Narrowing inequalities in infant mortality in Southern Brazil
Redução das desigualdades na mortalidade infantil na região Sul do Brasil

Marcelo Zubaran Goldani[a], Rosange Benatti[a], Antônio Augusto Moura da Silva[b], Heloisa Bettiol[c], Joel Cristiano Westphal Correa[a], Marcos Tietzmann[a], Marco Antonio Barbieri.[c]

[a]Departamento de Pediatria e Puericultura da Faculdade de Medicina da Universidade Federal do Rio Grande do Sul. Porto Alegre, RS, Brazil. [b]Departamento de Saúde Pública da Universidade Federal do Maranhão. São Luís, MA, Brazil. [c]Departamento de Puericultura e Pediatria da Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo. Ribeirão Preto. São Paulo, SP, Brazil

Abstract

Objective
To determine the trends of infant mortality from 1995 to 1999 according to a geographic area-based measure of maternal education in Porto Alegre, Brazil.

Methods
A registry-based study was carried out and a municipal database created in 1994 was used. All live births (n=119,170) and infant deaths (n=1,934) were considered. Five different geographic areas were defined according to quintiles of the percentage of low maternal educational level (<6 years of schooling): high, medium high, medium, medium low, and low. The chi-square test for trend was used to compare rates between years. Incidence rate ratio was calculated using Poisson regression to identify excess infant mortality in poorer areas compared to higher schooling areas.

Results
The infant mortality rate (IMR) decreased steadily from 18.38 deaths per 1,000 live births in 1995 to 12.21 in 1999 (chi-square for trend p<0.001). Both neonatal and post-neonatal mortality rates decreased although the drop seemed to be steeper for the post-neonatal component. The higher decline was seen in poorer areas.

Conclusion
Inequalities in IMR seem to have decreased due to a steeper reduction in both neonatal and post-neonatal components of infant mortality in lower maternal schooling area.

Resumo

Objetivo
Determinar as tendências da mortalidade infantil de 1995 a 1999, segundo a escolaridade materna, medidas em base geográfica, em Porto Alegre, Brasil.

Métodos
Estudo baseado em dados secundários de um banco de dados municipal, criado em 1994. Todos os nascidos vivos (119.170 nascimentos) e óbitos infantis (1.934 óbitos) foram considerados. Foram definidas cinco diferentes áreas geográficas segundo os quintis de percentagem de escolaridade materna baixa (menos de seis anos de estudo): alta, médio-alta, média, média-baixa e baixa escolaridade. Foi usado o teste do qui-quadrado para tendências de comparação das taxas entre as áreas. Foi calculada a razão de incidências pela regressão de Poisson para identificar excesso

Correspondence to:
Marcelo Zubaran Goldani
Departamento de Pediatria e Puericultura
Faculdade de Medicina (UFRGS)
Avenida Ramiro Barcellos, 2400
90035-003 Porto Alegre, RS, Brazil
E-mail: hegold@uol.com.br

de mortalidade infantil nas áreas mais pobres, em comparação com as mais ricas.
Resultados
A taxa de mortalidade infantil decresceu de 18,38 por 1.000 nascidos vivos em 1995 e para 12,21 em 1999 (qui-quadrado para tendência p<0,001). Ambos os componentes neonatal e pós-neonatal foram reduzidos, embora a queda pareceu ser mais intensa no componente pós-neonatal. A maior redução foi observada nas áreas mais pobres.
Conclusão
Desigualdades na taxa de mortalidade infantil parecem ter sido reduzidas principalmente às custas de uma redução nos componentes de mortalidade neonatal e pós-neonatal em área de mais baixa escolaridade materna.

INTRODUCTION

Despite a steady decrease in infant mortality in Brazil from 52.0/1,000 in 1989 to 36.1/1,000 in 1998,[6] the country has one of the highest levels of socioeconomic inequality in mortality of children under 5-year old.[15] Also, a strong association between low maternal social status and higher infant mortality rates has been well documented.[3,5,11] However, there is scarce information about the trends of social inequalities in infant mortality in the country. One of the reasons for that is the poor quality of data regarding socioeconomic variables in registry sources.

A new municipal database, the SINASC (Sistema de Informação sobre Nascidos Vivos - Live Births Information System), was set up in order to collect systematic information about mothers and anthropometric measurements of newborns in the early 1990s.[10] Information on infant deaths has been obtained by the SIM (Sistema e Informações sobre Mortalidade – Mortality Information System) since the late 1970s.

Nevertheless, the available data has not been much analyzed and its application in defining the scale of inequality in health is hardly explored. The aim of this study was to analyze the trends of infant mortality in Porto Alegre, South Brazil, using information routinely available at the municipal level and a geographic area-based measure of maternal education. The following issues were raised: did infant mortality rate reduce from 1995 to 1999? If so, was the reduction steeper for the post-neonatal or the neonatal component? Were there inequalities in infant mortality? If so, were they evident for both components? Did inequalities show evidence of reduction from 1995 to 1999? Were they still noticeable in 1999?

METHODS

A registry-based study was carried out in the city of Porto Alegre, South Brazil. All live births and deaths data of the same group of children during their first year of life in the period between 1995 and 1999 were col-lected. A total of 119,170 live births and 1,934 infant deaths occurred from 1995 to 1999 in 82 districts of Porto Alegre. The number of deaths was obtained from the SIM, where virtually all deaths in the city are reported.[10] This database provides a systematic collection of death certificates from all registry offices, providing the annual number of deaths from different areas of the city. Death reporting in Porto Alegre follows nationally determined convention based on international norms.

The number of live births and percentage of mothers with educational level under six years of schooling in each urban district were obtained from the SINASC, a database based on birth certificates from all births in the city.[7] Since 1994, this database provides information about hospital deliveries, which are estimated to correspond to 99% of all deliveries in the city. Missing data of maternal educational level was 0.6% of all live-births.

Information about home deliveries was obtained monthly by consulting all registry offices in the city. Under enumeration of births has been estimated in 0.1% of all live-births. Deaths and live-births were analyzed independently as there was no link between the two systems.

Complete information about family addresses in the urban area of Porto Alegre was included in both databases, so the location of each family in each administrative urban area could be found.

It was used a geographic area-based measure of maternal education. Urban districts of the city were divided in five groups according to their percentage of mothers with low educational level (less than six years of schooling). Percentages corresponding to each district were sorted out and a quintile distribution was created. The five district groups were classified as high, medium high, medium, medium low and low based on their level of maternal education. Infant mortality rate (IMR) and its components, neonatal mortality rate (NMR) and post-neonatal mortality rate (PNMR), were determined for each area in the study period.

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Chi-square test for trend was applied to indicate trends in infant mortality rates according to area for each year. The excess of infant mortality rate per area was demonstrated using the incidence rate ratio (IRR) calculated by Poisson regression with 95% confidence interval, contrasting medium low and low with medium high and high areas. Areas were collapsed to increase precision of the estimates.

RESULTS

The largest number of live births and deaths occurred in low and medium low areas of maternal schooling.

The trend remained constant over the five years (Table 1). Neonatal deaths tended to predominate in all areas, although post-neonatal deaths were the most important in low, medium low and medium areas in some years (Table 2).

Infant mortality rate declined steadily from 1995 to 1999. IMR also decreased significantly in low and medium areas. Both neonatal and post-neonatal mortality rates decreased although the drop seemed to be steeper for the post-neonatal component. The low area showed a significant reduction in both neonatal and postneonatal components over the study period. A significant drop in post-neonatal mortality rate was also observed for medium low area. Mortality rates in medium high and high areas showed little variation (Table 2).

There was a significant improvement in the percentage of mothers with less than 6 years of schooling in all areas (Table 3). Comparing 1995 to 1999

Table 1 - Neonatal deaths, post-neonatal deaths and live-births from 1995 to 1999 according to geosocial class in Porto Alegre, Brazil, 1995/1999.

	Low			Low Medium			Medium		
	ND	PND	LB	ND	PND	LB	ND	PND	LB
1995	72	92	7079	51	61	6323	61	39	4931
1996	80	72	6230	81	81	9237	26	31	3064
1997	65	46	5603	75	59	8753	26	30	3535
1998	45	52	5966	90	82	8970	31	23	2988
1999	42	31	5760	72	53	9646	23	14	3117
Total	304	293	30638	369	336	42929	167	137	17635

	High Medium			High			Total		
	ND	PND	LB	ND	PND	LB	ND	PND	LB*
1995	30	16	3263	21	7	2881	235	215	24477
1996	31	15	3305	14	11	2136	232	210	23972
1997	31	11	3351	23	8	2460	220	154	23702
1998	18	20	3380	10	6	1873	194	183	23177
1999	19	16	2603	14	7	2716	170	121	23842
Total	129	78	15902	82	39	12066	1051	883	119170

*Home deliveries were not included: 1995=29; 1996=12; 1997=15; 1998=16; 1999=11.
ND = neonatal deaths;   PND = postneonatal deaths;   LB = live-births.

Table 2 - Neonatal mortality rate, post-neonatal mortality rate and infant mortality rate (per thousand) from 1995 to 1999 according to geosocial class in Porto Alegre, Brazil, 1995/1999.

Year	Low			Low Medium			Medium		
	NMR**	PNMR**	IMR**	NMR	PNMR*	IMR	NMR	PNMR	IMR*
1995	10,17	13,00	23,17	8,07	9,65	17,71	12,37	7,91	20,28
1996	12,84	11,56	24,40	8,77	8,77	17,54	8,49	10,12	18,60
1997	11,60	8,21	19,81	8,57	6,74	15,31	7,36	8,49	15,84
1998	7,54	8,72	16,26	10,03	9,14	19,18	10,37	7,70	18,07
1999	7,29	5,38	12,67	7,46	5,49	12,96	7,38	4,49	11,87
All	9,92	9,56	19,49	8,60	7,83	16,42	9,47	7,77	17,24

Year	High Medium			High			Total		
	NMR	PNMR	IMR	NMR	PNMR	IMR	NMR**	PNMR**	IMR**
1995	9,19	4,90	14,10	7,29	2,43	9,72	9,60	8,78	18,38
1996	9,38	4,54	13,92	6,55	5,15	11,70	9,68	8,76	18,44
1997	9,25	3,28	12,53	9,35	3,25	12,60	9,28	6,50	15,78
1998	5,33	5,92	11,24	5,34	3,20	8,54	8,37	7,90	16,27
1999	7,30	6,15	13,45	5,15	2,58	7,73	7,13	5,08	12,21
All	8,11	4,91	13,02	6,80	3,23	10,03	8,82	7,41	16,23

*P<0.05;   **P<0.01   Chi-square for trend.
NMR = neonatal mortality rate;   PNMR = post-neonatal mortality rate;   IMR = infant mortality rate.

there was a significant decrease in the contribution of low (from 28.9% to 24.2%), medium (from 20.1% to 13.1%), and high areas (from 11.8% to 11.4%) of maternal schooling in the total of live births (p-value for trend <0.001). An increase of live births in medium low (from 25.8% to 40.5%) and medium high (from 13.3% to 10.9%) maternal schooling areas was also evident (p-value for trend <0.001 - percentages not shown in the table).

Table 4 depicts incidence rate ratio estimates for neonatal, post-neonatal and infant mortality, according to a geographic area-based measure of maternal education, contrasting low and medium low areas with medium high and high areas between 1995 and 1999. An estimate for the entire period and a p-value for trend across all quintiles were also calculated. A statistically significant difference between low and high areas was evident for infant, neonatal and post-neonatal mortality when the five years were considered together (Table 4).

IMR and post-neonatal mortality rates tended to increase from high to low areas in all years except for 1999. Neonatal mortality rates increased from high to low areas only in 1996 (Table 4). The excess of infant mortality in low areas compared to high areas dropped from 1.71 (71%) in 1995 to 1.22 (22%) in 1999 probably due to a higher decline of deaths in low areas over the period. However, the difference between high and low areas remained statistically significant until 1998. The differentials between areas were larger in the post-neonatal period and smaller or

even absent in the neonatal period (Table 4).

Inequalities in post-neonatal mortality decreased in the study period. However, inequalities in neonatal mortality seemed to be smaller and had little variation over time. Inequalities in IMR, NMR, and PNMR were not statistically significant at the end of the time series in 1999 (Table 4).

DISCUSSION

Maternal educational level related to persistent social inequalities has been used to discriminate social differences and measure their impact on infant health.[14,17]

In the case of Porto Alegre, the adjusted model, using a geographic area-based measure of maternal education, demonstrated significant disparities in terms of infant mortality among five different areas. There seem to have been a more accentuated decline in infant mortality in the less privileged areas, and a reduction in IMR inequalities, despite overlapping confidence intervals in comparisons between years. Differentials between areas were larger in the post-neonatal period and smaller or absent in the neonatal period, corroborating other studies.[16]

The fact that inequalities in neonatal and post-neonatal mortality were not evident in 1999 might have been due to small sample size. If more births and deaths had occurred, a significant difference between areas might have arisen. The power to detect an

Table 3 - Percentage of mothers with less than sic years of schooling in each quintile per year in Porto Alegre, Brazil.

Year	Low %	Low Medium %	Medium %	High Medium %	High %	Total %
1995	66.5	55.5	45.9	29.8	17.9	48.9
1996	64.7	52.7	38.7	25.8	16.2	47.0
1997	62.0	50.7	39.7	27.2	14.1	44.6
1998	64.3	51.2	38.7	23.9	12.9	45.9
1999	64.1	51.7	37.9	25.5	14.8	45.8

%=P<0.01;   Chi-square for trend.

Table 4 - Incidence rate ratio for neonatal, post-neonatal and infant mortality according to geosocial class and year. Porto Alegre, Brazil, 1995/1999.

Year	Low medium and low value high medium and high	Neonatal	Post-neonatal	Infant
1995	IRR (95% CI)	1.11 (0.80-1.52)	3.05 (1.97-4.73)	1.71 (1.32-2.21)
	P-value for trend (quintiles)	0.526	<0.001	<0.001
1996	IRR (95% CI)	1.26 (0.90-1.75)	2.07 (1.37-3.14)	1.56 (1.20-2.01)
	P-value for trend (quintiles)	0.015	<0.001	<0.001
1997	IRR (95% CI)	1.05 (0.77-1.44)	2.24 (1.37-3.65)	1.36 (1.05-1.76)
	P-value for trend (quintiles)	0.299	0.002	0.005
1998	IRR (95% CI)	1.70 (1.13-2.55)	1.81 (1.19-2.76)	1.75 (1.31-2.35)
	P-value for trend (quintiles)	0.117	0.006	0.002
1999	IRR (95% CI)	1.19 (0.81-1.76)	1.26 (0.80-2.00)	1.22 (0.91-1.64)
	P-value for trend (quintiles)	0.352	0.185	0.117
All	IRR (95% CI)	1.21 (1.04-1.42)	2.04 (1.68-2.49)	1.51 (1.34-1.70)
	P-value for trend (quintiles)	0.004	<0.001	<0.001

IRR = Incidence rate ratio

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excess of 50% in mortality in low and medium low areas (exposed) in relation to medium high and high areas (unexposed) was 86.1% in 1999. However, the power decreased to 64.1% for a 40% excess risk and to 34.7% for a 30% excess risk in infant mortality.

Inequalities in neonatal mortality were only observed in 1996. This is less likely to be explained by random variability but this possibility could not be entirely ruled out.

There are some difficulties in using geographic area-based measures as a parameter for urban social inequality. There are demographic similarities between district borders. Also, large geographic areas may have low demographic homogeneity whereas geographic areas with large random variability of events can make it difficult to identify districts at risk.[1]

A significant decrease in the percentage of live births in districts with high prevalence of low maternal education as a total of live births was observed. This may be interpreted as either a drop in births of low maternal schooling mothers or an improvement of social conditions, or both. In fact, levels of illiteracy in Brazil declined from 17.0% in 1995 to 15.1% in 1999[18] and a decrease in the percentage of low schooling mothers among all births has been observed in the city of Pelotas.[2]

Three main factors can explain this steady decline in IMR, mainly in its post-neonatal component. First, the rise of living standards, especially the increase of maternal educational, and improvements in environmental conditions can partially explain the trends observed in the study.[11-13] These changes could have positively influenced a sustained improvement of living standards and a more accelerated reduction in neo and post-neonatal mortality of the two less privileged groups from 1996 onwards, contributing to decrease social inequalities in IMR.

The second factor could be a positive impact on neonatal mortality rates of synthetic surfactant therapy for respiratory distress syndrome.[4] Its use was introduced in public hospitals in Porto Alegre in the early 1990s. Since the speed of decline of neonatal mortality seemed to be similar in all areas, it appears that access to perinatal and neonatal care is universal in the city.

Thirdly, the mild decline in infant mortality in more privileged areas might also be accounted for by their lower infant mortality rate, which would have reached the limits of local health technology. Similarly, further improvements in environmental conditions and maternal educational level may have had a smaller impact in better-off groups.

There could be another possible explanation. Live births of those who died just after delivery could have been underreported or misclassified as stillbirths. This possible bias could have occurred mainly in less privileged groups and in newborns weighing less than 1500 g, overestimating the decrease in neonatal mortality in these groups.[8] However, comparison between infant mortality coefficients from official database and from other sources did not reveal significant differences, making this hypothesis unlikely.[9]

In conclusion, the findings revealed a positive trend towards a reduction in infant mortality. The reduction seemed to have been greater for the post-neonatal component. The reduction of infant mortality rate seemed to be steeper in less privileged areas, especially in the post-neonatal period, despite the higher prevalence of low maternal educational. Differentials between areas were larger in the post-neonatal period and smaller or absent in the neonatal period. Although the small number of deaths in some areas made a more definite conclusion difficult, it seems there is a decrease of IMR inequalities in different geographic areas of Porto Alegre.

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