

# The prevalence of diarrheal disease among Brazilian children: trends and differentials from 1986 to 1996

Narayan Sastry<sup>a,\*</sup>, Sarah Burgard<sup>b</sup>

<sup>a</sup>*RAND Corporation, 1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138, USA*

<sup>b</sup>*University of Michigan School of Public Health, 1214 South University, Ann Arbor, MI 48104, USA*

Available online 24 August 2004

---

## Abstract

In this paper, we examine trends and differentials in diarrhea prevalence and treatment in Brazil between 1986 and 1996. Our results indicate that there was a very modest decline in diarrhea prevalence in Brazil over this ten-year period. However, treatment with oral rehydration therapy (ORT) increased greatly. Although deaths due to diarrhea were reduced, high disease rates continue to place a large number of children at risk of adverse nutritional and developmental outcomes. There were dramatic differences in diarrhea prevalence across socioeconomic groups and regions that persisted over time, although the large regional differential in ORT treatment that was present in 1986 had disappeared by 1996. The persistence of high rates of diarrhea indicates that reducing the prevalence of the disease continues to be a major public health priority. The large differential in the prevalence of diarrhea across socioeconomic groups and regions means that interventions to prevent the disease should be targeted towards the most disadvantaged segments in Brazil, which also face the highest child mortality rates.

© 2004 Elsevier Ltd. All rights reserved.

*Keywords:* Brazil; Diarrhea; Regional differences; Socioeconomic groups

---

## Introduction

The global under-five mortality rate fell from around 100 per 1000 births in the early 1980s to 70 per 1000 births by the end of the 1990s (Ahmad, Lopez, & Inoue, 2000). A dramatic reduction in diarrhea mortality was responsible for a substantial part of this decline. The estimated deaths due to diarrhea among children under five years of age fell from 4.6 million in 1980, to 3.0 million in 1990, to 1.6 million in 2000 (Snyder & Merson, 1982; Bern, Martines, De Zoysa, & Glass, 1992; World Health Organization, 2001). Understanding the factors that led to the decline in diarrhea mortality is an

important research and policy issue. Of particular interest is the potential role played by the decline in diarrheal disease and the expanded use of oral rehydration therapy (ORT), which has been widely identified as a key factor in the decline of child mortality due to diarrheal disease.

In this paper, we examine trends and differentials in diarrhea prevalence and treatment in Brazil over a ten-year period, from 1986 to 1996. Victora and colleagues (1996) suggest that a large increase in the use of ORT played a central role in reducing deaths due to diarrhea in Brazil and, moreover, that the reduction in diarrhea deaths accounted for a large part of the substantial increase in child survival from the mid-1980s to the mid-1990s. One of our goals is to investigate whether the apparent decline in diarrhea mortality over this period was accompanied by a decrease in diarrheal morbidity.

---

\*Corresponding author. Fax: +1-310-393-4818.

*E-mail addresses:* [sastry@rand.org](mailto:sastry@rand.org) (N. Sastry), [burgards@umich.edu](mailto:burgards@umich.edu) (S. Burgard).

The answer will help us to better understand the factors responsible for the decline in mortality due to diarrhea. A large decline in diarrhea morbidity would suggest a more limited contribution of ORT toward reducing mortality due to diarrhea, given that ORT does little to prevent diarrheal disease.<sup>1</sup> On the other hand, a small decline in diarrhea morbidity would be consistent with ORT reducing child mortality due to diarrhea. The second of our goals is to identify the social, economic, and behavioral factors that were associated with diarrheal disease and its treatment. Identifying important covariates and examining how they have changed over time will uncover those groups that are at greatest risk of diarrheal disease and suggest how policy interventions should be targeted to further promote child health and survival.

### Conceptual framework and statistical methods

Child health is determined directly by a set of biological and behavioral factors that reflect a child's exposure to the risk of disease and protection from these disease risks. For example, exclusive breastfeeding protects children from exposure to diarrhea-causing pathogens. Better household sanitation and water supply also play protective roles. These factors are typical of the inputs that, collectively, produce child health. In Mosley and Chen's (1984) conceptual framework, the complete set of inputs is identified as intermediate determinants of child health. Four groups of factors are relevant: (1) maternal factors, (2) environmental contamination, (3) nutrient deficiency, and (4) personal illness control.

The specific health-related inputs for a particular child are determined by the choices and constraints the child's parents face. For instance, parents choose how much of their families' resources to allocate to promoting their children's health. They may trade off time spent at work, which brings in income, with time spent at home caring for their children. These choices may also be influenced by characteristics of the child, such as the child's sex, and attributes of the community, such as the availability of health care services.

If we combine the two notions that children's health outcomes are produced using a set of inputs, and that levels of inputs reflect choices made by families, we can

derive a simplified, reduced-form relationship between a particular child health outcome,  $H$ , and background child, family, and community characteristics ( $X^C$ ,  $X^F$  and  $X^N$ , respectively):

$$H = f(X^C, X^F, X^N). \quad (1)$$

In this reduced-form model, child characteristics include age and sex; family characteristics include socioeconomic status, parents' education, and family structure and composition; and community characteristics include indicators of the physical environment and the availability of health care services.

### Modeling approach

We use multilevel logistic regression to model the relationship between diarrhea prevalence and the background and intermediate factors identified above. Our dependent variable is a binary response, which indicates whether a child had diarrhea in the recent past or not. Drawing on our conceptual framework, we first estimate the reduced-form model that includes only the background child, family, and community covariates. We next add intermediate child and family covariates representing inputs to child health to the model. Together, these two models allow us to study how background factors directly and indirectly affect diarrhea prevalence.

Our analysis of diarrhea treatment focuses on the estimation of models based on the reduced-form model alone. These models of the demand for health care are estimated only for children who were reported to have had diarrhea in the past two weeks.

### Decomposing changes in diarrhea prevalence over time and across regions

One goal of this paper is to better understand trends and differentials in the prevalence of diarrhea in Brazil. Over the period of study, rates of diarrhea decreased relatively modestly—especially in the Northeast region. However, there were substantial changes in background demographic and socioeconomic characteristics of the population and in intermediate factors representing the proximate determinants of child health. An important question is the extent to which these secular changes were responsible for the observed trends in diarrhea prevalence. A related question is the degree to which the dramatic differences in these factors between the Northeast region and the rest of Brazil accounted for the significantly higher rates of diarrheal disease in the Northeast.

We answer these questions by decomposing the differences in diarrhea prevalence across regions and over time. We examine two types of counterfactuals. First, looking at trends, we predict the prevalence of

<sup>1</sup>Increased use of ORT might have been associated with lower diarrhea prevalence if there was a connection between promotional health care focusing on ORT use, on the one hand, and public health programs that focus on preventive care on the other. More directly, by limiting nutritional damage from an episode of diarrhea, the use of ORT might reduce the severity and duration of subsequent episodes of diarrhea (Feachem, 1986).

diarrhea in the later period (1996) assuming that the relationships that held in 1986 did not change. The difference between the actual prevalence of diarrhea in 1986 and the predicted prevalence of diarrhea in 1996 (based on relationships from 1986) shows the contribution of improvements in the *characteristics* of the population in terms of its demographic, socioeconomic, and health-related attributes to the changed rates of diarrheal disease. The remaining difference—i.e., between the predicted 1996 rates and the actual 1996 rates—reflects changes in *relationships* between population characteristics and diarrhea prevalence that occurred over this period or the effects of unmeasured factors. In the second counterfactual, we perform a similar decomposition to study differentials in diarrhea prevalence between the Northeast region and the rest of Brazil.

## Data

Data for this study come from two nationally representative surveys conducted in Brazil in 1986 and 1996 as part of the Demographic and Health Survey (DHS) Program. The surveys interviewed women of reproductive age and collected detailed information on child health and mortality, health-related behavior, use of health care services, fertility and fertility-related behavior, and several other topics. In general, the measures across the two surveys are quite comparable, although there were some important changes that are discussed below. The quality of the data collected in DHS surveys is generally quite high, and the surveys of Brazil are no exception.

The first Demographic and Health Survey in Brazil (DHS-1) selected a total of 8369 dwelling units for the survey across 337 primary sampling units (PSUs). The PSUs represented the entire country except rural areas of the North region (which are sparsely populated areas in the Brazilian Amazon basin). Interviews were completed with 5892 women aged 15–44 years, and information on diarrhea was obtained for 3183 children born to these women in the five years preceding the survey, of which 1238 were in the Northeast and 1945 were in the rest of Brazil.<sup>2</sup>

The third DHS survey of Brazil (DHS-3) selected a total of 842 PSUs for the survey. All areas of the country were represented, again with the exception of rural areas of the North region. Interviews were completed with 12,612 women aged 15–49 years. Information was collected on 4617 children born to these women in the five years preceding the interview, of which 2099 were in the Northeast and 2608 were in the rest of Brazil.

<sup>2</sup>The various counts of children with information on diarrhea exclude twins and a small number of cases missing information on key covariates.

## *Questions on diarrhea prevalence and treatment*

Information on diarrhea episodes and treatment was collected from mothers about their living children under five years of age at the time of the survey. The appendix lists the questions on diarrhea episodes that were asked in Portuguese, along with their English translations. Note that there was a change in the questionnaire wording and order between the two surveys: the order was reversed for the question asking about current diarrhea and the one asking about diarrhea during the past two weeks. This change occurred in response to suspected over-reporting of diarrhea episodes in the 24 h preceding the survey. In addition, while DHS-1 asked about current diarrhea in the past 24 h, DHS-3 asked about diarrhea “today.” These differences mean that the only measure of diarrhea that is comparable across the two surveys is whether the child had an episode of diarrhea in the past two weeks. It is this measure of the two-week-period prevalence of diarrhea that we use as our primary outcome of interest. An advantage of using the two-week measure is that it captures the greatest possible number of diarrhea cases in the sample. This is an important issue because, for certain groups, diarrhea was a relatively rare event.

The questions on treatment of diarrhea were asked only for children who had diarrhea in the past two weeks. Women were asked whether they or anyone else had done anything to treat the diarrhea and, if so, what treatments were provided. In DHS-1, the interviewer matched unaided mentions of treatments to several listed categories, including home remedies, various types of oral rehydration therapy, and hospitalization. In DHS-3, interviewers asked about the use of an ORT packet before inquiring about any other diarrhea treatments. For our analysis, we focus on use of a consistent set of treatments, corresponding to the early, expanded definition of ORT (which referred to the use of oral rehydration salts or the use of recommended home fluids) that was in use at the time of DHS-1.<sup>3</sup> This includes the use of an ORT packet (a commercially prepared ORT solution sold in pharmacies and shops) or a recommended homemade solution of water, salt, and sugar. The increased prompting for use of an ORT packet in DHS-3 leads us to expect less underreporting over time and hence an upward bias for trends in ORT treatment.

<sup>3</sup>The definition of oral rehydration therapy has changed over time (Victora, Bryce, Fontaine, & Monasch, 2000; Victora et al., 2000). The earliest definition referred to the use of oral rehydration salts (ORS) alone; soon after, it was expanded to include the use of recommended home fluids (RHF). Later, continued feeding and increased fluids became components of ORT.

### Data quality

There are a number of potential problems and issues associated with collecting information from mothers on their children's episodes of diarrhea. However, it is generally difficult to assess the quality and completeness of survey information on children's diarrhea because there is rarely an external "gold standard," such as administrative records or medical tests, with which to compare self-reports. Moreover, it is usually not possible to correct data quality problems that are uncovered. Nevertheless, identifying problems in the data is important, because they can affect how we evaluate and interpret our results. In this section, we investigate the implications of the particular questions that were used and differences in the accuracy and completeness of reports across groups and over time.

In the DHS surveys, the definition of diarrhea is left up to each individual respondent. By contrast, epidemiological studies typically provide an explicit definition of diarrhea and guidelines for determining when an episode of diarrhea has ended. Determining whether an episode of diarrhea has ended or is continuing is important for estimating current diarrhea prevalence or the number of diarrhea episodes. It is less significant when asking about diarrhea episodes during a two-week window, the focus of this study. Of perhaps greater concern is the ability of mothers to recall all diarrhea episodes occurring during the two-week period and to correctly separate events that fell within those two weeks from those that fell outside it. There is a well-documented tendency for respondents to increasingly forget events the farther back in time they occurred (Sudman, Bradburn, & Schwarz, 1996), especially for events that are less memorable to respondents (as a child's episode of diarrhea may be, especially when rates are high). The choice of a two-week recall period, in DHS and many other health surveys, balances the competing concerns of keeping recall error to a minimum and identifying enough outcome events by having a sufficiently wide window (Ross & Vaughan, 1986).<sup>4</sup>

<sup>4</sup>Estimates of recall error for mother's retrospective reports of diarrhea for their children fall within a fairly narrow range, and the average level of recall error can reasonably be classified as "modest." Assessments of two-week retrospective reports are generally based on comparing these prevalence estimates with those based on data collected through daily calendars. In Guatemala, a diarrhea prevalence estimate from the DHS survey of 20% was very close to an estimate of 22% obtained using a more detailed calendar that worked to reduce recall error (Goldman, Vaughan, & Pebley, 1998). A study in Bangladesh found that diarrhea estimates based on a two-week recall period produced results that were highly similar (Kappa value of 0.83, indicating excellent agreement) to those from a calendar that was recorded daily (Stanton et al., 1987).

The accuracy and completeness of reports on diarrhea prevalence and treatment may vary over time and across groups, complicating the study of trends and differentials. For instance, different women may not have the same definition of diarrhea, may not identify the termination of a diarrhea episode in the same way, may identify the two-week period differently, or may have a differing likelihood of giving "don't know" responses or having missing information (Boerma, Black, Sommerfelt, Rutstein, & Bicego, 1991). Studies that have evaluated retrospective diarrhea reports have either not found convincing evidence of selective recall error (e.g., Boerma et al., 1991) or have found no evidence of selectivity at all (e.g., Stanton et al., 1987). We were able to examine only rates of missing information on diarrhea in the Brazil DHS surveys, which were stable over time. Information on diarrhea is missing for 2.0% of eligible children in DHS-1 and 1.8% of eligible children in DHS-3. Mother's education and child's age and sex were weakly associated with missing information on diarrhea. Controlling for these factors in our models will ensure that missing data do not bias our results.

Another factor that may affect the comparability of diarrhea reports over time is that the DHS surveys in Brazil were fielded during different months of the year.<sup>5</sup> This is relevant because diarrhea infection rates vary with the season. Given the Brazil DHS surveys' structure and timing, it is not possible to identify the effects of seasonality separately from secular changes in diarrhea prevalence. (Note, however, that when we analyzed each wave separately, we found no significant effect of the month of interview). Only a handful of studies have examined diarrhea over a period of one year or more in Brazil, and they all suffer from having small sample sizes and focusing on a single community in either the North or Northeast region. Nevertheless, one consistent finding was that diarrhea episodes peaked during January-February and October (Giugliano, Bernardi, Vasconcelos, Costa, & Giugliano, 1986; Schorling et al., 1990; Guerrant, Kirchoff, & Shields, 1983; Linhares, Moncao, & Gabby, 1983).<sup>6</sup> If this pattern holds for other years, estimates of diarrhea prevalence in the Northeast may be lower than expected in both DHS-1 and DHS-3. However, there is no way to gauge the magnitude of this effect.

<sup>5</sup>Interviews for the 1986 DHS-1 took place between May and August, with the majority occurring in June and July. The 1996 DHS-3 was fielded between March and July, with the bulk of interviews completed in April and May.

<sup>6</sup>In the Northeast, January and February correspond to the wet and rainy summer months, whereas October falls at the end of the dry period.

### Trends and differentials in diarrhea prevalence and treatment

Diarrhea prevalence in Brazil declined moderately between 1986 and 1996, as shown in Table 1. The two-week prevalence of diarrhea among children under age five for all of Brazil fell from 17.8% in 1986 to 14.8% in 1996, a statistically significant change. In the Northeast region, the two-week prevalence was 21.4% in 1986 and 19.0% in 1996. The 1996 rate was not significantly different from the 1986 rate. For the rest of Brazil, the two-week diarrhea prevalence was 15.6% in 1986 and fell to 11.6% in 1996, a statistically significant change. There were statistically significant differences in the two-week diarrhea prevalence rates between the Northeast and the rest of Brazil, with the Northeast having a higher rate in both 1986 and 1996. In 1986, diarrhea rates in the Northeast were 14% higher than in the rest of Brazil while in 1996 they were 28% higher.

Diarrhea episodes were more likely to have been treated in 1996 than in 1986. Table 1 shows that for all of Brazil, 87% of cases were treated in 1996, up from 76% in 1986. This change was statistically significant, as were changes by region. In the Northeast, there was an increase in diarrhea cases being treated, from 75% in 1986 to 86% in 1996. In the rest of Brazil, the 1996 rate of 87% was nine percentage points higher than the 1986 rate of 78%. More dramatic changes are evident in the use of ORT: for Brazil as a whole, only 15% of diarrhea cases were treated with some form of oral rehydration therapy in 1986, while the figure for 1996 reached 54%.<sup>7</sup> The increase was especially large in the Northeast, where it jumped from 9% in 1986 to 54% in 1996. In the rest of Brazil, 55% of diarrhea cases were treated using ORT in 1996, up from 20% in 1986. All of these changes were statistically significant.

Regional differences in diarrhea treatment were eliminated between 1986 and 1996. In both periods, roughly the same proportion of diarrhea cases were treated in the Northeast and the rest of Brazil. However, in 1986, ORT treatment rates for the Northeast were half the rate for the rest of Brazil; by 1996, ORT treatment rates were very similar for the two regions.

<sup>7</sup>A large proportion of the packaged ORS supply in Brazil has traditionally been directed to the Northeast region (about half the packets in 1990). The Brazilian government began distributing ORS in 1982, and the supply showed a secular increase, with the notable exception of 1986 when it fell to under five million packets from 15 million the year before (Victora et al., 1996). This one-year aberration may partially explain the low level of ORT use in the Northeast in 1986. However, packaged ORS accounts for only part of all ORT use, and the drop in 1986 should not have altered the use of homemade solutions.

Table 1  
Means (and standard deviations) for diarrhea prevalence and treatment by survey year and region

Variable	Survey year			
	1986 DHS-1	1996 DHS-3		
<i>All of Brazil</i>				
Diarrhea				
Past 2 weeks	0.178	(0.383)	0.148	(0.355)
Treatment for diarrhea				
Any	0.762	(0.426)	0.867	(0.340)
ORT	0.150	(0.357)	0.544	(0.498)
Number of observations	3183		4617	
<i>Northeast</i>				
Diarrhea				
Past 2 weeks	0.214	(0.410)	0.190	(0.393)
Treatment for diarrhea				
Any	0.747	(0.435)	0.864	(0.343)
ORT	0.091	(0.288)	0.537	(0.499)
Number of observations	1238		2009	
<i>Rest of Brazil</i>				
Diarrhea				
Past 2 weeks	0.156	(0.363)	0.116	(0.320)
Treatment for diarrhea				
Any	0.776	(0.418)	0.871	(0.336)
ORT	0.201	(0.402)	0.553	(0.498)
Number of observations	1945		2608	

Source: Authors' calculations.

### Model covariates

We have identified two sets of covariates for our analysis, composed of background variables (at the child, family, and community levels) and intermediate variables (at the child and family levels). We identify and present summary statistics for these variables in Table 2 for the Northeast region and the rest of Brazil.

Background factors at the child level include age and sex. Background factors at the family level include mother's education, parents' marital status, father's education, and household wealth, while at the community level they include rural-urban place of residence and region. We created an index of household wealth through a principal components analysis of household assets following the approach of Filmer and Pritchett (2001).<sup>8</sup>

<sup>8</sup>For DHS-1, the index of household wealth was based on possession of an automobile, television, radio, vacuum cleaner, and a maid; for DHS-3, the index covered possession of an automobile, television, radio, refrigerator, vacuum cleaner, washing machine, and videocassette recorder, the number of maids, number of rooms in the house, house construction material, and electrical connection. We did not include indicators of household water supply and sanitation in the wealth index because of our interest in directly studying the effects of these variables on diarrhea prevalence.

Table 2  
Means (and standard deviations) or percent by category for independent variables by region and survey year

Variable	Northeast		Rest of Brazil	
	1986 DHS-1	1996 DHS-3	1986 DHS-1	1996 DHS-3
<i>Child age (months)</i>	29.9 (17.2)	29.2 (17.4)	30.2 (17.4)	29.4 (17.1)
<i>Child sex</i>				
Female	50.4%	49.6%	47.5%	48.9%
Male	49.6	50.4	52.5	51.2
<i>Mother's education (years)</i>	3.48 (3.57)	4.60 (3.62)	5.47 (4.01)	6.25 (3.66)
<i>Marital status</i>				
Married	72.1%	53.4%	76.8%	63.9%
Cohabiting	19.5	31.8	14.3	20.5
Never married	1.9	5.2	3.4	6.9
Previously married	6.5	9.7	5.5	8.7
<i>Father's education</i>				
None	23.3%	21.8%	8.7%	5.6%
Primary or more	74.7	65.7	87.4	84.7
Don't know/missing	0.1	7.4	0.5	2.8
<i>Household wealth index</i>				
Bottom 60%	81.9%	74.0%	43.9%	46.6%
Top 40%	18.1	26.0	56.1	53.5
<i>Place of residence</i>				
Urban	50.4%	61.1%	80.1%	85.2%
Rural	49.6	38.9	19.9	14.8
<i>Birth order</i>				
First born	22.3%	31.8%	32.8%	36.8%
Order 2-4	43.8	49.2	50.8	53.3
Order 5+	33.9	19.1	16.5	9.9
<i>Child still breastfeeding</i>				
No	85.7%	79.2%	82.0%	78.0%
Yes	14.3	20.8	18.1	22.0
<i>Household water supply</i>				
Piped	27.7%	53.5%	67.2%	72.7%
Well/Undeveloped	72.3	46.6	32.8	27.4
<i>Household toilet facilities</i>				
Flush toilet	9.9%	47.3%	41.6%	71.0%
Septic/None	90.0	52.7	58.4	29.0
Number of observations	1238	2009	1945	2608

The index was constructed on a national basis for each year, using the full sample of households. Intermediate factors at the child and family level include the child's breastfeeding status (reflecting whether the child is fully weaned or not), the child's birth order, and household sanitation and water supply. We also examined the effects of duration of breastfeeding,

whether the child was immunized against measles, mother's age, and preceding and succeeding birth intervals. None of these latter variables emerged as significant covariates of diarrhea prevalence and, because their exclusion did not alter the effects of other covariates, they were omitted from the final set of models we present.

## Results

Our results are presented in three subsections. We first examine the covariates of two-week diarrhea prevalence using multilevel logistic regression models estimated separately for the Northeast region and the rest of Brazil. We then present our decomposition results, which allow us to identify the factors that account for the decline in diarrhea prevalence between 1986 and 1996 within each region and the factors that account for differences between regions. Finally, we discuss results for models of treatment for diarrhea among children who had diarrhea in the two weeks preceding the survey.

### *Models of diarrhea prevalence by region*

The results for models of diarrhea estimated separately for the Northeast and the rest of Brazil are presented in Table 3. All of the models fit the data, and the family and cluster-level random effects were all highly significant. The variance of the family level random effects was large in both the Northeast and in the rest of Brazil. For the Northeast in Model I, the family level random effect was 2.55 and the intra-family correlation coefficient was 0.41. For the rest of Brazil, the variance of the family level random effect was 2.15, and the intra-family correlation coefficient was 0.37. In the Northeast, the variance of the cluster-level random effect was 0.35, about one-seventh of the variance of the family level random effect, and the intra-cluster correlation coefficient was 0.06. In the rest of Brazil, the variance of the cluster-level random effect was 0.31 and the intra-cluster correlation coefficient was 0.05.

The results for the two regions were generally similar, although there were some notable differences. We begin our discussion with results from Model I, which includes only the background covariates. We found that the effects of mother's education were slightly stronger in the Northeast region. Although mother's education had a negative and statistically significant association with diarrhea in both areas, in the Northeast a one-year increase in education for the mother was associated with a 9% decline in the probability of her child having diarrhea, compared to a 7% decline in the rest of Brazil.

In the Northeast, children of mothers who were cohabiting or were previously married experienced a higher likelihood of having diarrhea compared with children of currently married mothers; similar results were found for the rest of Brazil. Father's education was associated with lower rates of diarrhea for children, but only in 1996.<sup>9</sup> The results for both regions were again

virtually identical. Children of an educated father experienced approximately 45% lower diarrhea rates in both regions, and this effect was significant at the 0.01 level in the Northeast (where the effect was  $1.007 \times 0.531 = 0.535$ ) and in the rest of Brazil (where the effect was  $0.802 \times 0.683 = 0.548$ ).

There were substantial differences between the Northeast and the rest of Brazil in the effects of place of residence. A somewhat unexpected finding was that, in 1996, diarrhea risks were 50% lower in rural areas than in urban areas of the Northeast ( $1.093 \times 0.460 = 0.503$ ). In the rest of Brazil and in the Northeast region in 1986, place of residence was unrelated to diarrhea. Finally, taking into account all the interaction effects between year and other covariates, we find that the risk of diarrhea declined over time. However, the change was statistically significant only in the rest of Brazil, where the risk of diarrhea in 1996 was 38% lower than it was in 1986. In the Northeast, the risk of diarrhea was 15% lower in 1996, but this effect did not reach statistical significance.

We turn now to the results for each area from Model II, which includes both the background and intermediate factors. The intermediate covariates were jointly significant at the 0.01 level in the Northeast, but were not significant in the rest of Brazil. Only two significant results emerged for the rest of Brazil and one, concerning breastfeeding, relates simply to a difference in the covariate effect between 1986 and 1996 (with the effects in neither year reaching statistical significance). The other significant result concerns the effects of household water supply. In 1986, children in households without piped water had diarrhea rates 64% higher than children in households with piped water; by 1996, however, the beneficial effects of piped water had evaporated ( $1.639 \times 0.566 = 0.928$ ).

In the Northeast region, there were a number of statistically significant effects for intermediate variables but, interestingly, none was consistent over time. In 1996 alone, breastfeeding was associated with a 55% lower risk of diarrhea ( $0.771 \times 0.582 = 0.449$ ). We might have expected breastfeeding to have a more beneficial effect in the earlier period, when undeveloped water supply and sanitation were more common. However, there was an increase in breastfeeding rates over the study period, and a more select group of women may have been recipients of these breastfeeding promotion efforts, which would account for the isolation of the effect to the later study year. There was some evidence for this assumption in the finding (not shown) that the likelihood of breastfeeding decreased with mother's education, but only in 1986. In contrast, there was a dramatically large effect associated with household toilet facilities. In 1986, having a flush toilet was associated with a risk of diarrhea approximately one-quarter of that for children with less-developed sanitation. By 1996, this advantage had

<sup>9</sup>When an interaction with year is included, the covariate effect for the later period (1996) is the product of the direct effect and the interaction (because we report exponentiated parameter estimates). We report the statistical significance of the total effects in the text, not in the tables.

Table 3  
Multilevel logistic regression models of two-week diarrhea prevalence for Northeast Brazil and rest of Brazil, 1986–96

Variable	Northeast				Rest of Brazil			
	Model I		Model II		Model I		Model II	
<i>Child age (spline)</i>								
0–5 months	1.334***	(0.085)	1.244***	(0.083)	1.399***	(0.091)	1.415***	(0.096)
6–59 months	0.952***	(0.005)	0.947***	(0.005)	0.958***	(0.004)	0.959***	(0.005)
<i>Child sex</i>								
Female <sup>†</sup>	—	—	—	—	—	—	—	—
Male	1.009	(0.125)	1.002	(0.125)	1.033	(0.119)	1.039	(0.120)
<i>Mother's education (years)</i>								
	0.908***	(0.023)	0.915***	(0.025)	0.926***	(0.019)	0.936***	(0.020)
<i>Marital status</i>								
Married <sup>†</sup>	—	—	—	—	—	—	—	—
Cohabiting	1.366*	(0.225)	1.351*	(0.225)	1.345*	(0.217)	1.324*	(0.215)
Never married	0.719	(0.262)	0.666	(0.253)	0.808	(0.275)	0.802	(0.282)
Previously married	1.460	(0.368)	1.418	(0.360)	1.248	(0.296)	1.217	(0.290)
<i>Father's education</i>								
None <sup>†</sup>	—	—	—	—	—	—	—	—
Primary or more (additive)	1.007	(0.259)	1.080	(0.280)	0.802	(0.227)	0.899	(0.257)
Primary or more (× 1996)	0.531*	(0.174)	0.466**	(0.155)	0.683	(0.237)	0.596	(0.211)
Don't know/missing	0.451**	(0.174)	0.454**	(0.176)	0.895	(0.437)	0.915	(0.450)
<i>Household wealth index</i>								
Bottom 75% <sup>†</sup>	—	—	—	—	—	—	—	—
Top 25%	0.874	(0.232)	0.934	(0.252)	0.808	(0.123)	0.861	(0.134)
<i>Place of residence</i>								
Urban <sup>†</sup>	—	—	—	—	—	—	—	—
Rural (additive effect)	1.093	(0.288)	0.775	(0.224)	1.461	(0.355)	1.158	(0.298)
Rural (× 1996)	0.460**	(0.152)	0.779	(0.291)	0.650	(0.222)	0.862	(0.318)
<i>Year</i>								
1986 <sup>†</sup>	—	—	—	—	—	—	—	—
1996	1.747*	(0.594)	10.636***	(6.500)	0.915	(0.306)	1.404	(0.535)
<i>Birth order</i>								
First born	—	—	1.190	(0.184)	—	—	1.093	(0.143)
Order 2–4 <sup>†</sup>	—	—	—	—	—	—	—	—
Order 5+	—	—	1.112	(0.194)	—	—	1.157	(0.213)
<i>Child still breastfeeding</i>								
No <sup>†</sup>	—	—	—	—	—	—	—	—
Yes (additive effect)	—	—	0.771	(0.217)	—	—	1.327	(0.290)
Yes (× 1996)	—	—	0.582*	(0.190)	—	—	0.620*	(0.167)
<i>Household water supply</i>								
Piped <sup>†</sup>	—	—	—	—	—	—	—	—
Well/undeveloped (additive)	—	—	1.572	(0.507)	—	—	1.639**	(0.375)
Well/undeveloped (× 1996)	—	—	0.565	(0.185)	—	—	0.566*	(0.176)
<i>Household toilet facilities</i>								
Flush toilet <sup>†</sup>	—	—	—	—	—	—	—	—
Septic/None (additive effect)	—	—	4.449***	(2.375)	—	—	1.106	(0.257)
Septic/None (× 1996)	—	—	0.202***	(0.115)	—	—	0.953	(0.284)
<i>Variance of random effects</i>								
Family	2.553***	(0.647)	2.547***	(0.652)	2.154***	(0.606)	2.164***	(0.606)
Community	0.354**	(0.156)	0.336**	(0.153)	0.311**	(0.147)	0.290**	(0.149)

Notes: \* $p < 0.10$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ ; standard errors in parentheses; <sup>†</sup> omitted category. Source: Authors' calculations based on data from a total of 3244 children under age 5 in the Northeast region and 3535 in the rest of Brazil from 1986 DHS-1 and 1996 DHS-2 surveys of Brazil.

Table 4

Decomposition results for changes in diarrhea prevalence between 1986 DHS-1 and 1996 DHS-3 (by region) and between the Northeast region and the rest of Brazil (by year): Mean predicted two-week diarrhea prevalence rates (and standard errors)

	1986		Predicted 1996 (background only)		Predicted 1996 (background and intermediate)		1996	
Northeast	0.214	(0.012)	0.202	(0.014)	0.161	(0.022)	0.190	(0.009)
Predicted rest of Brazil (background only)	0.185	(0.014)	—	—	—	—	0.171	(0.012)
Predicted rest of Brazil (background and intermediate)	0.153	(0.015)	—	—	—	—	0.169	(0.012)
Rest of Brazil	0.156	(0.008)	0.155	(0.010)	0.140	(0.023)	0.116	(0.008)

Note: Predicted 1996 rates are based on 1986 relationships and 1996 characteristics. Predicted rates for the rest of Brazil are based on relationships for the Northeast and characteristics for the rest of Brazil.

disappeared entirely ( $4.449 \times 0.202 = 0.899$ ), so that there was no statistically significant benefit associated with having a flush toilet. The presence of an effect associated with toilets in 1986 but not in 1996 occurred as the percentage of children living in a household with a toilet rose more than fourfold in the Northeast region, from 10% in 1986 to 47% in 1996. Already in 1986, a similar percentage of children (42%) lived in households with a flush toilet in the rest of Brazil. There was no beneficial effect of better sanitation then or in 1996, when 71% of children in the rest of Brazil lived in households with a flush toilet.

Comparing the results for the background variables in Models I and II for each region, we found that the major difference was in the effect of year. In the rest of Brazil, the effect of year was attenuated slightly, with the risk of diarrhea now 33% lower in 1996 and significant at the 0.05 level. In contrast, once intermediate variables were added to the model for the Northeast (and interactions between year and other covariates were accounted for), diarrhea rates in 1996 were 72% higher than diarrhea rates in 1986, an effect statistically significant at the 0.05 level. Our results suggest that the decline in diarrhea rates in the Northeast—after controlling for background demographic and socioeconomic characteristics—was more than accounted for by the substantial improvement in household sanitation that occurred over this period (and, to a much lesser extent, to higher rates and durations of breastfeeding). That is, the enormous improvements in infrastructure hid the deterioration in other factors that should have actually led to higher rates of diarrhea in 1996 than in 1986. This upward trend reflects the fact that unadjusted diarrhea rates declined very modestly over this period in the Northeast despite substantial improvements in a number of key factors, such as mother's education. It is difficult to speculate what other (unmeasured) factors might be important, although one of them is likely to be changes

in nutritional status. In particular, although child stunting (low height for age) decreased greatly in the Northeast between 1986 and 1996, child wasting (low weight for height) actually rose.<sup>10</sup> Lower levels of wasting are associated with diarrhea episodes of lesser severity and duration and lower diarrhea case fatality rates (Miller & Hirschhorn, 1995). Another contributing factor might be a greater awareness of diarrhea as a disease and a stronger association between the name of the disease and a common set of symptoms for children in Northeast Brazil. In other words, there may have been more complete and accurate reporting of diarrhea over time. Finally, it is important to note that because improved toilet facilities were not associated with lower diarrhea rates in 1996, there appears to be little prospect of further reducing diarrhea morbidity rates by investing further in sanitation (or in water supply, which had insignificant effects for both years).

#### Decomposing trends and differentials in diarrhea prevalence

In Table 4, we present the results of our decomposition analysis. The rows of this table show the decompositions across years, for each region, while the columns show the decompositions across regions, for each year. Predicted 1996 rates are based on covariate effects estimated for the 1986 data and characteristics for the 1996 sample. Predicted rates for the rest of Brazil are based on covariate effects estimated for the North-

<sup>10</sup>One-fifth of children under five in the Northeast were stunted in 1996, down from approximately one-third in 1986; the percent wasted increased from 3% to 5%. Stunting was a significant covariate of diarrhea risk. However, it was omitted from the models because data on stunting was not collected outside the Northeast region in the 1986 DHS-1 survey.

east and characteristics for the rest of Brazil. Shown in each corner of the table are the actual rates for the corresponding region and year. Two predicted values are shown in the table: The first was based on background factors only, while the second was based on both background and intermediate factors. With one exception (to be identified), no differences between pairs of adjacent estimates in the “Predicted rest of Brazil” rows were statistically significant. Although there were a number of other statistically significant results, which we will highlight, the decomposition findings should overall be viewed as being only suggestive.

The regional differential in diarrhea prevalence between the Northeast and the rest of Brazil was statistically significant in both 1986 and 1996. In 1986, differences in background and intermediate characteristics together accounted for the entire differential, with each part explaining approximately 50%. Changes by 1996 meant that differences in background and intermediate characteristics now accounted for only a quarter of the regional differential. Instead, differences in relationships, or omitted variables, emerged as being important. This finding suggests that improvements in measured socioeconomic characteristics, health related behaviors, and household facilities on their own could not have closed the gap in diarrhea prevalence between the Northeast and the rest of Brazil (as might have been the case in 1986). Rather, changes in additional background and intermediate characteristics needed to be considered, and the effects of given child and family characteristics on diarrhea prevalence probably needed to be altered so that improvements in these factors deliver more-beneficial results.

In the Northeast, the total decline in diarrhea prevalence from 21% to 19% between 1986 and 1996 was not statistically significant. Half of this small decline was explained by changes in background characteristics. When we accounted for changes in intermediate factors, however, the predicted decline between 1986 and 1996 was statistically significant (at the 0.10 level) and large—in fact, larger than the actual decline. This suggests that positive changes in intermediate characteristics in the Northeast were quite favorable for reducing rates of child diarrhea, with improvements in toilet facilities appearing to play an especially important role. However, the beneficial effects on diarrhea rates of these intermediate factors disappeared over this period, so that the actual decline in diarrhea prevalence was substantially smaller than what might have been expected.

In the rest of Brazil, changes in background characteristics alone had essentially no effect on the statistically significant decline in diarrhea prevalence between 1986 and 1996. Rather, it was changes in intermediate factors and, especially, changes in relationships or the effects of unmeasured characteristics that

appear to have been important. The results show interesting regional variation: For the rest of Brazil, a given set of characteristics appears to have had a more beneficial effect on reducing child diarrhea in 1996 than in 1986, while the reverse held true in the Northeast.

#### *Analysis of patterns and trends in diarrhea treatment*

In the final part of our analysis, we examined treatment patterns among children who had diarrhea in the two weeks preceding the survey. We focus on the effects of background variables on the probability of a child receiving any treatment for diarrhea and, separately, on the probability of receiving oral rehydration therapy. Because treatment of diarrhea is conditional on having the disease—and information on treatment was collected only for children having the disease in the two weeks preceding the interview—the sample size for this analysis was reduced substantially from the previous analysis.

We estimated a variety of treatment models using data for all of Brazil, the Northeast region, and Brazil minus the Northeast region (results not shown). The only consistent finding that emerged from our analysis was the presence of a strong, secular increase in treatment for diarrhea. This increase was not accounted for by changes in characteristics of children, mothers, or families. The effects of survey year were extremely large and highly significant in the models that we estimated, with few exceptions. For example, for all of Brazil, there was an 85% increase between 1986 and 1996 in the probability of a child with diarrhea receiving any form of treatment. This was the only effect statistically significant at the 0.05 level in a model that controlled for child age and sex, mother’s education and marital status, father’s education, household wealth, rural-urban place of residence, and region.

The results for treatment of diarrhea using ORT were more dramatic. Children across all of Brazil were ten times more likely to receive ORT in 1996 than in 1986. In the Northeast, ORT treatment rates were 16 times higher in 1996 than in 1986, while in the rest of Brazil there was a sevenfold increase in treatment rates over this ten-year period. Aside from this regional differential in the improvement in ORT treatment rates, no other consistent pattern of covariate effects emerged.

#### **Conclusions**

In this paper, we examined trends and differentials in diarrhea prevalence in Brazil over a ten-year period, between the mid-1980s and the mid-1990s. Diarrhea prevalence declined modestly for the country as a whole during this time. The decline was smaller in the poor and less-developed Northeast region of the country, which

experienced higher diarrhea prevalence rates and, more generally, worse child health outcomes. The two-week diarrhea prevalence rate fell from 21% in 1986 to 19% in 1996 in the Northeast, a statistically insignificant change. If the decline over the decade had been as large as that in the rest of Brazil, the rate of diarrhea prevalence in Brazil would have been almost 3 percentage points lower in 1996.

Was the persistence of high rates of diarrhea morbidity in the Northeast region a consequence of the fall in diarrhea mortality rates and, in particular, of very high diarrhea morbidity among children who would otherwise have died from the disease? Our calculations suggest that the fall in diarrhea mortality rates could have resulted in the decline in diarrhea prevalence rates being roughly half what they otherwise might have been.<sup>11</sup> Nevertheless, under this counterfactual, the decline in diarrhea prevalence in the Northeast region would at best have been no larger than that in the rest of Brazil (most likely, a lot smaller). We conclude that the decline in diarrhea prevalence in Brazil over the study period was indeed modest and that it was at least partly due to the absence of strong public health efforts to prevent children from getting the disease. From a policy perspective, efforts should be made to reduce diarrhea prevalence both in the Northeast region and in the rest of Brazil. Although in comparison to the Northeast the rest of the country is doing quite well, it seems unacceptable that in 1996 one in ten children should have suffered from diarrhea over a two-week period.

Our results suggest that diarrhea prevalence rates in the Northeast could be reduced through improvements in mother's education, father's education, and breastfeeding. The fact that improved household water supply and sanitation are not likely to contribute to further lowering of diarrhea rates in the Northeast suggests that expanding the infrastructure is not enough. Rather, changes in hygienic behaviors and practices need to

accompany these improvements. The positive effects of current breastfeeding in the Northeast indicate that environmental factors and hygienic behaviors are important. For the rest of Brazil, our results suggest that improvements in mother's education essentially represent the only pathway to lower diarrhea prevalence.

The rise in the use of ORT for children with diarrhea, from 15% in 1986 to 54% in 1996, represents a major achievement for the Brazilian public health system. It is well known from studies around the world that ORT treatment is effective in saving the lives of children who might have died from dehydration associated with diarrhea. Support for the notion that the increased use of ORT represents a success primarily for the health system comes from the fact that ORT use is not strongly or systematically associated with socioeconomic or demographic characteristics. The increase in ORT use was twice as large in the Northeast as in the rest of Brazil and, by 1996, roughly half of the children with diarrhea in both regions were being treated with ORT.

One key policy and research question that needs to be answered concerns the factors that caused the large apparent decline in infant and child mortality due to diarrhea in Brazil over this period. In particular, was it true, as several researchers have suggested (e.g., *Victora, Olinto, Barros, & Nobre, 1996*), that it was largely due to the success of efforts to promote oral rehydration therapy? There is considerable uncertainty regarding trends in mortality by cause, because death registration is not complete and information on death certificates that are filed is often missing or inaccurate. Nevertheless, our results suggest that declining diarrhea prevalence was very unlikely to have been responsible for the decline in infant mortality due to diarrhea—especially in the Northeast region—simply because the decline in prevalence was so meager. Hence, our findings are consistent with those of the other researchers—namely, that the spread of ORT did play an important role in reducing infant deaths due to diarrhea. On the other hand, the decline in mortality due to diarrhea could have been brought about instead by other interventions to treat diarrhea, such as continued feeding of children with the disease (which helps prevent deterioration in the child's nutritional status) and antimicrobial treatment of dysentery (which works to shorten the illness); other health-related changes, such as increased measles immunization rates (which reduces deaths due to diarrhea); improved nutritional status (which reduces a child's risk of death for any given illness episode); and, finally, changes in the duration and severity of diarrhea.

#### Acknowledgement

Support from NIH grant HD38556 is gratefully acknowledged.

<sup>11</sup>The decline in infant mortality in the Northeast region (from about 100 per 1,000 births in 1986 to 60 per 1000 births in 1996) and in the proportion of infant deaths due to diarrhea (from 41% in 1986 to 15% in 1996—as estimated by *Victora et al., 1996*) together suggest that a maximum of  $[(100 \times 0.41) - (60 \times 0.15)] = 32$  infants per 1000 who would have died from diarrhea in the earlier period did not do so in the later period. The actual number was likely to have been lower because these children were exposed to competing mortality risks. Applying this to our 1996 sample suggests that as many as 17% of children with diarrhea in 1996 might have been alive to suffer from the disease because they did not previously die from it (although even in this counterfactual we would not expect all of these children to have suffered from diarrhea in the past two weeks). Excluding these cases from the 1996 sample would result in a diarrhea prevalence rate of 0.163 (rather than the observed rate of 0.190) and a decline in diarrhea prevalence from 1986 of 24% (rather than the observed decline of 11%).

## Appendix

Questions on diarrhea prevalence in Brazil DHS surveys, in Portuguese with English translation

---

**1986 DHS-1.** Asked for all children born since January 1981 who are still alive, starting with the youngest
 

---

Nas últimas 24 horas [NOME] teve diarreia?	Has [NAME] had diarrhea in the past 24 hours?
Sim	Yes
Não	No
Não sabe	Don't know
If No or Don't know:	If No or Don't know:
Nas últimas duas semanas [NOME] teve diarreia?"	Has [NAME] had diarrhea in the past two weeks?
Sim	Yes
Não	No
Não sabe	Don't know

---

**1996 DHS-3.** Asked for all children born since January 1991 who are still alive, starting with the youngest
 

---

[NOME] teve diarreia nas últimas duas semanas?	Did [NAME] have diarrhea in the past two weeks?
Sim	Yes
Não	No
Não sabe	Don't know
If Yes:	If Yes:
[NOME] está com diarreia hoje?	Did [NAME] have diarrhea today?
Sim	Yes
Não	No
Não sabe	Don't know

---

## References

- Ahmad, O. B., Lopez, A. D., & Inoue, M. (2000). The decline in child mortality: A reappraisal. *Bulletin of the World Health Organization*, 78, 1175–1191.
- Bern, C., Martinez, J., De Zoysa, I., & Glass, R. I. (1992). The magnitude of the global problem of diarrhoeal disease: A ten-year update. *Bulletin of the World Health Organization*, 70, 705–714.
- Boerma, J. T., Black, R. E., Sommerfelt, A. E., Rutstein, S. O., & Bicego, G. T. (1991). Accuracy and completeness of mothers' recall of diarrhoea occurrence in pre-school children in demographic and health surveys. *International Journal of Epidemiology*, 20, 1073–1080.
- Feachem, R. G. (1986). Preventing diarrhea: What are the policy options? *Health Policy and Planning*, 1, 109–117.
- Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data—or tears: An application to educational enrollments in states of India. *Demography*, 38, 115–132.
- Giugliano, L. G., Bernardi, M. G. P., Vasconcelos, J. C., Costa, C. A., & Giugliano, R. (1986). Longitudinal study of diarrhoeal disease in a peri-urban community in Manaus (Amazon-Brazil). *Annals of Tropical Medicine and Parasitology*, 80, 443–450.
- Goldman, N., Vaughan, B., & Pebley, A. R. (1998). The use of calendars to measure child illness in health interview surveys. *International Journal of Epidemiology*, 27, 505–512.
- Guerrant, R. L., Kirchhoff, L. V., Shields, D. S., Nations, M. K., Leslie, J., de Sousa, M. A., Araujo, J. G., Correia, L. L., Sauer, K. T., & McClelland, K. E., et al. (1983). Prospective study of diarrheal illnesses in northeastern Brazil: Patterns of disease, nutritional impact, etiologies, and risk factors. *Journal of Infectious Disease*, 148, 986–997.
- Linhares, A. C., Moncao, H. C., Gabbay, Y. B., Araujo, V. L., Serruya, A. C., & Loureiro, E. C. (1983). Acute diarrhea associated with rotavirus among children living in Belém, Brazil. *Transactions of the Royal Society for Tropical Medicine and Hygiene*, 77, 384–390.
- Miller, P., & Hirschhorn, N. (1995). The effect of a national control of diarrheal diseases program on mortality: The case of Egypt. *Social Science & Medicine*, 40, S1–S30.
- Mosley, W. H., & Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. In: W. H. Mosley, & L. C. Chen, (Eds.), *Child survival: strategies for research. Population and Development Review*, 10 (suppl.), 25–45.
- Ross, D. A., & Vaughan, J. P. (1986). Health interview surveys in developing countries: A methodological review. *Studies in Family Planning*, 17, 78–94.
- Schorling, J. B., Wanke, C. A., Schorling, S. K., McAuliffe, J. F., de Souza, M. A., & Guerrant, R. L. (1990). A prospective study of persistent diarrhea among children in an urban Brazilian slum. *American Journal of Epidemiology*, 132(1), 144–156.
- Snyder, J. D., & Merson, M. H. (1982). The magnitude of the global problem of acute diarrheal disease: A review of active

- surveillance data. *Bulletin of the World Health Organization*, 60, 605–613.
- Stanton, B., Clemens, J., Aziz, K. M. A., Khatun, K., Ahmed, S., & Khatun, J. (1987). Comparability of results obtained by two-week home-maintained diarrhoeal calendar with two-week diarrhoeal recall. *International Journal of Epidemiology*, 16, 595–601.
- Sudman, S., Bradburn, N. M., & Schwarz, N. (1996). *Thinking About Answers: The Application of Cognitive Processes to Survey Methodology*. San Francisco: Jossey-Bass.
- Victora, C. G., Bryce, J., Fontaine, O., & Monasch, R. (2000). Reducing deaths from diarrhoea through oral rehydration therapy. *Bulletin of the World Health Organization*, 78, 1246–1255.
- Victora, C. G., Olinto, M. T. A., Barros, F. C., & Nobre, L. C. (1996). The recent fall in diarrhoea mortality in Northeast Brazil: Did ORT play a role? *Health Policy and Planning*, 11, 132–141.
- World Health Organization (2001). Integrated management of childhood illness. <http://www.who.int/child-adolescent-health/integr.htm>.