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Temporal trends and inequality in under-5 mortality from diarrhea

Lígia C. F. L. Melli,[1] Eliseu A. Waldman[2]

Abstract

Objective: To analyze the trend in mortality due to diarrhea among children under 5 in the town of Osasco (SP), Brazil, between 1980 and 2000.

Methods: This is a descriptive observational study with two different designs, the first using individuals as the unit of study, and the other ecological, using groups of individuals as units of observation and including time series analysis. Data were obtained from the state of São Paulo information system of deaths and the results of the 1980, 1991 and 2000 censuses. Seasonal variations were described and log linear polynomial regression models were employed to analyze trends, using the sociodemographic characteristics of mothers and their children. Analyses were carried out of the changes in the town's sociodemographic indicators from 1980 to 2000, the average mortality rates among under-5s due to diarrhea and the differences between districts during the 1990s.

Results: There were a total of 1,360 deaths, 94.3% of which were before 1 year of age and 75.3% of which were before 6 months. There was a 98.3% reduction in mortality and the period of peak mortality shifted from summer to autumn/fall. The median age at death increased from 2 months at the first three quinquenium of study to 3 months at the last. The residual deaths were among the children of mothers aged 20 to 29 years and of mothers who had spent less than 8 years in education. The relative risk between the worst-affected district and the average rate for the town reduced from 3.4 to 1.3 from the first 5 years of the 1990s to the second half of the decade.

Conclusions: Our results demonstrate an increase in the age of greatest vulnerability and indicate that it is probable that the agent most often linked with mortality due to diarrhea has changed.

J Pediatr (Rio J). 2009;85(1):21-27: Diarrhea, infant mortality, time-series, social indicators, economic indicators.

Introduction

Over recent decades we have witnessed a significant reduction throughout Brazil in childhood morbidity and mortality due to diarrheal disease,[1,2] and one that has occurred in line with improvements in socioeconomic, demographic and health indicators. The most significant of these improved indicators are the increased coverage of basic sanitation, the reduction in infant malnutrition, and the increases in vaccination coverage,[3] breastfeeding and the educational level of mothers and also increased access to health services, oral rehydration treatment and information,[4] all of which have been identified by several studies as being linked with the behavior of this disease.[5]

Nevertheless, the progress achieved in these indicators can be subject to significant differences between and within each of the five administrative regions of Brazil.[4,6] A house-to-house survey carried out in Brazil in 1989 found a 10.5% prevalence of diarrhea among children less than 5 years old, ranging from 5.9% in the South region to 15.4% in the Northeast.[7] Surveys carried out in São Paulo (Southeast region), in 1984 and 1996, demonstrated that the prevalence of diarrhea among under-5s was higher among the poor-

1. Mestre, Centro Universitário FIEO (UNIFIEO), Osasco, SP, Brazil.
2. Doutor, Faculdade de Saúde Pública, Universidade de São Paulo (USP), São Paulo, SP, Brazil.

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est third of the population, despite the impressive reductions that had taken place between the two dates.[4]

Little research has been undertaken into the changes of epidemiologic profile of diarrhea-related infant mortality after 1980, which is when the greatest reductions began. More detailed knowledge about this subject is indispensable in order to subsidize the development of public policies and intervention strategies aimed at increasing health equity. The objective of this study was to investigate trends in mortality from diarrhea among children under 5, tracing seasonality between 1980 and 2000, and to describe spatial differences within the town of Osasco, from 1991 to 2000, taking districts as units of study.

Methods

This was exploratory observational research, using two different study designs: the first using individuals as the study unit, and the other ecological, using groups of individuals and including time-series analysis. The area studied is the town of Osasco, located within the greater São Paulo metropolitan area and with a population of around 650,000 inhabitants in 2000.[8] Also in 2000, the coefficient of infant mortality was at 19/1000 live births, the rate of illiteracy was 5.3% and the Human Development Index was 0.818.[9]

This study analyzes deaths occurring between 1980 and 2000 of children under 5 years old living in Osasco and ascribed to diarrhea as the underlying cause of death – codes 008 and 009 in the ninth revision of the International Classification of Diseases (ICD-9), from 1980 to 1995, and codes A08 and A09 on the ICD-10, from 1996 to 2000. All of the deaths identified were included in the trend analysis, but seven of the 137 (5.1%) deaths between 1991 and 2000 were excluded from the analysis by district of residence because their death certificates had missing or incomplete addresses.

The death statistics and death certificates were provided in electronic format by the Fundação Sistema Estadual de Análise (SEADE) (the State Data Analysis System),[10] a branch of the Sao Paulo State Government that is responsible for data collection and for the publication of statistics and studies on socioeconomic, demographic and health indicators; the state mortality database falls within their remit. Population estimates and socioeconomic indicators for the town were obtained from the results of the demographic censuses carried out in 1980, 1991, and 2000 and a population count carried out in 1996, undertaken by the Fundação Instituto Brasileiro de Geografia e Estatística (FIBGE) (the Brazilian Institute of Geography and Statistics)[8], a branch of the Brazilian Government that is responsible for demographic census. The Osasco Planning and Management Department provided tabulated population data by district and data on the evolution of health services and areas with substandard housing.[9]

The variables of interest were: sex, age, month of death, district of residence and age and educational level of mother. Data on medical care, birth weight, education and occupation of father and occupation of mother were not analyzed due to the high proportion of information that was missing from the databases available.

The administrative districts were characterized according to the following parameters: percentage of the population < 5 and ≥ 70 years old between 1991 and 2000, water and sewage coverage, proportion of literate people ≥ 10 years old, percentage of households per average monthly income stratum, number of years the head of each family had spent in education in 1991 and 2000, and the proportion of favela housing in 1996.

Analysis

The database were obtained in dBase format and converted for use with Epi-Info version 3.4 and Stata version 7, which were then used to perform the analyses.

The deaths from diarrhea were broken down for analysis into the periods 1980 to 1984; 1985 to 1989; 1990 to 1994 and 1995 to 2000, and by age, sex, month and place of residence, in addition to certain maternal variables such as age and educational level. The analyses of deaths by age and sex of child were based on medians plus measures of central tendencies.

Data were also analyzed by administrative district within Osasco, using the annual average mortality rates for the 5-year periods 1991 to 1995 and 1996 to 2000. We calculated the average under-5 mortality by age and district of residency by taking the number of deaths during each period as numerator and the estimated population of this age group on the first of June for the middle year of the period as denominator. We then calculated the relative risks (RR) and their respective 95% confidence intervals (95%CI) for the two 5-year periods, taking the mean rate for the whole town as reference (RR = 1.0).

The trends of mortality due to diarrhea between 1980 to 2000 were only analyzed for children under 1 year old, since above this age the number of deaths was too low for this type of analysis. Trends among under-1-year-olds were initially analyzed by age of child and maternal age and educational level. The mortality rate due to diarrhea among children under 1 year old was calculated by taking the number of deaths as the numerator and the total number of live births (LB) each year as the denominator.[10]

Trends were analyzed using *log*-linear models of polynomial regression for the time-series where the dependent variable (Y) was the *log* of the annual number of deaths from diarrhea in each of the categories studied, and the independent variable (X) was the years of the study period. The variable *time* was centered on the mid point of the historical series

in order to avoid self-correlation error.[11] Models were constructed by linear regression, based on first, second and third order models. The choice of best model was based on the coefficient of determination (r^2), in the analysis of residuals, meeting the assumptions of independence and constant variation of errors and statistical significance, where $p < 0.05$.

This research was approved by the Ethics Committee at the University's Public Health Department.

Results

During the period of interest, a total of 1,360 children under 5 died from diarrhea in the town of Osasco, 5.7% at ages from 12 to 59 months and 94.3% while less than 1 year old. Of these, 75.2% died while less than 6 months old. More male children died than females (55.8%).

In absolute figures, the annual number of deaths among children less than 5 years old reduced from 209, in 1980, to three, in 2000, with all three of these deaths being children aged from 1 to 11 months. During the first three periods, 1980-84, 1985-89 and 1990-94, there were 844, 346 and 127 deaths, respectively. Between 1995 and 2000 there were 43 deaths, with 51% of these affecting the age range of 1 to 5 months, while 30% of the children were between 6 and 11 months old (11% were more than 1 year old) and no children died before 28 days.

The median age of children who died aged less than 1 year was 2 months during the three first periods, rising to 3 months during the last period (1995-2000).

The coefficient of infant mortality from diarrhea dropped by 98.3%, from 11.9 deaths/1,000 LB in 1980, to 0.2 deaths/1,000 LB in 2000. The mortality rate due to diarrhea among children under 5 years reduced by 98.6%, over the same period, from 319.7 deaths/100,000 children under 5 per year, in 1980, to 5.5 deaths/100,000 children under 5 per year in 2000.

We detected a change in seasonal distribution during the period of interest, with a clear predominance during the period from January to March (summer in the Southern hemisphere) in 1980 to 1985 being displaced to May (autumn/fall) during the period from 1995 to 2000 (Figure 1).

There were more deaths from diarrhea among children under 5 years whose mothers were between 20 and 29 years old (59.7%) and had less than 8 years' education (98.7%).

The mortality at < 1 year for the different age strata (< 28 days, from 28 days to 5 months and from 6 to 11 months), maternal age groups (< 20, from 20 to 29 and 30 and over) maternal education levels (< 1 year and from 1 to 8 years) exhibited a downward trend, and the best fit model was the linear log ($LnY = 0 + 1\ X$) (Figure 2).

The analysis by district of residence included the 130 deaths of children under 5 years old. The average annual rate for the whole town between 1991 and 1995 was 33.0 deaths

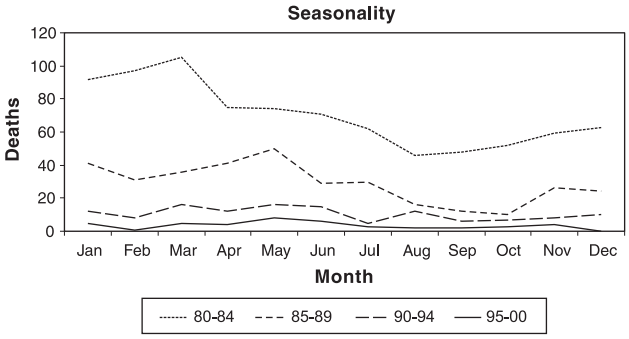

Figure 1 - Under-5 deaths from diarrhea, by month of death and five-year period

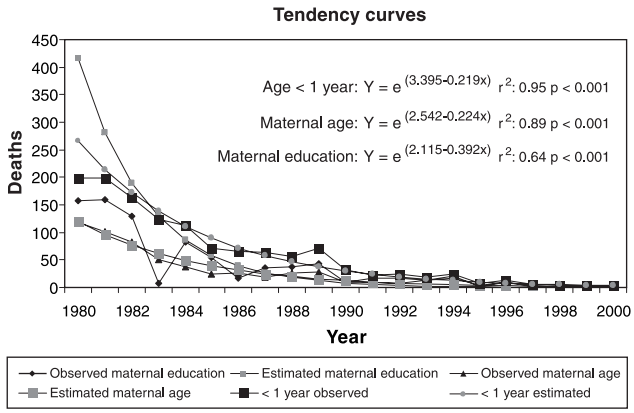

Figure 2 - Trends of deaths from diarrhea among children under 1 year old, by age < 1 year at death, age of mother between 20 and 29 years and maternal education of 1 to 8 years

from diarrhea/100,000 children under 5 per year, but in the North district it reached 103.6 deaths/100,000 children under 5 years old with a RR of 3.4 (95%CI 1.0-9.9) (Table 1). That district was the area that had the worst socioeconomic indicators and a population increase of around three times, with the highest proportion of people living in favela housing (40.1%) and the lowest domestic sewage system coverage (13.7%) (Table 2). In turn, the Central District, which had the lowest mortality rate (Table 1), had the best indicators, with a 29.2% reduction in the population of children under 5 and a 51.9% increase in the population of people ≥ 70, in addition to the best figures for illiteracy and income of the head of family (Table 2).

These differences remained during the second five-year period (1996-2000), although they were less accentuated. The district with the greatest differential with relation to the annual average rate for the whole town was the Northeast District, with a RR of 1.4 (95%CI 0.7-2.6), although this difference was not significant (Table 1). This district had, at that time, the second highest percentage of people living in favela housing and the highest rate of family heads with less than 1

Table 1 - Mortality rate due to diarrhea among children under 5 years old*, relative risks and confidence intervals by district and period

	1991-1995†			1996-2000‡		
District	**Mortality rate***	**RR**	**95%CI**	**Mortality rate***	**RR**	**95%CI**
North	103.6	3.1	1.0-9.9	0.0	-	-
Northeast	42.6	1.3	0.8-1.9	16.2	1.4	0.7-2.6
Northeast	29.5	0.9	0.5-1.5	6.4	0.5	0.2-1.8
Centro	23.3	0.7	0.3-0.9	0.0	-	-
Southwest	25.1	0.8	0.4-1.4	8.2	0.7	0.2-2.3
Southeast	24.9	0.7	0.4-1.3	14.1	1.2	0.5-2.8
South	37.6	1.1	0.7-1.8	14.0	1.2	0.6-2.5
Entire town	33.0	1.0 (ref)		11.8	1.0 (ref)	

95%CI = 95% confidence interval; ref = reference group for calculation of relative risk; RR = relative risk.
* Per 100,000 children under 5.
† Mean estimated population for 1st July of 1993.
‡ Mean estimated population for 1st July of 1998.

year's study, according to the demographic census of 2000 (Table 2).

With relation to the development of health services, towards the end of the 1990s the health service was taken under control of the town authorities and extended greatly, including both the primary care health centers and the hospitals, with emphasis on maternal and infant health. In 1990, Osasco had 27 basic healthcare centers (BHC), with care focused on child health, women's health and oral health, five emergency rooms and four walk-in centers. By 2000, there were 50 health units (24 BHC, seven walk-in centers, five emergency rooms, a general hospital, one maternity unit and two polyclinics).[9]

Discussion

This study detected significant reductions in mortality rate from diarrhea among children under-5 (98.3%) in the town of Osasco, during the 1980s and 1990s. There were, however, differences between the districts.[12] Several factors may have contributed to the reduction. Of note among these are the improvements in basic sanitation coverage, which was already good during the 1980s, the increase in health service coverage, improved prenatal and infant healthcare and the increase in educational level, in addition to the reduction in infant malnutrition in the greater São Paulo metropolitan area.[4] These results suggest that the reduction in infant mortality from diarrhea has been influenced by the expansion of health services and the sewage network.[12]

Studies carried out in Brazil have demonstrated a concurrent reduction in morbidity and mortality during the same period, and also a reduction in the severity of infant diarrhea, with faster reductions in hospital admissions than in diarrhea incidence,[4,13,14] indicating increased access to healthcare, improvements in the quality of childcare[15] and promotion of the use of oral rehydration.[16,17]

The process of taking health services under control of the Osasco town authorities was completed in 1996, with an increased number of BHCs and the addition of new responsibilities, primarily in order to conform with the principle of integrated care.

The significant expansion and improvement of prenatal and neonatal care, probably reducing the relative importance of factors such as prematurity as determinants of death,[18] is expressed by the total absence of deaths of infants less than 28 days old during the last 5 years of the study. This process also provides the conditions for more vulnerable segments of the population to access care and is a valuable instrument for reducing childhood mortality.[19]

Notable among strategies for child health promotion is encouraging breastfeeding which has been identified as an important factor in reducing mortality from diarrhea in some studies, including of the greater São Paulo metropolitan area.[4,20]

There is evidence that a discreet increase in the duration of breastfeeding may have contributed to the reduction in morbidity and mortality from diarrhea.[16] A survey of 14 municipal authorities in the greater São Paulo metropolitan area[21] estimated that exclusive breastfeeding by 17% of nursing mothers was responsible for an 84% reduction in deaths

Table 2 - Demographic and socioeconomic data by district (Osasco, 1991* and 2000†)

Indicators	North	Northwest	Northeast	Center	Southwest	Southeast	South	Entire town
Population								
1991	3,742	110,003	97,424	52,382	93,516	114,762	96,396	568,225
2000	12,893	146,602	102,496	49,645	93,872	113,829	131,656	650,993
Demographic density (inhabitants/ha)								
1991	3.9	114.0	125.8	58.3	94.6	120.9	89.9	85.9
2000	13.4	151.9	132.3	55.3	95.0	120.0	122.8	98.4
Inhabitants/household								
1991	4.2	4.1	4.0	3.6	4.0	4.0	4.2	4.0
2000	3.8	3.7	3.6	3.2	3.6	3.6	3.8	3.6
Household with running water (%)								
1991	91.2	99.0	99.1	99.9	99.5	99.8	98.9	99.3
2000	90.4	96.5	98.8	99.9	99.5	99.9	99.1	97.8
Household with connection to sewers (%)								
1991	13.7	44.1	25.7	91.7	76.7	82.3	59.7	61.3
2000	21.6	54.8	57.0	97.5	81.7	86.6	69.9	70.7
Literate population ≥ 10 years old (%)								
1991	87.5	92.4	90.6	96.0	90.1	93.3	90.0	91.8
2000	92.9	92.9	94.1	97.5	96.0	95.9	94.0	94.7
Family heads with < 1 year in education (%)								
1991	16.2	15.8	11.9	6.3	9.6	8.9	19.8	11.4
2000	9.3	9.5	8.1	3.5	5.8	6.1	8.3	7.4
Family heads with ≥ 15 years in education (%)								
1991	2.6	2.3	1.9	14.1	5.5	5.9	1.3	4.6
2000	2.4	3.1	3.3	19.6	7.9	8.9	3.1	6.3
Family heads earning > 10 x minimum wage (%)								
1991	7.9	6.3	7.6	24.3	12.1	12.2	4.2	10.3
2000	4.3	5.7	7.4	31.2	16.0	17.1	6.2	11.8
People living in favela housing (%)								
1991	40.1	22.7	22.2	0	7.2	7.9	19.7	15.2
2000	31.1	27.4	25.6	0	8.4	5.5	21.5	17.3
Variation (%) in population from 1991 to 2000								
< 5 years	227.3	19.1	-7.5	29.2	-19.5	-21.5	-21.0	-0.28
≥ 70 years	33.3	79.6	63.5	51.9	86.0	39.8	98.5	66.9

FIBGE = Fundação Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of National Statistics and Geography).
* FIBGE – 1991 census.
† FIBGE – 2000 census.

from diarrhea of infants less than 3 months old and a 39% reduction in deaths of children aged three to 11 months between 1999 and 2000 in Osasco.

The displacement, from the 1990s onwards, of the season of highest number of deaths from diarrhea from summer to autumn can be attributed to increased basic sanitation coverage. This is due both to a relative increase in the number of viral infections,[2,22] especially by rotavirus,[23,24] whose transmission is predominantly respiratory, and also due to a reduction in bacterial infections, particularly those caused by *Escherichia coli*,[25] which have a greater impact during the summer on communities without sanitation, since rainwater increases environmental contamination.

In contrast with what has been found in other studies that have observed reductions in mortality from diarrhea decelerate during the 1990s,[22,26,27] our results indicate a steady decline without major variations throughout the period, possibly as a result of the favorable combination of all of the factors mentioned above.

During the first 5 years of the 1990s, under-5 mortality from diarrhea was heterogeneously distributed across the town. These differences are consistent with the pattern of certain indicators in different districts, particularly those relating to educational level, living conditions, basic sanitary coverage and rapid demographic growth that outstrips increases in urban infrastructure.

The drastic reduction in these differences during the last five-year period (1996-2000), without similar improvement in the socioeconomic and health indicators, supports the hypothesis that public health interventions and improved healthcare have played a relevant role. The total absence of deaths in the North district, which had been most affected during the first study period, is possibly a reflection of interventions that have resulted in greater access to goods and services, improving health equity in this community.

Monitoring indicators in order to identify differences in morbidity and mortality profiles makes it possible to define higher risk groups within the population,[28] thereby providing the basis for healthcare policies which focus on improving social wellbeing and equity by means of public health interventions in the most vulnerable sections of the population.[29]

The results presented here, must be interpreted considering some limitations of the vital statistics, such as frequently incomplete death certificates, missing addresses and lack of information in these certificates from infectious agents linked with deaths by diarrhea. Nevertheless, despite these limitations, the results presented here are consistent with those of other studies carried out in the same region.[2,4,14]

Considering that a residual number of avoidable deaths from diarrhea are still occurring among children less than 5 years old, it is of interest to identify which groups are currently at risk and what the risk factors are today. Our results indicate that the age of greatest vulnerability has increased and that it is probable that the agent most frequently associated with death from diarrhea has changed. We nevertheless still have gaps in our knowledge on this subject, which indicates the relevance of developing a system for monitoring childhood diarrhea, with the objective of continually analyzing trends among factors related to disease severity (etiology, proportion of cases admitted to hospital, duration of episode), and of studying risk factors associated with severity. This knowledge would allow for the identification of prognostic factors and the improvement of educational programs focused on mothers, informing them about appropriate and opportune use of oral rehydration and emphasizing breastfeeding.[18,30]

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Correspondence:
Lígia Cristina Fonseca Lahoz Melli
Rua Ângelo Este, 99
CEP 06026-110 - Osasco, SP - Brazil
Tel.: +55 (11) 3683.9517
E-mail: lmelli@uol.com.br