Seasonal diarrhoeal mortality among Mexican children*

S. Villa,[1] H. Guiscafré,[2] H. Martínez,[2] O. Muñoz,[2] & G. Gutiérrez[2]

The study investigated the effects on diarrhoeal deaths among under-5-year-old Mexican children of the following variables: season (summer or winter), region (north versus south), age group, and place of death. Examination of death certificates indicated that the distribution of deaths in 1989–90 was bimodal, with one peak during the winter and a more pronounced one during the summer. In 1993–94, however, the winter peak was higher than that in the summer (odds ratio (OR) = 2.04). These findings were due mostly to deaths among children aged 1–23 months (OR = 1.86). Diarrhoeal mortality was highest among children aged 6–11 months (OR = 2.23). During the winter, there was a significant increase in the number of deaths that occurred in medical care units and among children who had been seen by a physician before they died, but deaths occurring at home showed no seasonal variation. In the northern states, the reduction in diarrhoeal mortality was less in winter than in summer (OR = 2.62). In the southern states, the proportional reduction during the winter was similar to that in the summer.

Voir page 379 le résumé en français. En la página 379 figura un resumen en español.

Introduction

The number of deaths from diarrhoea among children in Mexico is higher during the summer months. Between 1990 and 1995, diarrhoeal mortality among under-5-year-olds declined by 67% from 133.30 to 43.75 per 100 000 (*1*). Gutiérrez et al. have shown that this reduction was due to a lower incidence of diarrhoeal disease and to increased use of oral rehydration therapy (ORT) (*2*). The decrease in diarrhoeal disease was the result of improvements in water supply and sanitation (e.g., chlorination of drinking-water, increased distribution of potable water among the population, greater access to proper sewage disposal, and restrictions imposed on the use of contaminated water for agriculture). These measures were introduced after a cholera epidemic in the country in 1991 (*3–5*).

The decline in diarrhoeal mortality in Mexico is, however, not uniform throughout the year, with some workers having identified a lower decline during the winter than the summer months (*6–8*). This has been attributed to the incidence of rotavirus, the main etiological agent of diarrhoea (25–50%) in winter (*6*), which is not reduced by the sanitary measures that reduce diarrhoeas of bacterial origin which predominate in the summer (*9*).

In the present study of the decline in diarrhoeal deaths over consecutive 12-month periods between 1989 and 1995, we examined the influence on diarrhoeal mortality of season, region, child's age group, and place of occurrence of death.

Methods

Data on diarrhoeal deaths for the period from 1989 to 1995 were collected from the National Institute of Statistics, Geography and Information, Mexico City (*10*). These deaths included those coded as 001–009 in the International Classification of Diseases (Ninth Revision; ICD-9). All diarrhoeal deaths among under-5-year-olds were identified by month, to determine any seasonal pattern. To highlight the seasons, we plotted graphs of diarrhoeal deaths from October to the following September over successive years from 1989 to 1995. The winter period included deaths from November to January; those in summer occurred from June until August.

The odds ratio (OR) and 95% confidence intervals (CI) for each season were calculated using the baseline period, i.e. 1989–90, as the reference (OR = 1). The significance of changes over time was calculated by means of a chi-squared (χ^2) test for trends. To evaluate whether the seasonal changes were significantly different by age group, we plotted graphs of the monthly proportional distribution of deaths among children aged <1 month (excluding infants aged <1 week), 1–5 months, 6–11 months, 12–23 months, and 2–4 years. We calculated, by age group, the OR for the risk of dying in the summer versus that in the winter.

There was a seasonal variation in mortality, mainly among children aged 1–23 months. We therefore concentrated on this age group to calculate

* From the Inter-institutional Group for Health System Investigations, Mexican Social Security Institute, Secretariat for Health, Mexico City, Mexico.

[1] Centro Médico Nacional Siglo XXI, Coordinación de Investigación Médica, Edificio "B", Unidad de Congresos, 4o. Piso, Av. Cuauhtémoc 330, Col Doctores, C.P. 06725, Mexico, D.F., Mexico. Requests for reprints should be sent to Dr S. Villa at this address.

[2] Inter-institutional Health Services Research Group, Mexican Social Security Institute and Ministry of Health, Mexico City, Mexico.

Reprint No. **5779**

the monthly percentage distribution of deaths for the periods 1989–90 and 1994–95, taking into account the place of death, history of medical care prior to the death, and whether social security was available.

To determine whether the seasonal variation was similar in all regions in the country, we calculated the monthly percentage distribution of diarrhoeal deaths among children aged 1–23 months, during 1989–90 and 1994–95, for each state in the country. We then grouped the states into the following three regions: north (with an extreme climate and marked seasons), centre (with a wide variation in geographical conditions and climate, but without a clearly defined pattern), and south (with a tropical climate and less marked seasonal changes).

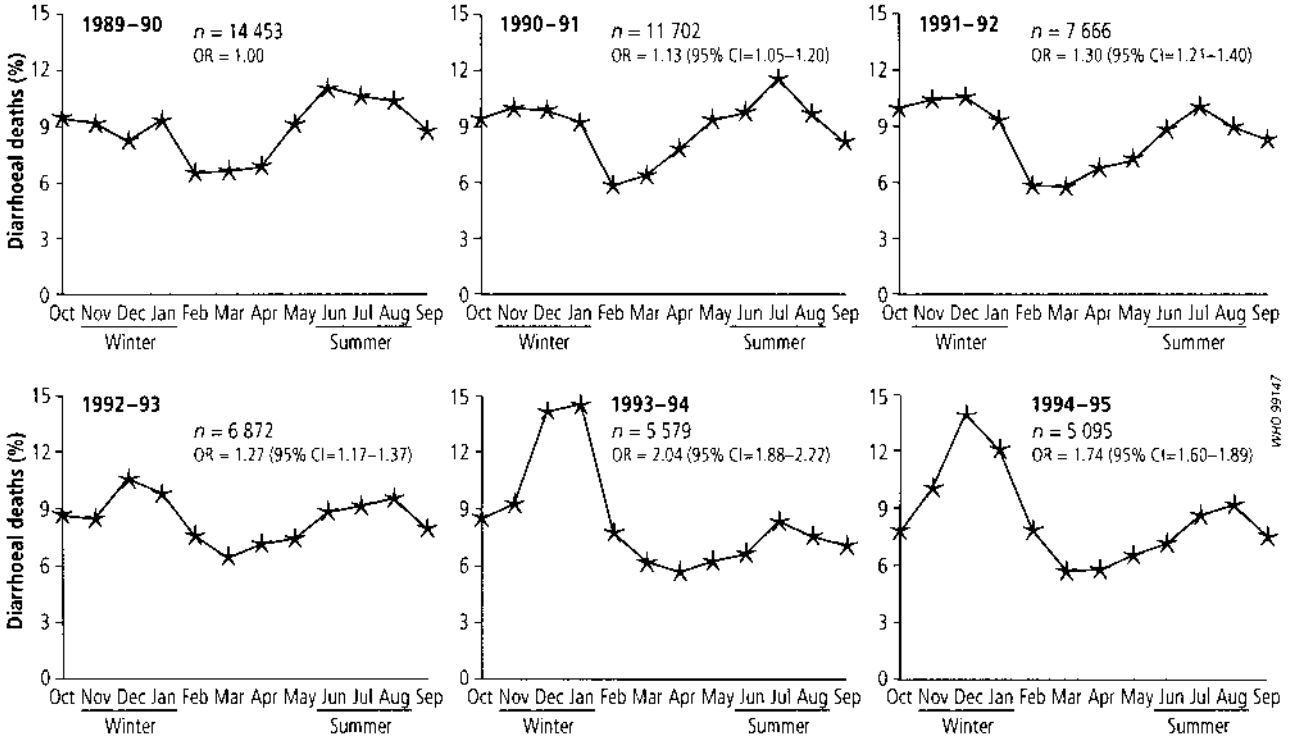
Results

Deaths due to diarrhoea among under-5-year-old children decreased by 64.7% from a total of 14 453 (October 1989 to September 1990) to 5095 (October 1994 to September 1995). Fig. 1 shows that there was a bimodal distribution of diarrhoeal deaths every year over the study period (1989–95). In 1989–90 and 1990–91 there was a peak in the winter months and a second, more pronounced peak in the summer months. For the next two periods, 1991–92 and 1992–93, the heights of the peaks were similar. Finally, for 1993–94 and 1994–95, the winter peak was much higher than the summer one. The χ^2 test for trends was highly significant ($P < 0.01$). The OR for each period studied increased significantly, reaching 2.04 (95% CI = 1.88–2.22) in 1993–94.

Fig. 2 shows the monthly proportional distribution of diarrhoeal deaths by age group. The proportion of deaths among children aged 1–23 months was greater during the winter for the period 1994–95 (compared with the baseline period, 1989–90). However, when we analysed these deaths by age group, the greatest risk of dying during the winter occurred among 6–11-month-old children (OR = 2.23; 95% CI = 1.88–2.65). There were no significant differences in proportional deaths between the two periods for children aged 7–29 days and 24–59 months, among whom the largest proportion of deaths occurred during the summer. It should be noted that Fig. 2 shows the proportional distribution of deaths for the study periods, not the total number of deaths, which did exhibit a significant decrease in both periods.

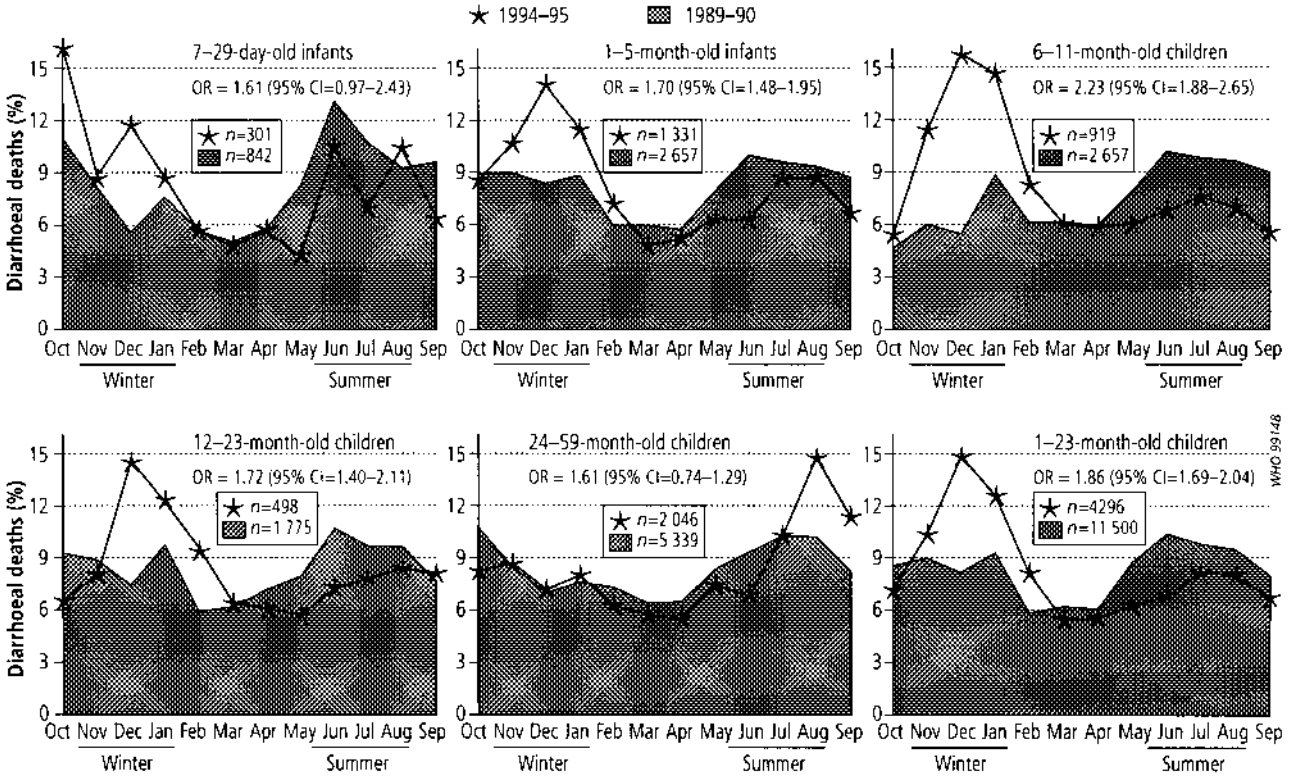
Table 1 compares the distribution of diarrhoeal deaths during the winter and summer for the periods 1989–90 and 1994–95, according to the place of death and whether the child had been seen by a physician. About 60% of the children died at home, with no significant difference between winter and summer for both periods. However, from the winter of 1989-90 to the winter of 1994–95 there was a significant increase (32.5–39.1%) in deaths occurring in medical care units, as well as in the proportion of children (73.5–80.8%) who had been seen by a physician before they died.

Fig. 1. **Monthly proportional distribution of diarrhoeal deaths among under-5-year-old study children, from October 1989 to September 1995**



n = total number of deaths from October to the following September for each period; OR = odds ratio (probability of death in winter, relative to the summer (OR = 1.00) of 1990); χ^2 test for trends, $P < 0.01$.

Fig. 2. **Monthly proportional distribution of diarrhoeal deaths among under-5-year-old study children, by age group, for two 12-month periods (1989–90 and 1994–95)**



n = number of deaths from October to the following September, OR = odds ratio (probability of death in the winter of 1994–95, with reference to the summer, relative to 1989–90; $P > 0.01$ for children aged 1–5 months, 6–11 months, 12–23 months, and all age groups.

Fig. 3 shows the proportional distribution of deaths in the states that formed the northern and southern regions for the periods 1989–90 and 1994–95. In the northern states, there were 1298 deaths in the period 1989–90 and 519 (60% reduction) in 1994–95, when there were fewer deaths during the summer and considerably more during the winter (OR = 2.62; 95% CI = 1.94–3.55). In the southern states, there were 3615 deaths in 1989–90, compared with 1295 (64% reduction) during 1994–95. These levels are nearly three times higher than those in the north. However, the monthly proportional distribution of deaths in the southern states was similar for both periods; any difference was not significant (OR = 1.29; 95% CI = 0.98–1.54).

Table 1. **Distribution of diarrhoeal deaths among under-2-year-olds[a] during the winters of 1989–90 and 1994–95 and during the summers of 1990 and 1995, by the place where the child died and whether medical care was given before death**

Place of death	Winter (November–January)		Summer (June–August)	
	1989–90	1994–95	1990	1995
At home (%)	60.9	59.3	62.4	61.6
In a health care unit (%)	32.5	39.1[b]	32.9	35.9
Received medical care before death (%)	73.5	80.8[b]	74.8	73.7

[a] Excluding children aged <1 month.

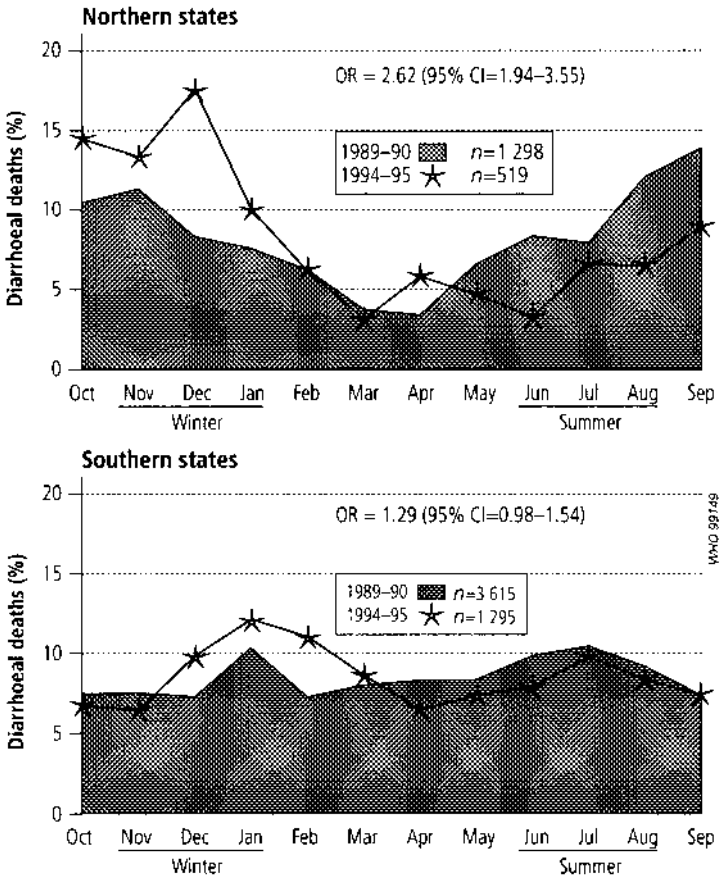
[b] $P < 0.01$ between 1989–90 and 1994–95 periods.

Discussion

Diarrhoeal deaths among under-5-year-olds in Mexico have fallen considerably over the last few decades (*1*). Previous studies showed that this reduction was largely due to improvements in general hygiene and environmental sanitation, the use of oral rehydration therapy, measles immunization (*11*), and improvements in women's literacy rates (*12*). During the 1970s and 1980s more deaths occurred in the summer, but the distribution since 1990 has been more even throughout the year. Some workers recently found a greater proportion of deaths during the winter, which they attributed to the increased prevalence of rotavirus (*6*).

In the present study, we found a significant decrease (67%) in diarrhoeal deaths in Mexico during the first half of the 1990s, probably as a result of improved sanitary measures and greater promotion of oral rehydration therapy, both of which were introduced after the 1991 cholera epidemic (*4*). Fig. 1 shows that there was a greater reduction in diarrhoeal deaths in the summer of 1994 and 1995, with more deaths occurring during the winter months. A similar observation was made in other countries (*13*, *14*). This seasonal change was not the same in all age groups or in all geographical and climatic regions of

Fig. 3. **Monthly proportional distribution of diarrhoeal deaths among study children aged 1–23 months in two regions of Mexico (northern and southern states for two 12-month periods: 1989–90 and 1994–95)**



OR = odds ratio (probability of death in the winter of 1994–95, relative to the summer, compared with 1989–90 in each region).

the country. The change was observed among children aged 1–23 months but not for other age groups (Fig. 2) and was more pronounced in the northern states (with clearly marked seasons) than in the south (with an even climate throughout the year). During the winter there was also an increase in the proportion of diarrhoeal deaths that occurred in the medical unit and among children who had been seen by a physician.

Although our study design precludes providing an explanation for these changes, we believe that the observed seasonal effect on diarrhoeal deaths was connected with rotavirus diarrhoea for the following reasons:

- Studies in developing countries have shown that about 20% of children who are hospitalized because of diarrhoea during the winter months have rotavirus as the etiological agent (*15*), while studies in developed countries have identified rotavirus in up to 70% of diarrhoeal episodes (*6*, *7*, *16*). These results, indicating an increase in the proportion of diarrhoea due to rotavirus in areas where the incidence of bacterial diarrhoea had decreased, suggest a lower level of response of rotavirus diarrhoea to current preventive interventions.
- It is well known that rotavirus diarrhoea is more prevalent in children aged 1–24 months (*17*), the main age group affected by seasonal change in our study.
- Epidemiological descriptions of the increased prevalence of rotavirus during the winter months show that this seasonal pattern occurs in countries with cold winters, but not in those with a milder climate (*6*, *7*). In our study, we found the seasonal change in diarrhoeal mortality only in the northern states, where the seasons are well marked.
- Sanitary measures, particularly those related to clean water programmes, are well known to have an impact on the incidence of diarrhoeas with a bacterial etiology, but not on those due to rotavirus. In our study, there was a change in seasonal mortality in 1993–94, following the implementation of extensive sanitary measures in response to the cholera epidemic in 1991.
- It has been well documented that rotavirus diarrhoeas are often associated with severe dehydration. Our finding of a larger proportion of deaths among children who were seen in the hospital or who demanded and received medical attention probably indicates serious dehydration due to the diarrhoea. This could indicate a problem in the quality of medical care in Mexico (*18*, *19*) and other countries (*20*), even when the studies were not specifically focused on diarrhoeal deaths occurring during the winter.

Conclusion

We have shown that there was a significant reduction in diarrhoeal deaths among children in Mexico between 1989 and 1995. However, this reduction was less evident in the winter months, particularly among under-2-year-olds and in regions where the seasons are well marked. We found that a larger proportion of diarrhoeal deaths during the winter, compared with the summer, occurred in medical care units or among children who had received some medical attention. We believe that these deaths were largely due to rotavirus infection.

Measures that specifically focus on preventing rotavirus diarrhoea and dehydration are needed. We therefore support the use of a rotavirus vaccine (*21–23*) and other interventions that will reduce diarrhoea incidence in general, such as hand washing (*24*, *25*). In a large number of developing countries, the main focus of primary health care services during the winter has been on acute respiratory infections; oral rehydration therapy, which is often used to prevent or treat dehydration, should be reinforced during the winter months. Finally, an important role for national programmes, which is promoted by WHO's Integrated Management of Childhood Illness (IMCI) programme (*26*), is the development and application of educational strategies to improve the quality of health care given to children with dehydrating diarrhoeas and other common diseases. ■

Résumé

Mortalité saisonnière d'origine diarrhéique chez des enfants mexicains

Cette étude se penche sur les effets que peuvent avoir, sur la mortalité d'origine diarrhéique d'enfants mexicains de moins de 5 ans, les variables suivantes : saison (été ou hiver), région (nord ou sud), tranche d'âge, et lieu du décès. L'examen des certificats de décès montre qu'en 1989-1990, la distribution des décès a été de type bimodal, avec un premier maximum en hiver et un autre, plus prononcé, en été. Toutefois, en 1993-1994, le maximum hivernal a dépassé le pic estival (*odds ratio* = 2,04). Ces résultats sont dus essentiellement aux décès survenus dans la tranche d'âge 1-23 mois (*odds ratio* = 1,86). C'est parmi les enfants âgés de 6 à 11 mois que la mortalité d'origine diarrhéique a été la plus élevée (*odds ratio* = 2,23). Au cours de l'hiver, il y a eu une augmentation sensible du nombre de décès dans les services de soins ainsi que parmi les enfants qui avaient déjà été vus par un médecin, mais aucune variation saisonnière n'a été observée dans le nombre de décès survenus au domicile. Dans les Etats du nord, la mortalité par diarrhée a moins diminué en hiver qu'en été (*odds ratio* = 2,62). Dans les Etats du sud, le taux de réduction a été le même en hiver qu'en été.

Resumen

Mortalidad estacional por diarrea entre niños mexicanos

En este estudio se analiza la influencia en las defunciones por diarrea de niños mexicanos menores de cinco años de las siguientes variables: estación (verano o invierno), región (norte frente a sur), grupo de edad y lugar de defunción. El examen de los certificados de defunción reveló que la distribución de las muertes en 1989-1990 fue bimodal, con un pico en invierno y otro más pronunciado durante el verano. En 1993-1994, en cambio, el pico invernal fue mayor que el estival (razón de posibilidades (OR) = 2,04). Estos resultados se deben principalmente a las defunciones registradas entre los niños de 1-23 meses (OR = 1,86). La mortalidad por diarrea fue más alta entre los niños de 6-11 meses (OR = 2,23). Durante el invierno aumentaba considerablemente el número de las defunciones que tenían lugar en unidades de atención médica y entre los niños que habían sido examinados por un médico antes de su fallecimiento, pero en cambio no se observó ninguna variación estacional de las defunciones que ocurrían en el hogar. En los Estados del norte del país, la reducción de la mortalidad por diarrea fue inferior en invierno que en verano (OR = 2,62). En los Estados del sur, la reducción proporcional durante el invierno fue parecida a la del verano.

References

1. [*Yearbook of statistics: mortality, 1990*]. Mexico City, Office of the Director-General of Statistics, Informatics and Evaluation, Secretariat of Health, 1990 (in Spanish).
2. **Gutiérrez G et al**. Impact of oral rehydration and selected public health interventions on reduction of mortality from childhood diarrhoeal diseases in Mexico. *Bulletin of the World Health Organization*, 1996, **74**: 189–197.
3. [*Clear Water Programme*]. Mexico City, National Water Commission, 1991 (in Spanish).
4. **Gutiérrez G.** [Treatment of cholera]. In: Kumate J, Sepúlveda J, Gutiérrez G, eds. [*Cholera: epidemic, endemic and pandemic*]. Mexico City, Información Profesional Especializada, 1993: 151–166 (in Spanish).
5. [*Epidemiology. National System of Epidemiological Vigilance*]. Mexico City, Sistema Unico de Información, Secretariat of Health, 1997, **14** (2): 4 (in Spanish).
6. **Kapikian AZ et al.** Human reovirus-like agent as the major pathogen associated with ''winter'' gastroenteritis in hospitalized infants and young children. *New England journal of medicine*, 1976, **294**: 965–972.
7. **Ho MS et al.** Rotavirus as a cause of diarrheal morbidity and mortality in the United States. *Journal of infectious diseases*, 1988, **158**: 1112–1116.
8. **Velázquez FR et al**. Cohort study of rotavirus serotype patterns in symptomatic and asymptomatic infections in Mexican children. *Pediatric infectious disease journal*, 1993, **12**: 54–61.
9. **Black RE et al.** A two-year study of bacterial, viral and parasitic agents associated with diarrhea in rural Bangladesh. *Journal of infectious diseases*, 1980, **144**: 660–664.
10. [*Death certificates issued in the Mexican Republic, 1989–1995.*] Mexico City, Institute of Statistics, Geography and Information (INEGI) (in Spanish).
11. **Koster FT et al.** Synergistic impact of measles and diarrhoea on nutrition and mortality in Bangladesh. *Bulletin of the World Health Organization*, 1981, **59**: 901–908.
12. [*Bulletín of Statistical Information. Resources and Services, No. 10*]. Mexico City, Office of the Director-General of Statistics, Informatics and Evaluation, Secretarat of Health, 1990 (in Spanish).
13. **Armah GE et al**. Seasonality of rotavirus infection in Ghana. *Annals of tropical paediatrics*, 1994, **14**: 223–229.
14. **Muhuri PK.** Estimating seasonality effects on child mortality in Matlab, Bangladesh. *Demography*, 1996, **33**: 98–110.
15. **Stoll BJ et al**. Surveillance of patients attending a diarrhoeal disease hospital in Bangladesh. *British medical journal*, 1982, **285**: 1185–1188.
16. **Konno T et al**. A long-term survey of rotavirus infection in Japanese children with acute gastroenteritis. *Journal of infectious diseases*, 1978, **138**: 569–576.
17. **Campos G de J et al**. [Infant morbimortality due to acute diarrhea in a metropolitan area of northeastern Brazil]. *Revista Saúde pública*, 1995, **29**: 132–139 (in Portuguese).
18. **Guiscafré H et al**. From research to public health interventions. I. Impact of an educational strategy for physicians to improve treatment practices of common diseases. *Archives of medical research*, 1995, **26**: S31–S39.
19. **Reyes H et al**. Infant mortality due to acute respiratory infections: the influence of primary care processes. *Health policy and planning*, 1997, **12**: 214–223.
20. **Sodeman M et al**. High mortality despite good care-seeking behaviour: a community study of childhood deaths in Guinea-Bissau. *Bulletin of the World Health Organization*, 1997, **75**: 205–212.

21. **Velázquez FR et al**. Rotavirus infection in infants as protection against subsequent infections. *New England journal of medicine*, 1996, **335**: 1022–1028.
22. **Institute of Medicine**. The prospects for immunizing against rotavirus, 1986. In: *New vaccine development: establishing priorities. Vol. 2. Diseases of importance in developing countries*. Washington, DC, National Academy Press, 1986: 308–318.
23. **De Zoysa I, Feachem RG**. Interventions for the control of diarrhoeal diseases among young children: rotavirus and cholera immunisation. *Bulletin of the World Health Organization*, 1985, **63**: 569–583.
24. **Stanton B, Clemens J**. An educational intervention for altering water-sanitation behaviors to reduce childhood diarrhea in urban Bangladesh. II. Randomized trial to assess the impact of the intervention on hygienic behaviors and rates of diarrhea. *American journal of epidemiology*, 1987, **125**: 292–301.
25. **Black R et al**. Handwashing to prevent diarrhea in day-care centers. *American journal of epidemiology*, 1981, **113**: 445–451.
26. **Integrated Management of Childhood Illness (IMCI)**. *IMCI information*. Geneva, World Health Organization, 1997.