THE DECLINE OF DIARRHEAL DISEASE AMONG BRAZILIAN CHILDREN, 1986 TO 1996†

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1. Introduction

Diarrheal disease is among the leading causes of death for children in less developed countries. In Brazil, deaths due to diarrhea comprise a large fraction of total child deaths, especially in the poor and underdeveloped Northeast region (Victora et al., 1996). Diarrhea is also an important morbid condition among children. If frequent or prolonged, it can lead to poor nutritional status—wasting, or low weight-for-height, in the short term and stunting, or low height-for-age, in the longer term. Poor nutritional status can also have lasting effects on health status and physical and cognitive development.

The high rates of diarrhea prevalence in Brazil and elsewhere are unfortunate because diarrheal disease can largely be prevented. Diarrhea can be caused by a variety of bacterial, viral, and parasitic enteropathogens with varying modes of transmission, but prevention techniques are often relatively simple. The most common bacterial pathogens in developing country settings are *Escherichia coli* and *Shigella*. Transmission of *E. coli* is thought to be primarily through water and food, so the avoidance of fecally contaminated water and attention to hygienic food handling techniques would help prevent illness. *Shigella* is transmitted by the fecal-oral route, as well as in contaminated food or water. Shigellosis is most common among children two to four years of age in developing countries (Black et al., 1982), and is usually mild, requiring only rehydration. Viral diarrheas are acute, self-limiting illnesses and the most common group, the rotaviruses, appear to be responsible for many of the serious sporadic diarrheas of young children. Rotavirus infection spreads by fecal-oral transmission, so prevention includes sanitary waste disposal, avoidance of fecally contaminated water and objects, and hygienic practices like handwashing. In addition, infants may derive some protection from breastfeeding since it contains specific rotavirus-neutralizing antibodies (Yolken et al., 1978), and children more than two years old and adults have substantial resistance to rotavirus diarrhea (Black et al., 1982b).

Public health efforts to lower rates of diarrhea, in Brazil and elsewhere, have focused principally on improving the water supply and sanitation systems. During the 1970s in Brazil there was a massive investment in sanitation and water supply. There was a major decline in child mortality over these years as a result of improved control over infectious and parasitic diseases. Reduction of diarrhea-related deaths accounted for a large proportion of these improvements, although in 1985 about 13 percent of infant deaths in Brazil and 41 percent of infant deaths in the Northeast region were still caused by diarrhea (Rodrigues, 1992:13). Merrick (1985) finds evidence that expansion of public piped water (and mother's education) played major roles in the reduction of child mortality across urban Brazil from 1970 to 1976. After 1980, however, the rate of decline in child mortality slowed. During the 1980s, the water supply improved markedly and government expenditure on health care and nutritional supplementation increased (Victora et al. 1996). Despite these investments, large differences in diarrhea prevalence existed across socioeconomic groups, regions, and urban or rural place of residence (Rodrigues 1992). Differences in rates of diarrhea by socioeconomic status may be due to differences in child care practices, such as preparation of weaning foods, boiling of drinking water, or personal hygiene (Black et al. 1983). Alternatively, they may be due to disadvantaged children having poor nutritional status, a factor associated with more prolonged diarrhea (Black et al. 1984).

Development of water and sanitation systems is a long-term solution for diarrheal disease; in the short term, the symptoms of diarrhea can be treated effectively with oral rehydration therapy (ORT). Introduced in 1979, ORT rapidly became the cornerstone of programs designed to control diarrheal disease (Victora et al. 2000). ORT involves the oral administration of sodium, a carbohydrate, and water, and is designed to rehydrate a child or prevent dehydration. In Brazil, ORT has been promoted through programs involving the Catholic Church (Finkam, 1989) and the World Health Organization (Victora et al. 2000), as well as the Ministry of Health. Information about rehydration therapy has been disseminated in several ways: health workers from governmental and non-governmental organization were trained in the preparation and use of oral rehydration solutions, a campaign for the use of home-made salt-and-sugar solutions for diarrhea treatment was launched, and instructions in preparing the solutions at home and advertisement for commercially-prepared ORS were broadcast on television and the radio (Barros et al. 1991).

There is some evidence that ORT was able to reduce diarrhea mortality on a large scale. In Northeast Brazil, ORT has been linked to the 57 percent decline over the 1980s in infant mortality attributable to diarrhea (Victora et al. 1996). During this period, admissions to major pediatric hospitals associated with diarrhea fell, while there were no comparably large declines for any other major cause of death or admission. Similar results were found for children aged one to four years. Despite its association with the decline in child mortality due to diarrhea, ORT and other treatments have no direct effect on the prevalence of diarrhea in the population. The reduction of child deaths due to diarrhea that accompanied the increased use of ORT has consequently reduced the urgency for infrastructure and environmental improvements that would reduce diarrhea prevalence and which have been the driving factor behind the child mortality transition.[1] Other approaches to reducing diarrheal disease and associated fatalities include the promotion of breastfeeding (Palloni and Millman 1986), improved supplemental feeding, female education, and immunization against measles. These may also help to mitigate some of the socioeconomic and geographic differences in the prevalence and severity of diarrhea.

Our goal in this paper is to examine trends in diarrhea prevalence and treatment in Brazil over a ten-year period, from 1986 to 1996. Other studies have documented a substantial increase in rates of child survival over this period and have provided some evidence that a decline in deaths due to diarrhea has played an important role. We find that rates of diarrhea prevalence declined only modestly between 1986 and 1996. However, treatment has improved dramatically, especially the use of ORT. This trend is consistent with the improvements in rates of child survival over the period of study. Nevertheless, the relatively high rates of diarrhea prevalence that have persisted are troubling because they suggest that children are likely to be suffering from related morbidities and that improvements in children's nutrition status, although substantial, were not as great as they might have been. In addition, there are dramatic differences in diarrhea prevalence and treatment across socioeconomic groups and regions. This

[1] Palloni (1981) suggests that Latin America is characterized by a distinctive age pattern of mortality, with excess levels of infant and child mortality for a given level of adult mortality. This is driven by excess mortality from water- and food-borne diseases in low-altitude tropical countries and from airborne diseases at high altitudes in semi-tropical countries. According to Palloni, this complex of water-food-airborne diseases does not respond to the introduction of isolated medical interventions, but requires improvement in the standard of living and sustained public health intervention.

indicates that further interventions that are targeted towards the most disadvantaged segments in Brazil—who also face the highest child mortality rates—are warranted.

We draw on data from three Brazilian surveys, conducted as part of the Demographic and Health Surveys (DHS) Program, to assess trends and differentials in the prevalence and treatment of diarrhea in Brazil. We begin, in the next section, by presenting our conceptual framework and statistical modeling approach. In Section 3, we provide a description of our data and a brief assessment of the quality of mothers' reports on child health and health related behaviors. The accuracy of these reports is an important issue in studying diarrhea trends and differentials. In the subsequent section we describe the covariates on which our analysis focuses. In Section 5, we present and discuss our results and we end the paper with a discussion of the implications of our results for policy and for the future improvement of child health in Brazil.

2. Conceptual Framework and Statistical Methods

Conceptual Framework

Child health outcomes in general—and child diarrhea prevalence in particular—are directly determined by a set of biological and behavioral factors that reflect the child's exposure to the risk of disease and protection from these disease risks. For example, breastfeeding protects children from exposure to diarrhea-causing pathogens until they first receive supplementary liquids or solids (Palloni and Millman 1986). Household sanitation and water supply play a similar protective role, while access to and use of health care services helps determine how children are treated for illness and disease. These factors represent the inputs that are combined to produce child health. In Mosley and Chen's (1984) conceptual framework, these inputs are identified as the proximate determinants of child health. Four groups of factors are relevant here: (1) maternal factors; (2) environmental contamination; (3) nutrient deficiency; and (4) personal illness control.

The specific set of health-related inputs for a particular child is determined by choices and constraints faced by parents. That is, parents choose how much of their families' resources to allocate to promoting their children's health. For example, they may trade-off time spent at work, which brings in income, against time spent at home caring for their children. They 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 development outcome, *H*, and child, family, and neighborhood characteristics (X^C, X^F and X^N, respectively):

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

In this reduced-form model, child characteristics include age and sex; family characteristics include socioeconomic status, parents' education, family structure and composition; and neighborhood characteristics include indicators of the physical environment and the availability of health care services. Child health outcomes are determined not only by measured inputs, but also by important unmeasured inputs, represented by ζ in the above equation, that reflect a mother's abilities to promote the health of her children or unobservable aspects of the home or neighborhood environment. The effects of unobserved heterogeneity at the family or neighborhood level are of substantive interest. In particular, the variance of the distribution of unobserved heterogeneity provides us with an indication of the strength of unmeasured or unmeasurable effects.

The proximate determinants should not ordinarily appear in the reduced-form equation for child health. Rather, they usually either belong in the health production function or may be analyzed as outcomes if they themselves are of interest. However, one reason for including the proximate determinants in the reduced-form equation for child health is to examine how the effects of background factors are changed by their inclusion. This provides insights into the ways in which the background factors operate to affect child health. In this hybrid production function/reduced-form model, the effects of background factors, such as education, must be interpreted carefully. This is because the effects of the background variables are changed to represent their net effects after accounting for many—but not all—of the pathways through which they work.[2]

Modeling Approach

We use multilevel logistic regression to model the relationship between diarrhea prevalence and the background and intervening factors identified above. Our dependent variable is a binary response, y_{ij}, that indicates whether the *i*th child of the *j*th family has had diarrhea in the recent past ($y_{ij} = 1$) or not ($y_{ij} = 0$). The probability of a child having diarrhea is defined as $p_{ij} = \Pr(y_{ij} = 1)$ and a logit transformation of p_{ij} is modeled as a linear function of the covariates in the model,

$$\log[p_{ij} / (1 - p_{ij})] = X'_{ij}\beta_1 + X'_j\beta_2 + u_j . \qquad (2)$$

Here, u_j represents a family-level random effect that is normally distributed with a zero mean and variance σ_j^2. We assume that the observations are independent once we condition on u_j, which captures any unobserved effects common to children from the same family.[3]

Drawing on our conceptual framework, we first estimate the reduced form model shown in Equation (2) that includes only the background child (X_{ij}) and family (X_j) covariates. We next add vectors of intermediate child (W_{ij}) and family (W_j) covariates to the model:

$$\log[p_{ij} / (1 - p_{ij})] = W'_{ij}\gamma_1 + W'_j\gamma_2 + X'_{ij}\beta_1 + X'_j\beta_2 + u_j . \qquad (3)$$

Together, these two models allow us to study how background factors directly and indirectly affect diarrhea prevalence. In particular, the model based on Equation (1) shows the total effect of each background factor on diarrhea prevalence (net of other background factors in the model).

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[2] One concern in applying this model is the endogenous nature of the proximate determinants, which may be reflected in correlation between these covariates and the error components. However, the cross sectional structure of the data and the absence of any plausible instrumental variables mean that there is no convincing statistical approach to correct for endogeneity.

[3] Since we do not include a community level random effect, the family level random effect also absorbs unobserved effects at the cluster level that are common to children from the same family.

Comparing these results with those from a model based on Equation (3) shows how the background factors operate through the intermediate variables that are added to the model.

Decomposing Changes in Diarrhea Prevalence Over Time and Across Regions

One of the goals of this paper is to understand trends and differentials in the prevalence of diarrhea for Brazil. Over the period of study, rates of diarrhea decreased relatively modestly—especially in the Northeast region. However, there have been substantial changes in demographic and socioeconomic characteristics of the population and in health-related behaviors. An important question is the extent to which these secular changes were responsible for trends in diarrhea prevalence. A related question is the extent to which the dramatic differences in these factors between the Northeast region and the rest of Brazil account for the significantly higher rates of diarrheal disease in the Northeast.

We answer these questions by using a decomposition of differences in diarrhea prevalence across regions and over time. We examine two counterfactuals: first, when looking at trends, we predict the prevalence of 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. 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. Second, we perform a similar decomposition to study differentials in diarrhea prevalence between the Northeast region and the rest of Brazil.

3. Data

In this section, we describe the three surveys, including the questions on diarrhea prevalence and treatment; we provide a brief assessment of the quality of mothers' reports on child health and health related behaviors; and we review trends and differentials in diarrhea prevalence and treatment.

Data for this study come from three surveys conducted in Brazil as part of the Demographic and Health Survey (DHS) Program. The first and third surveys, conducted in 1986 and 1996, were nationally representative. The second survey, conducted in 1991, was fielded in the Northeast region alone. All three 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 three DHS surveys are comparable, although there were some important changes that are discussed below. The three surveys share the same basic design in that they are each based on a multistage, clustered sampling scheme. The quality of the data collected in DHS surveys is generally quite high, and the Brazil surveys are no major exception.

The first Demographic and Health Survey in Brazil (DHS-1) was known as the *Pesquisa Nacional de Saúde Materno-Infantil e Planejamento Familiar Brasil 1986* (Arruda et al., 1987).

A total of 8,369 dwelling units was selected 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 5,892 women aged 15 to 44 years and information was collected on 3,573 children born to these women in the five years preceding the survey. The overall response rate was 87%. It varied from a low of 82% in the state of Rio de Janeiro to a high of 93% in the South region.

The *Pesquisa sobre Saúde Familiar no Nordeste Brasil 1991* (Ferraz, Ferreira, and Rutenberg, 1992) was the second DHS survey fielded in Brazil (DHS-2). The survey selected a total of 361 PSUs across the nine states that comprise the Northeast region.[4] Interviews were completed with 6,223 women aged 15 to 49 years. Data wer collected on 3,392 children born to the female respondents in the five years preceding the interview. The overall response rate was 87%. It varied from a low of 70% in the state of Paraíba to a high of 95% in the state of Maranhão.

The third DHS survey of Brazil (DHS-3) was the *Pesquisa Nacional Sobre Demografia e Saúde 1996* (Badiani et al., 1997). A total of 842 PSUs was selected 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 to 49 years. Information was collected on 4,782 children born to these women in the five years preceding the interview. The overall response rate was 69%. Response rates varied from a low of 47% in the state of Rio de Janeiro to a high of 86% in the North region (where only households located in urban areas were interviewed).

Questions on Diarrhea Prevalence and Treatment

Information on diarrhea episodes and treatment was collected from mothers for living children under 5 years of age at the time of the survey. Appendix A shows the questions on diarrhea episodes that were asked in Portuguese, along with their English translation. Note that there were changes in the questionnaire wording and order between surveys. In particular, between DHS-1 and DHS-2 the order was reversed of the questions asking about current diarrhea and diarrhea during the past two weeks. This occurred in response to suspected over-reporting of diarrhea episodes in the 24 hours preceding the survey. In addition, while DHS-1 and DHS-2 asked about current diarrhea in the past 24 hours, DHS-3 asked about diarrhea "today." These differences mean that the only measure of diarrhea that is comparable across the three surveys is whether the child had an episode of diarrhea in the past two weeks. It is this measure that we choose as our 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 issue because, for certain groups, diarrhea is a relatively rare event.

The questions on treatment of diarrhea (not shown) were asked only for children who had diarrhea in the past two weeks. We consider only the questions that were asked in at least two of the waves. After a woman reported that a child had diarrhea, she was asked whether she or anyone else had done anything to treat the diarrhea. If the answer was "yes," the woman was asked about all treatments that were provided, including ORT, hospitalization, and home remedies. In DHS-2 and DHS-3, information was also collected about the woman's medical

[4] The nine states that comprise the Northeast region are Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia.

advice or treatment-seeking behavior. Given the attention to the role of ORT in the decline of diarrhea-related infant and child mortality, our study focuses on ORT use among children with diarrhea. To allow for changing definitions, we include in our measure of ORT all treatments designed to rehydrate the child. In DHS-1, these options included the use of oral rehyration solution, sugar solution, *soro* (a commercially-prepared solution sold in pharmacies and shops), and rice-water solution. In DHS-2 and DHS-3, they included oral rehydration solution, recommended home solution, intravenous solution, and *soro*. In addition to ORT, we also considered two other treatment outcomes: the use of medical care and the use of any kind of treatment for diarrhea.

Data Quality

There are a number of potential problems and issues associated with collecting information from mothers on their children's episodes of diarrhea. Some of these issues are particular to DHS surveys while others are common to self- or proxy-reports on health. However, all may affect the analyses, conclusions, and policy implications of studies such as ours. 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 reports or medical tests, with which to compare results. Moreover, there are usually no corrections possible for data quality problems that are uncovered. Nevertheless, identifying existing problems is important, because they can affect how we evaluate and interpret our results. In this section, we examine the implications of the particular questions that were used and differences in the accuracy and completeness of reports across groups and over time.

It is as important to consider items omitted from the questionnaires as it is to consider the wording and structure of the questions that do appear. In the DHS surveys, the definition of diarrhea was left up to each individual respondent. In contrast, many epidemiological studies provide an explicit definition of diarrhea and guidelines for determining when an episode of diarrhea has ended.[5] 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 the two weeks from those that fell outside it. There is well-documented tendency for respondents to forget events the further back in time they occurred (Sudman, Bradburn, and Schwarz, 1996), especially for events that are less salient to respondents (as a child's episode of diarrhea may be, especially when rates are high).[6] 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

[5] However, epidemiological studies typically do not have nationally representative samples, cover a wide age range of children, or provide repeated cross-sections to study trends, all of which are integral features of the DHS.

[6] Omission of events further back in time may contribute to the problem of "telescoping," in which more events are recalled as having occurred in the most recent period and fewer in the more distant past. Telescoping would lead to the over reporting of diarrhea during the past 24 hours and underreporting for the period 2-13 days prior to the interview. There is some chance that it may not be a significant problem when looking at prevalence over a two-week period; however, there is no way to assess this directly.

identifying enough outcome events through having a sufficiently wide window (Ross and Vaughan, 1986).

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 differing likelihood of giving "don't know" responses or having missing information. There are reasons to suspect systematic differences in reporting among mothers according to characteristics such as educational attainment and socioeconomic status. Reports may also vary by cultural factors that are difficult to measure, but are reflected in proxy indicators such as region and urban or rural place of residence. Focusing on reporting differences by educational attainment, less educated mothers are more likely to extend the 24 hour recall period for current cases, to underreport illness episodes, to misdiagnose recovery following a diarrhea episode, and to displace episodes in time (Boerma et al., 1991). They may also miss the symptoms of relatively minor illness episodes or may have more stringent criteria for what constitutes an "illness" episode. Together, these effects would generally lead to downward bias in estimates of diarrhea among children of less educated mothers. Higher levels of household resources or urban residence may be associated with greater access to and use of formal health care services. This, in turn, could improve mothers' familiarity with the symptoms of common childhood ailments such as diarrhea and, therefore, make them more likely to report these conditions to interviewers. Exposure to a more modern viewpoint may be associated with more accurate recall of the timing of diarrhea episodes.

Rates of missing information on diarrhea in the Brazil DHS surveys were stable over time. Information on diarrhea was missing for 2.0 percent of eligible children in DHS-1, 1.6 percent in DHS-2, and 1.8 percent in DHS-3. Weakly associated with missing information on diarrhea are mother's education and, in certain waves, child age and sex. Controlling for these factors in our models will ensure that missing data do not bias our results.

Two factors may affect the comparability of diarrhea reports over time. First, reporting error may change over time, with changes in diarrhea prevalence or the awareness of illness symptoms. This latter effect is possible because several public campaigns to promote the use of ORT were active during the study period. Changing population composition may also play a role in aggregate changes in reporting error. Second, the three DHS surveys in Brazil were fielded during different months of the year.[7] This is potentially important because diarrhea infection rates are expected to vary with 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 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

[7] Interviews for the 1986 DHS-1 took place between May and September, with the majority occurring in June and July. The 1991 DHS-2 was fielded between September 1991 and January of the following year, with the bulk of interviews completed in October and November. Interviews for the 1996 DHS-3 were conducted between February and July, with the vast majority falling in April or May.

consistent finding was that diarrhea episodes peaked during January-February and October (Giugliano et al., 1986; Schorling et al., 1990; Guerrant et al., 1983; and Linhares et al., 1983).[8] If this pattern holds for other years, estimates of diarrhea prevalence in the Northeast may be lower than expected in DHS-1 and DHS-3 and higher in DHS-2. However, there is no way to gauge the magnitude of this effect.

Trends in Diarrhea Prevalence and Treatment

Diarrhea prevalence in Brazil declined moderately over the decade under consideration, as shown in Table 1. The two-week prevalence of diarrhea among children under age 5 for all of Brazil fell from 16.8 percent in 1986 to 13.3 percent in 1996, a statistically significant decline. Rates were higher in the Northeast region, where the two-week prevalence was 21.4 percent in 1986, 15.3 percent in 1991, and 18.0 percent in 1996. The figure for 1991 is lower than we expected and appears to be caused by underreporting of diarrhea in the period 2-14 days prior to the survey. This could indicate problems in recall or reporting accuracy, as noted above. The two-week prevalence was lower in the rest of Brazil than in the Northeast. It was 14.3 percent in 1986 and fell to 10.4 percent in 1996. Differences in rates from one wave to the next were statistically significant in both the Northeast and the Rest of Brazil, although the 1996 rate in the Northeast was not significantly lower than the 1986 rate.

The use of treatment for diarrhea episodes also increased between 1986 and 1996. For all of Brazil, Table 1 shows that use of any kind of treatment rose from about three-quarters of cases to about 85 percent, a statistically significant difference. In the Northeast, there was a rise from about 75 percent in 1986 to about 85 percent in 1991 and 1996, also statistically significant. In the rest of Brazil, however, the rise from 78 percent to 83 percent was not significant. More dramatic changes are evident in the use of ORT: for Brazil as a whole, only 16.1 percent of diarrhea cases were treated with some form of oral rehydration in 1986, while the figure for 1996 reached 90.7 percent.[9] The increase was especially large in the Northeast, where it jumped from 9.8 percent in 1986 to 24.9 percent in 1991 to 85.9 percent in 1996. All of these increases, including those in the rest of Brazil, were statistically significant. Questions about medical care were asked only in the second and third surveys, so the only difference that can be tested is in the Northeast where use of medical treatment for diarrhea did not change significantly from about one-quarter of all cases between 1991 and 1996.

Since our interest is to compare trends across years and differentials across regions of Brazil, we will focus on only the data from DHS-1 and DHS-3 in the remainder of the paper. The DHS-2 sample for 1991 contains important information that can be pursued in future research, but would complicate the presentation of the current analysis.

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[8] In the Northeast, January and February correspond to the wet, rainy summer months, while October falls at the end of the dry period.

[9] 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.

4. Model Covariates

We have identified four sets of covariates for our analysis, comprising of two types of variables (background and intermediate) and two levels of organization (child and family). We next identify the specific covariates and discuss how they are measured and operationalized. We present summary statistics for these variables in Tables 2A, 2B, and 2C, which show the means and standard deviations for all covariates for, respectively, all of Brazil, the Northeast region, and the rest of Brazil.

Background factors at the child level include child age and sex. There is a strong relationship between a child's age and his or her probability of having diarrhea. We expect that much of this is due to changes in feeding and mobility. We discuss breastfeeding below; here we note that as children learn to crawl, they are much more likely to be exposed to pathogens in their environment and, through hand-to-mouth contact, to get diarrhea. Child sex may be related to diarrhea prevalence through sex-selective reporting or due to genuine differences in diarrhea relating to patterns of care or treatment that differ by child sex. There is little evidence of systematic differences by child sex in reporting children's illnesses or in diarrhea prevalence or treatment, either in Brazil or elsewhere in Latin America. Nevertheless, including sex as a covariate ensures that if any of these problems were present, they will not result in biased estimates of parameters. The mean age for children in all of Brazil was about 30 months in each of the survey years. In the 1986 sample, 52 percent of children were male, and 51 percent were male in the 1996 sample. There were no major differences between regions, in either of the survey years, in the composition of the samples according to child age or sex.

At the family level, background factors include mother's education, parents' marital status, father's education, household wealth, rural-urban place of residence, and region. Mother's education is a key factor relating to child health and has been the topic of much research over the past 20 years.[10] Recent studies provide convincing evidence that the most important role of maternal education in improving child health is to provide women with the ability to acquire, understand, and act on information about how to raise healthy children (Barrera, 1990; Levine et al., 1994; Rosenzweig and Schultz, 1982; Thomas, Strauss and Henriques, 1991). In 1986, mothers averaged 4.8 years of schooling across all of Brazil, a figure that increased to 5.8 years a decade later. This increase in one full year of schooling was statistically significant at the .05 level. The average level of mother's schooling was lower in the Northeast, at 3.5 years in 1986 and 4.6 years in 1996, than in the rest of Brazil, where it was 5.5 years in 1986 and 6.6 years in 1996. In both regions, the increases in average attainment were statistically significant.

The parents' marital status covariate distinguishes between women who are married, cohabiting, formerly married, or never married. Unmarried mothers may have fewer total household resources than married women. Across Brazil, the proportion of mothers married at the time of the survey decreased significantly between 1986 and 1996. In the Northeast, 72 percent of mothers were married in 1986 compared to only 53 percent in 1996. There was an accompanying large rise in the number of mothers who were cohabiting, from 20 percent in 1986 to 32 percent a decade later. Similar, but less dramatic, changes in marital status are evident for

[10] For reviews see Cleland (1990), Cleland and van Ginneken (1988), and Strauss and Thomas (1995).

the rest of Brazil; in 1996, 66 percent of mothers were married, down from 78 percent in 1986. All of these changes in marital status between 1986 and 1996 are statistically significant. Father's education is likely to reflect milder effects similar to those of mother's education, as well as the effects of socioeconomic status. Table 2A shows that children in 1996 were slightly less likely to have a father with at least a primary education, due to the increases in women who did not have a partner or did not know their partner's schooling level. Trends in father's education were similar in the Northeast and the rest of Brazil.

We created an index of household wealth through a principal components analysis of household assets (see Filmer and Pritchett, 2001). The index was constructed using the full sample in each year (including all cases in both regions). Once we stratified each wave by region, the original measure identifying the top 40% of wealth distribution was altered slightly. In the poorer Northeast region, fewer children lived in families belonging to the top 40% of the wealth index compared to the rest of Brazil, as we expected. Region and rural-urban place of residence are important factors in the Brazilian context. The Northeast region and rural areas are underserved by infrastructure and score lower on many level-of-living indicators. The proportion of the sample living in urban areas increased between 1986 and 1996 across the country, from 68 percent to 75 percent. However, the rise in the Northeast (from 50 percent to 60 percent) was greater than that in the rest of Brazil (77 percent to 84 percent).

Intermediate factors at the child and family level include the child's breastfeeding status (reflecting whether the child is fully weaned or not) and duration of breastfeeding (that does not distinguish between exclusive and supplemented breastfeeding); whether the child was immunized for measles; the child's birth order; preceding and succeeding birth intervals; mother's age; and household sanitation and water supply.

Breastmilk provides protection against pathogens that cause diarrhea and exclusive breastfeeding lowers the chances that children will be exposed to contaminated water or food (Palloni and Millman 1986). We expect the likelihood of diarrhea to increase greatly when a child first receives supplementary liquids or solids, which was likely to occur at early ages in Brazil because breastfeeding durations were brief. Across all of Brazil in 1986, the average duration of breastfeeding was 6.8 months and, in our sample, 16 percent of children were still breastfeeding at the time of the interview. These figures increased significantly by 1996, to 20 percent and 7.9 months, respectively. There is evidence that a measles vaccination provides a child with some protection against diarrhea. However, this covariate may also reflect the mother's contact with, and ability to negotiate, the health care system as well as recognize the value of child immunization. Overall, there was a statistically significant increase from 71 percent to 79 percent in children who had received a measles vaccination at the time of the survey. Current breastfeeding status and average duration of breastfeeding did not differ dramatically between the Northeast and the rest of Brazil, although children in the Northeast were slightly less likely to have received a measles vaccination than their peers in the rest of Brazil.

Birth order and preceding and succeeding birth intervals are likely to be related to diarrhea prevalence through their effects on the family environment. First-born children are born to mothers who are generally less experienced in looking after children, while higher order births are associated with a larger number of siblings and increased opportunities for transmission of pathogens causing diarrhea. Similar effects are likely for children with a short preceding or succeeding birth interval. Due to declining fertility, there were significantly more first-born children and significantly fewer children of fifth or greater birth order in 1996. Also, the proportion of children with a short preceding or succeeding birth intervals decreased significantly. Children in the Northeast were more likely overall to be a higher-order birth and to have short inter-birth intervals. We control for mother's age at the birth of the child because of its close relationship to parity.

Improved household sanitation and water supply are expected to be the key factors associated with the decline of diarrheal disease in the long term. Sanitation and water supply have a direct effect in reducing exposure to pathogens. Previous studies have found that certain aspects, such as the quantity of water that is available, are more important than others. Indirect effects may occur as the higher prevalence of sanitation and water supply in a community change standard household hygienic practices. There was a dramatic increase in the availability of household piped water and modern flush toilets over the decade under study. For Brazil as a whole, the proportion of families with piped water in their home increased from 55 percent in 1986 to 70 percent in 1996, and those with flush toilets increased from 32 percent to 68 percent. Although the rest of Brazil had better water and sanitation infrastructure in 1986, statistically significant improvements occurred in both regions. For instance, in the Northeast the proportion of households with a flush toilet increased from 10 percent to 46 percent between 1986 and 1996, while in the rest of Brazil the increase was from 44 percent to 82 percent.

We present differentials in diarrhea prevalence according to several key covariates in Table 3. Diarrhea prevalence was inversely related to mother's education. Across all of Brazil in 1986, 23 percent of children with mothers who had no schooling had diarrhea, compared to only 9 percent among those whose mothers had 11 or more years of schooling. A similar pattern was apparent in 1996. Prevalence rates for each category of education did not change dramatically over the decade, so that the burden of having a poorly educated mother did not decline (although the proportion of mothers who were poorly educated did decline). For both 1986 and 1996, children of families in the top 40 percent of the wealth distribution were significantly less likely to have had diarrhea in the past two weeks compared to their poorer counterparts. However, while the prevalence for the bottom 60 percent declined from 21 percent in 1986 to 16 percent ten years later, among children of families in the top 40 percent of the distribution prevalence remained constant at about 10 percent. Children in rural areas were more likely to have diarrhea than children living in urban areas, but the difference decreased between 1986 and 1996. In 1986, 15 percent of urban children had diarrhea, compared with 21 percent of rural children; in 1996, the figures were 13 percent and 15 percent, respectively.

The second panel of Table 3 shows diarrhea rates by selected covariates for the Northeast region. Mother's schooling is negatively associated with diarrhea prevalence, although in 1996 the rate for mothers with 11 years of schooling or greater is unexpectedly high. There is a general coherence within categories of schooling across years, though in the Northeast it appears that for a given level of schooling, a slightly smaller proportion of children have diarrhea in 1996 than in 1986. As expected, children from homes in the top 40 percent of the wealth distribution were less likely to have diarrhea than those in the bottom 60 percent. The sample for the Northeast in 1996 is distinct because children living in rural areas are less likely to have diarrhea (16 percent) than those in urban areas (19 percent), in contrast to the other samples and years. In 1986, 23 percent of rural children and 20 percent of rural children had diarrhea.

The bottom panel in Table 3 shows diarrhea prevalence by covariate for the rest of Brazil. Mother's schooling and prevalence of diarrhea are negatively related, though the 1996 rate for children of mothers with 8 to 10 years of schooling appears to be too high. Children of mothers with no schooling are more likely to have diarrhea in the 1996 sample (29 percent) than in the 1986 sample (22 percent), counter to the general trend of lower prevalence rates in the later year. In the rest of Brazil, children of families in the lower 60 percent of the wealth distribution are more likely to have diarrhea, as are children from rural areas. These trends are similar in 1986 and 1996.

5. Results

Our results are presented in three subsections. We begin by examining models of the two-week diarrhea prevalence for children under age five for all of Brazil. Next, we relax the constraint that coefficient effects are the same throughout Brazil by estimating separate models for the Northeast region and the rest of Brazil. We discuss similarities and differences in covariate effects for these two regions. Finally, we turn to 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.

All results are estimated using the random effects logistic models described above. The tables of results (see Tables 4-5) show the exponentiated parameters and standard errors, and also indicate the level of statistical significance for the covariate effects. The coefficients in these tables are odds ratios, obtained by exponentiating the estimated parameters which are log odds ratios. Odds ratios are easier to interpret. In particular, the coefficients in the tables show the change in the probability of a child having diarrhea in a two-week period, associated with a one-unit increase for a continuous covariate or a one-category change for a categorical covariate. As an example, the first coefficient in Table 4 shows that the two-week probability of having diarrhea increases by 1.31, or 31 percent, with each month of age during a Brazilian child's first six months of life. The asterisks indicate that this effect is statistically significant at the .01 level.

Effects of Background and Intermediate Factors on Diarrhea Prevalence in Brazil

Our first set of results, presented in Table 4, show the effects of background factors and intermediate factors on the two-week diarrhea prevalence for children under age five for data pooled across regions and across the waves. These results form the baseline for evaluating results from models based on data from a single region that are presented next. One advantage of the pooled model is that it maximizes the efficiency of the parameter estimates. The cost, in the absence of a fairly comprehensive set of interaction effects with year or region, is that the covariate effects are constrained to be the same for all regions and all periods.

Model I in Table 4 shows the effect of background factors alone on diarrhea prevalence. There are strong effects on diarrhea of child age, mother's education, father's education, parents' marital status, household wealth, survey year, and region of residence. There are only weak effects of rural-urban place of residence. Overall, this model fits the data well. Although the average number of children per family in the sample is only 1.3, the family-level random effects are highly significant ($\chi^2 = 107.08$; $p < 0.01$). Hence, there is a strong correlation in the chances of having diarrhea among children in the same family. It is important to take this into account in order to obtain accurate standard errors and make appropriate statistical inferences.

We find the expected pattern of diarrhea prevalence with age: there is a large initial increase during ages 0-5 months, followed by a slow decline with age. The probability of a child having diarrhea reaches a peak at five months of age. There is a strong, negative linear effect of mother's years of education on a child's probability of having diarrhea. With every additional year of mother's education, the probability of her child having diarrhea declines by seven percent. Children of couples who are either cohabiting or were previously married have diarrhea rates about 30 percent higher than children of married couples. Having a father with primary or more schooling is associated with diarrhea rates being 39 percent lower than having a father with no schooling. This effect is comparable in size to that of living in a household in the top 40 percent of the wealth distribution. Not surprisingly, there are large effects of year and region. On average, the probability of a child having diarrhea declined by almost 40 percent between 1986 and 1996. Living in the Northeast region was associated with a diarrhea prevalence rate 45 percent higher than in the rest of Brazil.

Model II in Table 5 adds the intermediate factors discussed above. Note first that these variables are not jointly significant ($\chi^2 = 16.58$; $p = 0.166$). This indicates that this set of intermediate factors do a relatively poor job of capturing the pathways through which the background factors operate. This is possibly because of poor measurement of these variables—or diarrhea prevalence itself—or because important intermediate factors are omitted. Only two of these variables are statistically significant at the .05 level: whether the child is still breastfeeding (which is associated with a 31 percent decline in the probability of having diarrhea) and birth order of five or higher (which is associated with a 30 percent increase in the probability of having diarrhea). Effect sizes are small for all the other intermediate covariates except for having no toilet facilities (which, due to its relatively large standard error, is not statistically significantly different from zero). The effects of the background factors are attenuated, as expected, when intermediate factors are added to the model. However, the changes are relatively small in magnitude and no statistically significant effect is rendered insignificant.

Differences in Results Between the Northeast Region and the Rest of Brazil

We next relax completely the assumption that coefficient effects are the same in the Northeast and the rest of Brazil by stratifying the sample and estimating two separate sets of models. The results are presented in Table 5. All of the models fit the data and, again, the family-level random effects are highly significant. The variance of the random effects is substantially larger in the Northeast (0.212 in Model I) than in the comparable model for the rest of Brazil (0.124). The random effects are highly significant in both the Northeast ($\chi^2 = 59.3$; $p < 0.01$) and the rest of Brazil ($\chi^2 = 41.0$; $p < 0.01$). The greater importance of the random effects in the Northeast may be due in part to a greater clustering of observations that arises from larger family sizes in that region. There are data on an average for 1.42 children per family in Northeast compared to

1.27 in the rest of Brazil. However, it is more likely to reflect the greater importance of unmeasured factors common to children in the same family in the Northeast region.

The results for the both the Northeast region and the rest of Brazil are generally in line with those from the pooled model, although there are some notable differences. We begin our discussion with results from Model I, which includes only the background covariates. First, we find that the effects of mother's education are much stronger in the Northeast region. Although mother's education has a negative and statistically significant association with diarrhea in both areas, the magnitude of the effect in the Northeast is twice that in the rest of Brazil. Mother's education is more effective in lowering diarrhea rates in less developed areas with higher health risks for several possible reasons. The main one is probably that mother's education may provide women with access to health information and resources that would otherwise not be widely available (as in more developed areas).

Second, the effects of father's education are identical in the two regions (although statistically significant at only the .10 level in the rest of Brazil). This finding suggests that father's education operates differently than mother's education. In particular, it is likely to capture the effects of socioeconomic status or family background, rather than access to or successful use of health information and resources.

Third, there are substantial differences between the two areas in the effects of household wealth and place of residence. Household wealth is associated with substantially lower diarrhea rates in the rest of Brazil, but is unrelated to diarrhea in the Northeast. A somewhat unexpected finding is that diarrhea risks are 39 percent lower in rural areas of the Northeast than in urban areas of the region. In the rest of Brazil, place of residence is unrelated to diarrhea prevalence. Finally, the difference in diarrhea rates across years is not statistically significant in the Northeast, but is in the rest of Brazil. In fact, after controlling for background factors, diarrhea rates are even lower for the rest of Brazil in 1996 than indicated by the raw differences (shown in Table 1).

We turn now to the results for each area from Model II, which includes both the background and intermediate factors. The intermediate covariates are jointly significant in the rest of Brazil (χ^2 = 21.4; p = 0.045), but not in the Northeast region (χ^2 = 17.2; p = 0.144). The results for each region are again broadly similar to those from the pooled model. High birth order is associated with a significantly greater risk of diarrhea, though only in the rest of Brazil. On the other hand, a child still being breastfed has a probability of diarrhea that is significantly lower only in the Northeast region. Diarrhea is 76 percent lower among children being breastfed in the Northeast. The likely reason for this large effect is the higher exposure to pathogens in the Northeast, where levels of developed water supply and sanitation are still relatively low. Moreover, even in areas that have been newly reached by the piped water and the sanitation networks, hygienic behaviors may not have adapted yet to take advantage of these facilities. This conjecture has some support from the fact that the water supply and sanitation effects are insignificant in the Northeast, with moderate standard errors but particularly small parameters estimates.

Comparing the results for the background variables in Models I and II for each region, we find that the only meaningful change in parameter estimates is for mother's education in the rest of Brazil. This coefficient is cut roughly in half by adding the intermediate variables and is now only marginally significant. This suggests that the intermediate factors in our models—particularly household toilet facilities and birth order—explain the lower rates of diarrhea among the children of better educated mothers in the rest of Brazil. In contrast, the effect of mother's education in the Northeast region is not altered when the intermediate factors are included in the model.

Decomposing Trends and Differentials in Diarrhea Prevalence

In Table 6 we present the results of our decomposition analysis. Reading across the rows of this table shows the decompositions across years, for each region, while reading down the columns shows the decompositions across regions, for each year. Shown in each corner are the actual rates for the corresponding region and year. Two predicted values are shown: the first is based on background factors only, while the second is based on both background and intermediate factors. With one exception, no differences between pairs of adjacent estimates are statistically significant. Although there are a number of other statistically significant results, which we will highlight, the decomposition findings should overall be viewed as suggestive rather than definitive.

The differential in diarrhea between the Northeast and the rest of Brazil is 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 percent. 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 important. This 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 need to be considered, and the effects of given child and family characteristics on diarrhea prevalence probably need to be altered so that improvements in these factors deliver more beneficial results.

In the Northeast, the total decline in diarrhea prevalence from 21 percent to 19 percent between 1986 and 1996 is not statistically significant. Half of this small decline is explained by changes in background characteristics. When we account for changes in intermediate factors, however, the predicted decline between 1986 and 1996 is statistically significant (at the .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 positive relationships between these intermediate factors and diarrhea rates 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 is changes in intermediate factors and, especially, changes in relationships or the effects of unmeasured characteristics that appear to have been important. The results for the rest of Brazil are an interesting contrast to those for the Northeast region. In the former area, a given set of characteristics appear to have had a more beneficial effect on child diarrhea in 1996 than in 1986, while the reverse held true in the latter area.

6. Summary and Conclusions

Previous research suggests that diarrhea-related child mortality in Brazil declined dramatically over the decade under study (e.g., Victora et al., 1996). There is some uncertainty regarding the results of these studies because they are based on causes of death recorded on death certificates that, at least in the Northeast region, are often incomplete and inaccurate. Nevertheless, our results are consistent with these studies' claims, in that the use of oral rehydration therapy for children suffering from diarrhea increased dramatically over this period. It is well know 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. The rise in the use of ORT from 16 percent in 1986 to 91 percent in 1996 (among mothers seeking treatment for their child's diarrhea) constitutes a major achievement for Brazil.

Yet there is still room for improvement in both treating and preventing diarrheal disease among Brazilian children. The use of ORT should be increased in the Northeast region where, in 1996, it was used in 86 percent of diarrhea cases, compared to 96 percent in the rest of the country. Also, developments over this decade did little to reduce number of cases of diarrhea in the Northeast. The modest decline in the two-week prevalence rate for diarrhea, from 21 percent in 1986 to 18 percent in 1996, is statistically insignificant. (Data from DHS-2 suggest that diarrhea rates dropped in 1991 but then rose again.) If the decline over the decade in the Northeast had been as large as that in the rest of Brazil, the prevalence rate would have been almost three percentage points lower in 1996. (And if the decline observed in the Northeast between 1986 and 1991 had continued apace, the diarrhea rates in this region would by 1996 have been about the same as those in the rest of Brazil.) Diarrhea prevalence rates also should be reduced 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 were not associated with significant lower diarrhea rates in the Northeast suggests that expanding infrastructure is not enough. Rather, changes in hygienic behaviors and practices need to accompany these improvements. The large positive effects of current breastfeeding in the Northeast indicate that environmental factors and hygienic behaviors are important. Similar improvements in the rest of Brazil would contribute to reductions in diarrhea there; in addition, raising household wealth also appears to be important.

Diarrhea is clearly an extremely important disease in Brazil and elsewhere in the developing world. There are, however, some serious difficulties in studying it. Although information on diarrhea has been collected in dozens of DHS surveys, it has not been widely used. We suspect this is principally because of perceived problems with the quality of the data on diarrhea. However, given that an important policy goal is to reduce diarrhea prevalence—and, especially, deaths from diarrhea—it is essential that researchers try to exploit data on diarrhea from DHS and other surveys as best they can.

Alternative approaches to gathering data on diarrhea, featured in most epidemiological studies, are to collect objective measures and obtain detailed reports from mothers at frequent intervals. These methods virtually guarantee that much more complete and accurate information is obtained. However, they are only feasible for relatively small community studies. In order to understand regional, national, or global trends in diarrheal disease, it is necessary to collect information on diarrhea from large-scale demographic and health surveys. Our study has shown that while there are some specific concerns regarding mothers' reports on diarrhea prevalence and treatment, at least for Brazil the information in DHS surveys can be used effectively and does shed light on the nature of the trends and differentials in diarrhea prevalence and treatment. However, it is important to improve the collection of information on diarrhea in large surveys. In particular, validation studies would be useful for assessing the accuracy and completeness of reported information.

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Table 1. Means (and standard deviations) for diarrhea prevalence and treatment variables

Variable	1986 DHS-1		1991 DHS-2		1996 DHS-3	
	ALL OF BRAZIL					
Diarrhea						
Last 24 hrs	0.075	(0.264)	-		0.033	(0.178)
Last 2-14 days	0.093	(0.290)	-		0.100	(0.300)
Last 2 weeks	0.168	(0.374)	-		0.133	(0.339)
Treatment for diarrhea						
Any	0.763	(0.425)	-		0.845	(0.362)
ORS	0.161	(0.368)	-		0.907	(0.891)
Medical	-		-		0.316	(0.466)
Number of observations	3,175		-		3,604	
	NORTHEAST					
Diarrhea						
Last 24 hrs	0.101	(0.302)	0.059	(0.236)	0.054	(0.227)
Last 2-14 days	0.113	(0.317)	0.094	(0.292)	0.125	(0.331)
Last 2 weeks	0.214	(0.410)	0.153	(0.360)	0.180	(0.384)
Treatment for diarrhea						
Any	0.747	(0.435)	0.850	(0.358)	0.862	(0.346)
ORS	0.098	(0.298)	0.249	(0.233)	0.859	(0.878)
Medical	-		0.251	(0.434)	0.275	(0.447)
Number of observations	1,237		2,816		2,007	
	REST OF BRAZIL					
Diarrhea						
Last 24 hrs	0.062	(0.240)	-		0.020	(0.139)
Last 2-14 days	0.082	(0.274)	-		0.084	(0.277)
Last 2 weeks	0.143	(0.350)	-		0.104	(0.305)
Treatment for diarrhea						
Any	0.776	(0.417)	-		0.828	(0.379)
ORS	0.213	(0.410)	-		0.959	(0.904)
Medical	-		-		0.360	(0.482)
Number of observations	1,938		-		1,597	

Table 2A. Means (and standard deviations) for independent variables by survey year for all of Brazil

Variable	1986 DHS-1		1996 DHS-3	
Child age (months)	30.2	(17.3)	29.5	(17.2)
Child sex				
Female	.	.	.	.
Male	0.517	(0.500)	0.507	(0.500)
Mother's education (years)	4.77	(3.94)	5.80	(3.79)
Marital status				
Married	0.757	(0.429)	0.614	(0.487)
Cohabiting	0.159	(0.366)	0.238	(0.426)
Never married	0.028	(0.166)	0.058	(0.234)
Previously married	0.055	(0.228)	0.090	(0.286)
Father's education				
None	0.130	(0.337)	0.109	(0.312)
Primary or more	0.838	(0.368)	0.782	(0.413)
Don't know	0.028	(0.166)	0.058	(0.234)
Household wealth index				
Bottom 60%	.	.	.	.
Top 40%	0.438	(0.496)	0.479	(0.500)
Place of residence				
Urban	.	.	.	.
Rural	0.322	(0.467)	0.254	(0.436)
Birth order				
First born	0.295	(0.456)	0.356	(0.479)
Order 2-4	0.487	(0.500)	0.515	(0.500)
Order 5+	0.217	(0.412)	0.128	(0.335)
Preceding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.081	(0.273)	0.054	(0.227)
Succeeding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.031	(0.174)	0.017	(0.128)
Child still breastfeeding				
No	.	.	.	.
Yes	0.162	(0.368)	0.204	(0.403)
Months of breastfeeding	6.79	(8.49)	7.92	(9.07)
Received measles vaccination				
No	.	.	.	.
Yes	0.709	(0.454)	0.787	(0.410)
Mother's age at child's birth	26.0	(6.09)	26.1	(6.39)
Household water supply				
Piped	0.547	(0.498)	0.696	(0.460)
Well/public tap	0.225	(0.417)	0.230	(0.421)
Undeveloped source	0.229	(0.420)	0.074	(0.261)
Household toilet facilities				
Flush toilet	0.318	(0.466)	0.680	(0.467)
Septic tank	0.175	(0.380)	0.144	(0.351)
None	0.507	(0.500)	0.176	(0.381)
Number of observations	3,175		3,604	

Table 2B. Means (and standard deviations) for independent variables by survey year for Northeast Brazil

Variable	Year			
	1986 DHS-1		**1996 DHS-3**	
Child age (months)	29.9	(17.2)	29.3	(17.4)
Child sex				
Female	.	.	.	.
Male	0.496	(0.500)	0.498	(0.500)
Mother's education (years)	3.49	(3.57)	4.58	(3.64)
Marital status				
Married	0.721	(0.449)	0.534	(0.499)
Cohabiting	0.195	(0.396)	0.317	(0.465)
Never married	0.019	(0.135)	0.052	(0.221)
Previously married	0.065	(0.247)	0.098	(0.297)
Father's education				
None	0.234	(0.423)	0.229	(0.420)
Primary or more	0.748	(0.434)	0.645	(0.478)
Don't know	0.019	(0.135)	0.052	(0.221)
Household wealth index				
Bottom 60%	.	.	.	.
Top 40%	0.229	(0.420)	0.255	(0.436)
Place of residence				
Urban	.	.	.	.
Rural	0.496	(0.500)	0.404	(0.491)
Birth order				
First born	0.223	(0.417)	0.310	(0.462)
Order 2-4	0.438	(0.496)	0.496	(0.500)
Order 5+	0.339	(0.473)	0.195	(0.396)
Preceding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.123	(0.328)	0.087	(0.282)
Succeeding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.049	(0.215)	0.029	(0.169)
Child still breastfeeding				
No	.	.	.	.
Yes	0.143	(0.350)	0.207	(0.405)
Months of breastfeeding	6.07	(7.38)	7.74	(8.74)
Received measles vaccination				
No	.	.	.	.
Yes	0.611	(0.488)	0.724	(0.447)
Mother's age at child's birth	26.4	(6.41)	25.7	(6.42)
Household water supply				
Piped	0.276	(0.447)	0.528	(0.499)
Well/public tap	0.275	(0.447)	0.348	(0.477)
Undeveloped source	0.449	(0.498)	0.124	(0.330)
Household toilet facilities				
Flush toilet	0.099	(0.299)	0.459	(0.498)
Septic tank	0.125	(0.331)	0.169	(0.375)
None	0.775	(0.418)	0.372	(0.483)
Number of observations	1,237		2,007	

Table 2C. Means (and standard deviations) for independent variables by survey year for rest of Brazil

Variable	1986 DHS-1		1996 DHS-3	
	Mean	(SD)	Mean	(SD)
Child age (months)	30.4	(17.3)	29.6	(17.0)
Child sex				
Female	.	.	.	.
Male	0.529	(0.499)	0.512	(0.500)
Mother's education (years)	5.47	(3.95)	6.56	(3.69)
Marital status				
Married	0.777	(0.417)	0.664	(0.473)
Cohabiting	0.140	(0.347)	0.189	(0.392)
Never married	0.033	(0.181)	0.062	(0.242)
Previously married	0.049	(0.217)	0.085	(0.279)
Father's education				
None	0.074	(0.262)	0.035	(0.183)
Primary or more	0.887	(0.316)	0.867	(0.340)
Don't know	0.034	(0.181)	0.062	(0.242)
Household wealth index				
Bottom 60%	.	.	.	.
Top 40%	0.552	(0.497)	0.618	(0.486)
Place of residence				
Urban	.	.	.	.
Rural	0.226	(0.419)	0.162	(0.369)
Birth order				
First born	0.335	(0.472)	0.385	(0.487)
Order 2-4	0.514	(0.500)	0.527	(0.499)
Order 5+	0.151	(0.358)	0.087	(0.283)
Preceding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.059	(0.235)	0.034	(0.182)
Succeeding birth interval				
≥ 12 months	.	.	.	.
< 12 months	0.022	(0.146)	0.009	(0.094)
Child still breastfeeding				
No	.	.	.	.
Yes	0.172	(0.378)	0.203	(0.402)
Months of breastfeeding	7.17	(9.01)	8.03	(9.27)
Received measles vaccination				
No	.	.	.	.
Yes	0.763	(0.426)	0.826	(0.379)
Mother's age at child's birth	25.7	(5.89)	26.3	(6.35)
Household water supply				
Piped	0.694	(0.461)	0.800	(0.400)
Well/public tap	0.197	(0.398)	0.157	(0.364)
Undeveloped source	0.109	(0.312)	0.042	(0.202)
Household toilet facilities				
Flush toilet	0.437	(0.496)	0.816	(0.387)
Septic tank	0.202	(0.402)	0.129	(0.335)
None	0.361	(0.480)	0.055	(0.228)
Number of observations	1,938		1,597	

Table 3. Means (and standard deviations) of two-week diarrhea prevalence by selected independent variables

	Year			
Variable	**1986 DHS-1**		**1996 DHS-3**	
	ALL OF BRAZIL			
Mother's education				
0 years	0.233	(0.423)	0.241	(0.428)
1-3 years	0.204	(0.403)	0.162	(0.369)
4-7 years	0.169	(0.375)	0.125	(0.331)
8-10 years	0.091	(0.279)	0.119	(0.324)
11+ years	0.087	(0.282)	0.084	(0.278)
Household wealth index				
Bottom 60%	0.212	(0.409)	0.164	(0.371)
Top 40%	0.112	(0.315)	0.098	(0.298)
Place of residence				
Urban	0.149	(0.356)	0.128	(0.335)
Rural	0.209	(0.407)	0.145	(0.352)
Region				
Northeast	0.143	(0.350)	0.104	(0.305)
Rest of Brazil	0.214	(0.410)	0.180	(0.384)
Number of observations	3,175		3,604	
	NORTHEAST			
Mother's education				
0 years	0.244	(0.430)	0.227	(0.420)
1-3 years	0.237	(0.426)	0.191	(0.393)
4-7 years	0.217	(0.413)	0.183	(0.387)
8-10 years	0.136	(0.345)	0.118	(0.324)
11+ years	0.096	(0.297)	0.143	(0.351)
Household wealth index				
Bottom 60%	0.227	(0.419	0.187	(0.390)
Top 40%	0.170	(0.376)	0.160	(0.367)
Place of residence				
Urban	0.197	(0.398)	0.192	(0.394)
Rural	0.231	(0.422)	0.162	(0.369)
Number of observations	1,237		2,007	
	REST OF BRAZIL			
Mother's education				
0 years	0.220	(0.415)	0.292	(0.461)
1-3 years	0.173	(0.379)	0.128	(0.461)
4-7 years	0.154	(0.361)	0.097	(0.296)
8-10 years	0.078	(0.269)	0.119	(0.324)
11+ years	0.084	(0.278)	0.062	(0.242)
Household wealth index				
Bottom 60%	0.198	(0.399)	0.137	(0.344)
Top 40%	0.099	(0.298)	0.083	(0.276)
Place of residence				
Urban	0.132	(0.338)	0.101	(0.301)
Rural	0.183	(0.387)	0.119	(0.324)
Number of observations	1,938		1,597	

Table 4. Odds ratios from logistic regression models with family random effects of two-week diarrhea prevalence for all of Brazil using data from DHS-1 and DHS-3

	Model I		**Model II**	
Constant	0.175***	(0.029)	0.216***	(0.043)
Child age (spline)				
0-5 months	1.312***	(0.050)	1.274***	(0.053)
6-23 months	0.951***	(0.010)	0.938***	(0.012)
24-59 months	0.960***	(0.005)	0.959***	(0.005)
Child sex				
Female	.	.	.	.
Male child	1.037	(0.087)	1.033	(0.087)
Mother's education (years)	0.931***	(0.014)	0.940***	(0.015)
Marital status				
Married	.	.	.	.
Cohabiting	1.274**	(0.120)	1.257**	(0.121)
Never married	0.738	(0.261)	0.682	(0.268)
Previously married	1.330*	(0.180)	1.311*	(0.181)
Father's education				
None	.	.	.	.
Primary or more	0.607***	(0.147)	0.626**	(0.149)
Don't know	0.584	(0.297)	0.621	(0.298)
Household wealth index				
Bottom 60%	.	.	.	.
Top 40%	0.625***	(0.112)	0.686***	(0.116)
Place of residence				
Urban	.	.	.	.
Rural	0.792*	(0.115)	0.700**	(0.127)
Year				
1986	.	.	.	.
1996	0.632***	(0.097)	0.738**	(0.110)
Region				
Rest of Brazil	.	.	.	.
Northeast	1.450***	(0.102)	1.389***	(0.107)
Birth order				
First born	.	.	1.106	(0.111)
Order 2-4	.	.	.	.
Order 5+	.	.	1.296**	(0.146)
Preceding birth interval				
≥ 12 months	.	.	.	.
< 12 months	.	.	0.967	(0.172)
Succeeding birth interval				
≥ 12 months	.	.	.	.
< 12 months	.	.	1.076	(0.273)
Child still breastfeeding				
No	.	.	.	.
Yes	.	.	0.693**	(0.154)
Months of breastfeeding	.	.	1.004	(0.006)
Received measles vaccination				
No	.	.	.	.
Yes	.	.	1.138	(0.137)
Mother's age at child's birth	.	.	0.986	(0.009)
Household water supply				
Piped	.	.	.	.
Well/Public tap	.	.	1.073	(0.134)
Undeveloped source	.	.	1.096	(0.162)
Household toilet facilities				
Flush toilet	.	.	.	.
Septic tank	.	.	0.984	(0.138)
None	.	.	1.232	(0.149)
Number of observations	6,779		6,779	
Model chi-square (df)	394.5***	(14)	412.1***	(26)

*p<.10; **p<.05; ***p<.01; standard errors in parentheses.

Table 5. Odds ratios from logistic models with family random effects of two-week diarrhea prevalence for Northeast Brazil and rest of Brazil using data from DHS-1 and DHS-3

	Northeast				**Rest of Brazil**			
	Model I		**Model II**		**Model I**		**Model II**	
Constant	0.233***	(0.043)	0.287***	(0.067)	0.174***	(0.040)	0.171**	(0.056)
Child age (spline)								
0-5 months	1.354***	(0.075)	1.280***	(0.079)	1.262***	(0.065)	1.261***	(0.069)
6-23 months	0.934***	(0.014)	0.909***	(0.017)	0.970**	(0.012)	0.969**	(0.015)
24-59 months	0.952***	(0.007)	0.950***	(0.007)	0.965***	(0.006)	0.966***	(0.006)
Child sex								
Female	.	.	.	.	.	.	.	.
Male child	1.009	(0.134)	1.018	(0.134)	1.050	(0.111)	1.059	(0.112)
Mother's education (years)	0.898***	(0.025)	0.903***	(0.027)	0.952***	(0.017)	0.968*	(0.018)
Marital status								
Married	.	.	.	.	.	.	.	.
Cohabiting	1.343*	(0.178)	1.341*	(0.183)	1.183	(0.163)	1.152	(0.164)
Never married	0.715	(0.408)	0.693	(0.422)	0.679	(0.361)	0.687	(0.370)
Previously married	1.381	(0.275)	1.377	(0.278)	1.262	(0.237)	1.217	(0.237)
Father's education								
None	.	.	.	.	.	.	.	.
Primary or more	0.594**	(0.197)	0.596**	(0.200)	0.591*	(0.248)	0.690	(0.251)
Don't know	0.369	(0.394)	0.403	(0.399)	1.011	(0.493)	1.163	(0.495)
Household wealth index								
Bottom 60%	.	.	.	.	.	.	.	.
Top 40%	0.979	(0.200)	1.018	(0.209)	0.415***	(0.130)	0.501***	(0.134)
Place of residence								
Urban	.	.	.	.	.	.	.	.
Rural	0.609**	(0.172)	0.558**	(0.193)	1.060	(0.158)	0.920	(0.173)
Year								
1986	.	.	.	.	.	.	.	.
1996	0.761	(0.162)	0.892	(0.190)	0.529***	(0.118)	0.648***	(0.131)
Birth order								
First born	.	.	1.207	(0.216)	.	.	1.044	(0.138)
Order 2-4	.	.	.	.	.	.	.	.
Order 5+	.	.	1.187	(0.177)	.	.	1.438**	(0.203)
Preceding birth interval								
≥ 12 months	.	.	.	.	.	.	.	.
< 12 months	.	.	1.049	(0.230)	.	.	0.877	(0.263)
Succeeding birth interval								
≥ 12 months	.	.	.	.	.	.	.	.
< 12 months	.	.	1.335	(0.358)	.	.	0.668	(0.434)
Child still breastfeeding								
No	.	.	.	.	.	.	-	-
Yes	.	.	0.238***	(0.240)	.	.	1.103	(0.195)
Months of breastfeeding	.	.	0.998	(0.010)	.	.	1.006	(0.007)
Received measles vaccination								
No	.	.	.	.	.	.	.	.
Yes	.	.	1.205	(0.195)	.	.	1.061	(0.196)
Mother's age at child's birth	.	.	0.996	(0.015)	.	.	0.978	(0.012)
Household water supply								
Piped	.	.	.	.	.	.	.	.
Well/Public tap	.	.	1.025	(0.209)	.	.	1.116	(0.175)
Undeveloped	.	.	1.079	(0.235)	.	.	1.197	(0.244)
Household toilet facilities								
Flush	.	.	.	.	.	.	.	.
Septic tank	.	.	1.001	(0.232)	.	.	0.942	(0.168)
None	.	.	1.204	(0.234)	.	.	1.314*	(0.193)
Number of observations	3,244		3,244		3,535		3,535	
Model chi-square (df)	196.6***	(13)	215.4***	(25)	170.7***	(13)	188.9***	(25)

**p*<.10; ***p*<.05; ****p*<.01; standard errors in parentheses.

Table 6. Decomposition results for changes in diarrhea between 1986 DHS-1 and 1996 DHS-3 (by region) and between the Northeast region and the rest of Brazil (by year): Mean predicted 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)	0.104	(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.

Appendix A. 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 diarréia?	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 diarréia?”	Has [NAME] had diarrhea in the last two weeks?
Sim	Yes
Não	No
Não sabe	Don’t know

1991 DHS-2. Asked for all children born since January 1986 who are still alive, starting with the youngest

[NOME] teve diarréa nas ultimas 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] teve diarréia nas últimas 24 horas?	Did [NAME] have diarrhea in the past 24 hours?
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 diarréia 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 diarréia hoje?	Did [NAME] have diarrhea today?
Sim	Yes
Não	No
Não sabe	Don’t know