saloum Family Health Project and (2) to establish baseline data in order to evaluate the impact of the second phase of the project.

The survey was population-based and retrospective. Interviews were carried out in 80 rural census districts, which were selected with probability proportionate to their 1976 population. Clusters of 10 or 15 compounds (easily distinguished extended family housing units) with a random starting point were selected in each of the districts. All ever-married women between the ages of 15 and 44 living in selected compounds were targeted for interview; 1,894 such women were successfully surveyed. A more detailed description of the survey and its findings can be found in the Survey Report (US Agency for International Development, 1984).

Respondents were asked to provide information on each of their children born since the beginning of 1977. For any of these children who were no longer alive at the time of interview, the respondent was asked to provide considerable information regarding the child's death. Included in this information were questions on whether or not the child exhibited each of 16 specified symptoms during the illness leading to his or her death. In all, data were obtained on 2,733 children born to respondents, of whom 383 reportedly had died.

Rather than relying solely on the cause of death as alleged by the mother (which was often unreliable, as evidenced by the fact that 11 children reportedly died from evil spirits), the probable cause of death was determined by using all relevant information supplied by the respondent. By synthesizing the data on symptoms, age at death, the cause of death given by the mother, and duration of illness, two physicians made a determination as to the most likely cause of death. Not only did this procedure allow us the assignment of causes of death with much greater reliability than otherwise, it also reduced considerably the proportion of deaths of wholly or partially indeterminate cause, from 42 percent to 20 percent of all deaths.

MORTALITY LEVELS

Table 5.1 displays lifetable probabilities of death during infancy and early childhood according to the Sine-Saloum Family Health Survey as well as the Senegal Fertility Survey of 1978. The SSFHS infant mortality rate of 72 deaths per 1,000 live births is undoubtedly an underestimate. For a number of reasons it is highly unlikely that infant mortality has fallen to so low a level (relatively speaking). Infant mortality in rural West Africa is generaly held to be over 100 per 1,000 births and in most populations is far above that level. Prospective studies by Cantrelle and Garenne (1984) from the early 1960's to the early 1980's for smaller areas within the Sine-Saloum Region, have found infant mortality to be considerably higher than the survey rate. In addition, the ratio of mortality from ages 1 to 4 ($_4q_1$) to infant mortality ($_1q_0$) in the survey, about 2:1, is extreme even for West Africa where such ratios tend to be the highest in the world.

It is generally taken for granted that retrospective surveys, such as this one, in developing countries fail to obtain complete reports of infant and child deaths. Owing to forgetfulness, superstition, unwillingness to talk about dead children, not considering children who died very young to have been live births, and possibly other factors, women sometimes do not provide interviewers with complete lists of children who are no longer alive. The fact that the survey estimates appear too low indicates that the Sine-Saloum Survey is no exception to the rule of underestimates of early mortality in surveys. Thus, it was decided that adjustment of the mortality data was mandatory in order to obtain more reliable results. The adjustment procedure used is based on the assumptions that mortality from ages 1 to 5 is almost fully reported and that the ratio of infant to early childhood mortality is fixed. (This procedure is described along with a more detailed description of mortality levels and differentials in Goldberg et al. (1983).) This adjustment results in an estimated probability of death during infancy ($_1q_0$) of .110 and before age 5 ($_5q_0$) of .246.

D. CAUSE OF DEATH

Table 2 displays cause-specific mortality rates in infancy and early childhood with no adjustment for underreporting of deaths. As with overall mortality, these mortality rates should be adjusted to take into account the omission of some deaths. The adjustment procedure is the same as that used for overall mortality, with adjusted rates shown in Table 3. Since omission is assumed to occur most frequently for children dying very young, rates for

those diseases which tend to kill very early, most notably tetanus, are affected most by the adjustment. Unfortunately, the procedure does not allow for the possibility that a child's cause of death is related to the probability of that death being reported by his or her mother, all else being equal, including the age at death.

Both unadjusted and adjusted rates (Tables 2 and 3, respectively) indicate that diarrheal and respiratory diseases (excluding measles) are the two leading causes of death among young children. It is estimated that these types of diseases kill about 7.6 percent and 6.3 percent, respectively, of all children by age 5. Before the first birthday they are of about equal importance, each causing the death of about 3 percent of infants.

Malaria and measles are next in importance, killing an estimated 3 percent and 2 percent of children, respectively. As one might expect, given the usual immunity against these diseases during much of the first year of life, mortality from both of these causes is very low relative to some other causes during infancy. Over half of measles mortality occurs between the first and second birthdays, the period when measles mortality typically is highest. It is quite likely that some of the diarrhea and respiratory problems which reportedly caused deaths were really complications of measles which had occurred earlier.

Tetanus ranks fifth in overall mortality, killing an estimated 1.4 percent of children. However, almost 90 percent of tetanus deaths occur in infancy, with the vast majority of deaths during the first month after birth. Meningitis

was the only other specific disease to which an appreciable number of deaths were attributed.

Another way of examining child deaths, and one which can help tell more about useful directions for health policy and interventions, is simply to describe the symptoms present among children before they died and to avoid attributing causes of death. Table 4 shows the proportions of children dying who were reported to have exhibited several of the symptoms related to the most common causes of death. This also eliminates the hazards associated with making a diagnosis in the presence of sometimes scanty information.

More than four-fifths of children were reported to have had a fever during their terminal illness. The vast majority of children who had either diarrhea, cough, or a rash had it in conjunction with fever. Fifty-one percent of children had diarrhea, 39 percent had a cough, and 14 percent exhibited a rash. Every individual and combination of symptoms examined was substantially less common among infants than among older children. This may be due partially to the presence of maternal antibodies transmitted prenatally or through breast milk and partially to the relatively large proportion of infant deaths from causes likely to be accompanied by fewer of these symptoms (tetanus, prematurity, etc.).

One learns from these results such things as the fact that although one-fourth of deaths were attributed to diarrheal disease, twice that many children had diarrhea prior to death. Some might argue that mortality could be attacked

through treatment of symptoms as well as root causes. For instance, measles may be prevented through vaccination, but its mortality might be reduced through treatment of the diarrhea which sometimes occurs as a complication.

PROJECTED IMPACT ON MORTALITY

In its second phase, the Sine-Saloum Family Health Project is planning to expand significantly, both geographically and in terms of services offered. It very likely will move into the parts of the region not covered in the past. New interventions may also be added, some of which could have a significant effect on infant and child mortality levels.

We have attempted to project the probable effects on early childhood mortality of two of the interventions which will possibly become more widely and readily available through the program: the provision of oral rehydration solution (ORS) and measles immunizations. These are designed to act directly on two of the most common causes of death among Senegalese children.

ORAL REHYDRATION SOLUTION (ORS)

In the survey, diarrheal disease was found to be the most important cause of death among children under 5--responsible for at least 24 percent of deaths. Additionally, one-half of all children who died were reported to have had diarrhea during the illness preceding their death. Premeasured packets of oral rehydration salts (ORS), ready to be added to water, may eventually be

distributed by project health facilities. ORS packets contain the electrolytes necessary to replace those lost during dehydration resulting from diarrhea. These packets are relatively inexpensive and easy to use and have been shown to be effective when given in the presence of watery diarrhea before dehydration has become very severe (WHO, 1981).

In our projection, we look at the potential effect only of ORS packets administered by health facilities or community health workers and not other types of oral rehydration therapy (ORT). These others types of ORT include homemade salt/sugar solutions and the administration of other liquids such as rice water, soups, juices, and teas, which might serve to prevent dehydration once diarrhea has begun. These other therapies can also be highly effective and, in fact, can often prevent the need for ORS or even more serious measures, if given appropriately. However, one assumption we make is that these other types of ORT (i.e., strategies to prevent dehydration) do not change significantly. We also will assume that those factors which influence the incidence of diarrhea, such as breast-feeding practices and water and sanitation, do not change.

Projecting the amount of decline in mortality requires the estimation of four parameters: access, utilization, coverage, and efficacy of treatment in a manner laid out by Moore (1984).

Access: In the Sine-Saloum Family Health Survey, 56 percent of respondents lived less than 3 kilometers from a health facility, while only 22 percent lived 5 or more kilometers from one. Access probably will not improve in most of the region but is very likely to get better in the one department

(and that is the largest department) with a very limited number of facilities and no health huts. For these estimates, it is assumed that access is constant at 80 percent, equivalent to saying that all health facilities have ORS, while almost all people living less than 5 kilometers from a health facility have access to ORS, and almost no one 5 or more kilometers away has access.

Utilization: Utilization represents the proportion of children with access starting to become dehydrated who are actually taken to a health facility for treatment. Survey results indicate that mothers in Sine-Saloum are not reluctant to use either health facilities or Western medicines--about half of diarrhea cases are currently treated with antibiotics. Thus, there is reason to believe that utilization would be good if women recognized the onset of dehydration and were made aware that effective treatment for it was available at health facilities. In our projections, utilization is varied from 50 to 90 percent.

Coverage: Coverage represents the proportion of children brought to a facility and requiring ORS who are actually given ORS. With adequate training of personnel and supplies of ORS, this figure should approach 100 percent. In our projections, we vary the coverage from 70 to 100 percent.

Efficacy: The World Health Organization (1981) has estimated that oral rehydration therapy is theoretically capable of preventing about two-thirds of diarrhea deaths in a developing country population. This assumes that about 95 percent of acute watery diarrhea deaths, and only at most 5 percent of dysentery and chronic diarrhea deaths, can be prevented and that most diarrhea is of the acute watery type. This figure, however, is theoretical efficacy (when treatment is timely and administered properly). We are more interested in "use-effectiveness," which will vary from 50 percent to 67 percent in the projections.

Tables 5A and 5B show the projected effects on diarrhea mortality of the implementation of facility-based ORS under the ranges of parameters discussed. From 14 percent to 48 percent of diarrhea deaths are projected to be eliminated. Assuming that only deaths categorized in the survey as caused by diarrheal disease were affected, the reduction in overall mortality would be from 4 percent to 14 percent. This would coincide with a decrease in ${}_5q_0$ from .246 to .211-.236.

As these are projections and not predictions, we would not venture a guess as to the most likely course of events. However, the less extreme assumptions seem the most realistic, since it is unlikely that all three variables would fall at one extreme or the other. Midlevel projections imply reductions in diarrhea mortality of about 20 percent to 30 percent and overall reductions of about 5 percent to 10 percent. In a given year, there are approximately 50,000 births to women in rural Sine-Saloum. At current mortality levels an

estimated 13,000 children born each year would die before their fifth birthday, with about one-fourth of those deaths attributable to diarrheal disease. A 20 percent to 30 percent reduction in diarrhea deaths would result in the averting of about 700 to 1,050 early childhood deaths per cohort.

Given constant access and little control over ORS efficacy, one can easily see that improvements in utilization and coverage can make a substantial difference in survival rates. For instance, a 20 percent increase in utilization (achieved mainly by information, education, and communication activities), given that all other parameters are constant, would decrease diarrhea mortality by about 5 deaths per 1,000 births. An increase in coverage of 15 percent (achieved mainly by improved logistics and worker training) would reduce diarrhea mortality by slightly less.

These projections have two major omissions which must be taken into consideration. The first has been referred to as synergism and applies to the idea that there is not necessarily a one-to-one correspondence between preventing a diarrhea death and the ultimate effect on mortality. There are three ways in which the relationship between preventing a specific death and mortality change might work:

(1) The eventual mortality decrease is less than the number of deaths directly prevented. Children receiving ORS are selected such that they are the most likely to die, or the survivors are weakened such that they still have an increased risk of mortality in

general. Thus, once saved from death, they will be more likely than others to die in childhood of another cause or of another severe case of diarrhea.

(2) The eventual mortality decrease is more than the number of deaths directly prevented. Those who survive have a decreased risk of mortality from future diarrhea or from other causes, or treating the dehydration prevented another condition, e.g., malnutrition or pneumonia, which might have killed the child.

(3) The eventual mortality decrease is just the amount of diarrhea mortality reduction. Those surviving the disease have the same probability of dying of future diarrhea and all other diseases as other children, i.e., there is no synergism.

In the case of diarrhea, unlike some other diseases, the first and third options appear the most plausible. It seems unlikely, a priori, that the total effect of ORS on mortality will be greater than the immediate effect on diarrhea mortality. However, it is quite likely that those who have been saved by ORS are more likely than others to be seriously ill again, because they are a selected group and/or they have been weakened by the experience. It is to be expected, then, that the proportion of diarrhea deaths averted by ORS intervention would be slightly lower than implied by our projections.

A second serious omission is that implicit in the survival probabilities projected is that once a child is saved from dehydration, he or she will no longer be at risk of dying from diarrheal disease later on. Of course, this is not the case, and many children will require repeated episodes of ORS treatment in order ultimately to avert death during childhood. Thus, the reductions in mortality, again, are likely to be somewhat less than indicated in Tables 5A and 5B.

A final note concerns the cause of death diagnoses. The 24 percent of deaths attributed to diarrheal disease should be viewed as the minimum number to whom the projections in Tables 5A and 5B apply. As seen in Table 4, one-half of all children who died reportedly had diarrhea during the illness leading to death. No doubt, some deaths attributed to other causes could be prevented by treating the dehydration resulting from diarrhea associated with the underlying cause. This does not affect the projection of proportionate decreases in diarrhea mortality but does act to decrease projected levels of overall mortality, quite possibly in a substantial way. If one assumes that diarrhea contributes to death in many of the cases where it was present but not the assigned cause of death, the overall mortality in Tables 5A and 5B could be appreciably higher.

MEASLES IMMUNIZATION

Measles, although not as important a cause of death as diarrheal diseases, nevertheless, brought about at least 7 percent of child deaths recorded in the survey and is responsible for more than 2 percent of all children dying before

their fifth birthday. These figures are likely to be even higher in reality, because many measles-associated deaths occur several weeks after the measles rash disappears and, thus, may be categorized as respiratory, diarrhea, or "unknown infectious disease" deaths. Virtually all measles deaths occur more than 6 months after birth, with 1-year-olds the highest risk group.

Measles vaccination levels are surprisingly high when compared to vaccination against other diseases in Sine-Saloum and in light of the fact that there is no ongoing vaccination effort being made in rural areas. About one-third of children from 9 months to 5 years of age had reportedly been vaccinated against measles. Apparently, though, many children receive their immunizations beyond the optimal age, since only 19 percent of 1 year-olds had been vaccinated.

One intervention being considered for the Sine-Saloum Family Health Project is to make vaccinations available at all health facilities. In projecting the probable impact on mortality of adding this intervention, we follow the same procedure that we did for projecting ORS impact.

Access: It is assumed that access to measles vaccination would be somewhat higher than access to ORS. First, a woman does not have to have access at a given point in time (when a child is ill), but only needs to get to a health facility any time after her child reaches the minimum age of vaccination and before measles exposure. Secondly, access for vaccination does not require transporting an ill child. We assume, for all projections, that 90 percent of mothers of young children would have access to health facilities.

Utilization: The fact that a substantial proportion of children have been vaccinated against measles, despite the limited availablity and absence of any promotion of the vaccine, implies that utilization would be high if vaccination became part of the Project. In our projections we vary utilization from 50 percent to 90 percent. (Utilization is defined as taking a child for a vaccination prior to the child's having had measles, despite the fact that this may mean getting vaccinated well beyond the optimal age.)

Coverage: We assume that coverage will be 100 percent--that any child beyond the minimum vaccination age will receive a vaccination. If supply problems arise, coverage could be somewhat lower.

Efficacy: A study by Hull et. al. (1983) in The Gambia, which borders on Sine-Saloum, found vaccine efficacy of 89 percent in children from 9 to 47 months of age. Feachem and Koblinsky (1983) list seroconversion rates for a number of countries, showing them to vary around 90 percent in most instances for children 9 months of age and over. For these projections, we vary efficacy from this upper limit of .90 down to .80, reflecting a circumstance in which some children may be vaccinated too young or some vaccine stored improperly.

Table 6 shows the projected effect of measles vaccination on mortality, given the various combinations of parameters. The six projections shown indicate a reduction in the number of measles cases by 36 percent to 73 percent. Most projections estimate reductions in the proportion of children dying of measles to about 1 percent (from 2 percent). Since at least some of the 20 percent of deaths from unspecified infectious disease or indeterminate cause are sure to

have been measles-associated, the decrease in mortality is likely to be somewhat more than 1 percent. A 50 percent reduction in mortality, directly attributable to measles, would result in saving about 500 to 750 of the children born in Sine-Saloum in any given year if 1 percent to 1.5 percent of children survived because of immunizations.

In one way, projections for measles immunization impact are considerably simpler than for ORS impact: Once a child is effectively immunized or gets measles, he or she is no longer at risk of getting measles; therefore, measles survival is permanent. However, in another way, projecting measles immunization is far more difficult than ORS, that is, in addressing the issue of synergism.

It has been argued both that the ultimate effect of measles immunization is less than and more than the number of measles deaths directly averted. A study in Zaire by the Kasongo Project Team (1981) showed that gains in survival following vaccination tended to diminish later on, implying that it is the weakest who die of measles and even if they survive it, have a greater chance of dying than others. On the other hand, Feachem and Koblinsky (1983), estimated that measles vaccinations could prevent 1 percent to 4 percent of diarrhea episodes and 6 percent to 26 percent of diarrhea deaths among children under 5 years of age. Likewise, Aaby (1981) demonstrates that measles vaccinations avert a considerable number of post-measles diarrhea deaths. Robertson et al. (1984) cite studies that show measles-related deaths occurring several months following measles outbreaks. One study in Bangladesh

by Koster et al (1981) reported that just over one-third of diarrhea deaths were measles-related. Apparently because of secondary infection, some deaths categorized as being due to diarrheal or respiratory causes really stem from measles which occurred earlier.

Because of the preponderance of evidence we assume that measles vaccination prevents more deaths than just those that would be attributed to measles. As a rough estimate for our projections, Table 7 we assume that 10 percent or 20 percent of diarrhea deaths and 10 percent of respiratory disease deaths are measles-associated. This would mean that the proportion of children dying because of measles, either directly or indirectly, would be nearly double the 2.0 percent attributed directly to measles. Since the same proportion of indirectly as directly caused deaths would be prevented by immunization, an estimated 36 percent to 73 percent of these deaths would also be averted. When diarrhea and respiratory deaths are counted among those averted, the projected overall ${}_5q_0$ declines to .211-.225 from .246, a very impressive reduction. (This does not even consider that some of the 20 percent of children with unknown cause of death are likely to have died of measles.) A 50 percent reduction in measles mortality would eliminate about 900 childhood deaths per cohort.

It should be noted that the diarrhea deaths, which would be averted by measles immunization, are thought not to be, for the most part, among the diarrhea deaths that would be averted by ORS (Feachem & Koblinsky, 1983), since much measles-related diarrhea seems to be dysenteric (McGregor, 1964; Black et al., 1980). Thus, the diarrhea mortality averted by ORS and immunization is probably close to being additive.

DISCUSSION

This exercise has attempted to demonstrate that both of the health interventions discussed, ORS and measles immunization, have the potential to decrease early childhood mortality appreciably in rural Sine-Saloum. The most surprising result is not the amount by which mortality is likely to be affected, but the fact that the projections imply that the net effect of a measles immunization program could easily exceed that of a facility-based ORS program, in spite of the fact that diarrhea mortality is estimated to be 3 to 4 times greater than measles mortality. There are several reasons for this. ORS is, at most, effective two-thirds of the time it is used (and some claim that in Africa the proportion of diarrheas susceptible to ORS is much less than that). In actuality, efficacy may be much less, since ORS must be given before dehydration has progressed too far. On the other hand, measles immunization is highly efficacious, and the only timing requirement is that it be given after 6 (or 9) months of age. Diarrhea also has the possibility of repeated disease episodes, which measles does not. Lastly, synergism works such that the net effect on mortality of measles vaccinations is appreciably greater than it appears, but there is less evidence that this is true for ORS.

These results are not meant to advocate that measles immunization should be given higher priority than ORS as a part of the health project. However, ORS has been espoused by many health planners and policymakers as a measure of almost limitless value in reducing mortality. These projections should at least make planners consider that its effect, although significant, might

be less than anticipated and that other measures may be just as effective. It is also possible that an oral rehydration program could take a form different from the facility-based, ORS packet type described here. Some countries have stressed use of homemade oral rehydration solutions prior to the onset of dehydration. The estimates of mortality effects of a different type of ORS program would be quite different.

We fully realize that the implementation of either of the interventions will not automatically reduce mortality to the extent indicated by our estimates. First, the assumed levels of the parameters in the calculations might not be reflected in reality. Such factors as utilization or efficiency could vary widely from assumed levels, owing to any number of unforeseen circumstances. Secondly, the projections assume that the program interventions are functioning smoothly, i.e., that resources (both financial and otherwise) are adequate to sustain the programs, that logistics are adequate to make supplies available, and that personnel are sufficient and able enough to implement the interventions at the local level. For instance, the logistics of supplying and properly storing measles vaccine may present enough problems to bring efficacy far below the levels projected, thus reducing the mortality impact of the intervention.

This paper should not be viewed by itself as an indication that one intervention would be more important than the other or an advocation that one should be given priority over the other. Other factors not taken into account here must be considered. The resources necessary to implement and sustain the

interventions may differ significantly, as well as various problems in administering and maintaining the programs. The writers do not purport to be able to advise policymakers, planners, and program officials regarding those aspects of these health interventions. These projections merely provide information regarding potential impact on mortality in Sine-Saloum and very possibly in other places with similar health problems and needs. Lastly, actions such as implementation of health interventions, do not occur in a vacuum. Along with such activities would certainly occur changes in attitudes and behavior of the population in addition to changes in policy and other facets of the health project, which could themselves directly or indirectly alter mortality themselves.

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TABLE 1

Probabilities of Dying During Infancy and Early Childhood, 1977-82
Sine-Saloum Family Health Survey

	Probability of Dying		
	Before 1 Year ($_1q_0$)	Between 1 and 5 Years ($_4q_1$)	Before 5 Years ($_5q_0$)
Sine-Saloum Family Health Survey, 1977-82*			
Direct estimate	.072	.146	.207
Adjusted**	.110	.153	.246
Senegal Fertility Survey, ****	.118	.191	.286

*Dates refer to the years for which mortality rates were computed
**Assumes that: (1) $_4q_1$ is underestimated by 5 percent;
(2) $_4q_1/_1q_0=1.4$
****Results for the entire Sine-Saloum Region, not just rural areas.

Source: H.I. Goldberg, F.G. M'bodji, J.S. Friedman, and D.L. Heymann, "Infant and Early Childhood Mortality in the Sine-Saloum Region of Senegal", presented at the 1983 Annual Meeting of the American Public Health Association, Dallas Texas.

TABLE 2

Unadjusted Cause-Specific Mortality By Age and
Selected Causes of Death
Sine-Saloum Family Health Survey

Cause of Death	1-90	491	590
Diarrheal disease	.018	.043	.060
Respiratory disease	.019	.031	.049
Malaria	.003	.026	.029
Measles	.001	.017	.018
Tetanus	.007	.002	.009
Meningitis	.004	.003	.006
All Causes	.072	.146	.207

TABLE 3

Adjusted Cause-Specific Mortality By Age, For
Selected Causes of Death
Sine-Saloum Family Health Survey

Cause of Death	1q0	4q1	5q0
Diarrheal disease	.028	.045	.072
Respiratory disease	.029	.032	.060
Malaria	.004	.028	.032
Measles	.002	.018	.020
Tetanus	.011	.002	.013
Meningitis	.008	.003	.009
All Causes	.110	.153	.246

*Assumes that: Deaths at 1 to 5 years are underreported by 5 percent and deaths before the first birthday are underreported by 35 percent.

TABLE 4

Percentage of Children No Longer Alive Born
Since 1977 Who Reportedly Exhibited Selected Symptoms Before
Death According to Age at Death
Sine-Saloum Family Health Survey

Symptoms	Age at Death			
	All Ages	<1	1	2-5
Fever	81.4	73.8	86.2	89.2
Diarrhea	50.7	42.2	58.7	60.9
Cough	39.0	35.1	47.8	38.9
Rash	14.3	11.1	19.3	16.1
Fever and diarrhea	45.1	35.0	52.1	57.1
Fever and cough	34.3	27.7	42.1	38.9
Fever and rash	13.7	10.4	19.3	16.1
Diarrhea and cough	24.7	18.1	33.4	31.0
Diarrhea and rash	10.8	9.1	12.5	13.0
Rash and cough	9.3	5.5	15.8	11.0
Fever, diarrhea and cough	22.8	15.6	29.7	31.0
Number of Children	(370)*	(161)	(78)	(109)

*Individual ages do not sum to total because age at death was unknown for 22 children. The number of children for whom the presence of a symptom was unknown varied slightly from symptom to symptom.

TABLE 5A

Projected Effect on Diarrhea and Overall $5q_0$ of Facility-Based Oral Rehydration Solution With 50 Percent Efficacy Under Varying Levels of Other Parameters

Assumptions				Projected Effects				
				Diarrhea Deaths Eliminated				
Access	Utilization	Coverage	Net Coverage	%	Number*	New Diarrhea $5q_0$	% Overall $5q_0$ Reduction	New Overall $5q_0$
80	50	70	.28	14	500	.062	4	.236
80	70	70	.39	20	700	.058	6	.232
80	90	70	.50	25	900	.054	7	.228
80	50	85	.34	17	600	.060	5	.234
80	70	85	.48	24	850	.055	7	.229
80	90	85	.61	31	1110	.050	9	.224
80	50	100	.40	20	700	.058	6	.232
80	70	100	.56	28	1000	.052	8	.226
80	90	100	.72	36	1300	.046	11	.220

Original diarrhea $5q_0$ estimate=.072
Original overall $5q_0$ estimate =.246

*Number per cohort based on an estimated 50,000 births per year in rural Sine-Saloum

TABLE 5B

Projected Effect on Diarrhea and Overall 5q0 of Facility-Based Oral Rehydration Solution With 67 Percent Efficacy Under Varying Levels of Other Parameters

Assumptions				Projected Effects				
				Diarrhea Deaths Eliminated		New Diarrhea	% Overall	New Overall
Access	Utilization	Coverage	Net Coverage	%	Number*	5q0	5q0 Reduction	5q0
80	50	70	.28	19	700	.058	6	.232
80	70	85	.39	26	950	.053	8	.227
80	90	100	.50	34	1200	.048	10	.222
80	50	70	.34	23	800	.056	7	.230
80	70	85	.48	32	1150	.049	9	.223
80	90	100	.61	41	1500	.042	12	.216
80	50	70	.40	27	950	.053	8	.227
80	70	85	.56	38	1350	.045	11	.219
80	90	100	.72	48	1750	.037	14	.211

Original diarrhea 5q0 estimate=.072
Original overall 5q0 estimate =.246

*Number per cohort based on an estimated 50,000 births per year in rural Sine-Saloum

TABLE 6

Projected Effect on Measles and Overall 5q0 of Measles Immunization
With Varying Utilization and Efficacy of Vaccine

Assumptions					Projected Effects				
Access	Utilization	Coverage	Net Coverage	Efficacy	Measles Death Eliminated %	Measles Death Eliminated Number*	New Diarrhea 5q0	% Overall 5q0 Reduction	New Overall 5q0
90	50	100	.45	.80	36	350	.013	3	.239
90	70	100	.63	.80	50	500	.010	4	.236
90	90	100	.81	.80	65	650	.007	5	.233
90	50	100	.45	.90	41	400	.012	3	.238
90	70	100	.63	.90	57	550	.009	4	.235
90	90	100	.81	.90	73	750	.005	6	.231

Original diarrhea 5q0 estimate =.020
Original overall 5q0 estimate =.246

*Number per cohort based on an estimated 50,000 births per year in rural Sine-Saloum

TABLE 7

Projected Effects on Overall $5q_0$ of Measles Immunization
With Varying Utilization, 90% Efficacy and with Effect on Diarrhea and Respiratory Deaths*

Assumptions					Projected Effects		
Access	Utilization	Coverage	Efficacy for Preventing Measles	% Reduction in Diarrhea Mortality	Number of Overall Deaths Averted**	% Overall $5q_0$ Reduction	New Overall $5q_0$
90	50	100	.90	10	1050	9	.225
90	70	100	.90	10	1200	10	.222
90	90	100	.90	10	1400	11	.218
90	50	100	.90	20	1400	11	.218
90	70	100	.90	20	1550	13	.215
90	90	100	.90	20	1750	14	.211

Original overall $5q_0$ estimate =.246
Original diarrhea $5q_0$ estimate =.072
Original respiratory disease $5q_0$ estimate =.061
Original measles $5q_0$ estimate =.020

*Assumed to eliminate 10-20 percent of diarrhea deaths and 10 percent of respiratory deaths.
**Number per cohort, based on an estimated 50,000 births per year in rural Sine-Saloum.