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Increased survival among lower-birthweight children in Southern Brazil

ABSTRACT

OBJECTIVE: To analyze factors associated with survival in the first year of life.

METHODS: A historical cohort study was carried out using data from live birth and mortality information systems, including 90,153 live birth records and 1,053 records of death before age one year in hospitals in the cities of Florianópolis and São José, Southern Brazil, between 1999 and 2006. Survival curves were estimated (Kaplan-Meier) for birthweight categories, date of birth (four-year periods), and type of maternity. Proportional hazard ratios for mortality were calculated using Cox regression.

RESULTS: Survival (98.8%) did not change among all birthweight categories, but increased among babies born weighing under 2,000 g (77.7% to 81.2%, p=0.029), between 1999-2002 and 2003-2006. There was an increase in the proportion of babies under 2,000 g in the second period. Type of hospital was significantly associated with probability of survival.

CONCLUSIONS: Probability of survival is higher among babies born in private hospitals and in the teaching hospital in all birthweight categories combined and for babies born weighing under 2,000 g. Survival among the latter increased in the most recent period. However, the infant mortality rate did not change between the two periods given the increase in the prevalence of children with ligther birth weight.

DESCRIPTORS: Infant Mortality. Neonatal Mortality (Public Health). Birth Weight. Survival Analysis. Cohort Studies.

INTRODUCTION

The rapid reduction in post-neonatal mortality in the last decades has resulted in a relative increase in neonatal mortality in developed and industrialized countries,[22] as well as in Brazil.[21] In developing countries, technological advances and the organization of health care models have helped increase the probability of survival of extreme preterm and very low birthweight babies. This increase was more pronounced during the first half of the 1990's.[11]

Saigal & Doyle[19] reported an increment in the survival of extremely low birthweight (ELBW) babies (birthweight < 1,000 g) from 25% in 1979/1980 to 73% in 1997 in a region of Australia. The authors also described the differences in survival between ELBW babies born in general and regional reference hospitals in a number of developed countries. In these countries, efforts are focused on reducing sequelae among risk newborns and on extending the limit of viability of preterm babies.[19]

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Post-neonatal mortality is amenable to traditional public health measures; reducing neonatal mortality, on the other hand, depends on improvements in antenatal, delivery, and high-complexity neonatal care, and requires large investments in human and technological resources.[22] Presence of an organized and hierarchical health care system, as well as the characteristics of the site of care, can influence the probability of survival of high-risk neonates.[20]

The establishment of health information systems has allowed for better evaluation of vital statistics and organization of health care. The Live Birth Information System (SINASC) was created in Brazil in 1990. This was followed by the digitization of the country's Mortality Information System (SIM), that had been operating since 1976. Of the epidemiological and demographic variables included in SINASC, gestational age is the one showing the strongest positive association with infant survival. In spite of the excellent coverage and completeness of this variable, data quality is not satisfactory.[17,18] On the other hand, birthweight, which is regarded as a proxy for gestational age, also has excellent coverage and completeness, and such data are reliable and can be easily obtained. For this reason, this variable is frequently used in surveys, and is regarded as the most powerful predictor of morbidity and mortality in the first year of life.[10]

Knowing the survival rates of newborns in different birthweight groups, the impact of birthweight on post-neonatal morbidity, and the differences in survival according to hospital of birth in each region will help organize the regionalization of perinatal care.

The aim of the present study was to analyze survival in the first year of life according to period of birth, birthweight, and type of maternity ward.

METHODS

We carried out a historical cohort study based on secondary data from SINASC and SIM. We studied the survival in the first year of life of babies born alive in hospitals in the cities of Florianópolis and São José, Southern Brazil, between January 1, 1999 and December 31, 2006, weighing at least 500 g, and who were registered as live births in SINASC. SINASC data from prior to 1999 are in a different format and have a low rate of completion, justifying our choice of study period.

Florianópolis, the capital of the state of Santa Catarina, Southern Brazil, had an estimated population of 396,723 inhabitants in 2007.[a] In addition to a political and administrative center, this city is also strong in the tertiary sector, especially in commerce, services, and tourism. It is also a regional reference in health care. São José, a city adjacent to the capital, with a population of 196,887 in 2007,[a] is characterized by commercial and industrial activities. These two contiguous cities constitute the greatest urban area in the state of Santa Catarina, and concentrate almost all deliveries taken place in this region.

At the start of the studied period, there were three public and four private maternity wards in these two cities. Public maternities were as follows: one within a general hospital located in the city of São José (Hospital A – HA) and one maternity ward in Florianópolis (Hospital B – HB), both of which are run by the State Department of Health and which admit preferentially patients enrolled through the National Health Care System (SUS); and a teaching hospital (HTeach), which admitted SUS patients exclusively. Given the small number of births, the four private clinics were grouped into the "private hospital" category (HPriv). All three public hospitals as well as one of the private facilities included neonatal care units of similar complexity.[14]

In HB, HTeach, and HA, 15.0%, 14.4%, and 12.4% of pregnant women had 12 or more years of schooling, respectively. In HPriv, this proportion was 56.7%.[b]

Live births in each year were treated as belonging to a cohort that was followed-up until the date of their first birthday (according to presence in or absence from SIM). Each of the children in the yearly cohorts had two possible outcomes: survival (status=0) or death in first year of life (status=1).

We excluded any live births with birthweight under 500 g, following the trend in other studies of perinatal epidemiology,[2] as well as babies whose records did not include birthweight, babies born outside hospitals, and babies whose place of birth was not recorded. Babies that died in one of the studied hospitals but who were born in outside Florianopolis/São José were also excluded from the study.

In order to estimate survival curves according to birthweight categories, we measured the outcome in terms of time to death (in days) and the status of each individual (death or censured, the status given to survivors at the end of the observation period).

All analyses were stratified according to birthweight category, period, and maternity of birth.

[a] Instituto Brasileiro de Geografia e Estatística (IBGE). Banco de dados – cidades. [cited 2009 Jun 16]. Available from: http://www.ibge.gov.br/cidadesat/
[b] Secretaria de Estado da Saúde de Santa Catarina. Informações em Saúde – Indicadores de Saúde. [cited 2009 May 13] Available from: http://www.saude.sc.gov.br./

Birthweight was categorized into 500 g intervals (500 to 999 g, 1,000 to 1,499 g, 1,500 to 1,999 g, 2,000 to 2,499 g, and 2,500 g or more). Births were divided into two four-year periods (1999 to 2002 and 2003 to 2006) because this division led to greater consistency, especially among lower-frequency birthweight categories (under 1,000 g). The maternities investigated were HA, HTeach, HB, and HPriv.

Number of births, exposure variables, and variables used for linking the different databases were obtained from SINASC, whereas data pertaining to mortality were obtained from SIM for the period from 1999 to 2007.[c]

To cross-reference the SINASC and SIM data, we used the database linking software RecLink II, which is based on the probabilistic registry linking technique.[5] Pairing the two databases involved a process of standardization, blocking, and record pairing by probabilistic linking of homologous fields in the two registries.

Variables used for the six successive blocking and pairing steps included: birth certificate number, year of birth, mother's modified first name (soundex code), mother's modified last name, sex and year of birth, mother's name, date of birth, birthweight, and mother's age. Other SINASC and SIM variables were used as accessories to identify true paired records.

Given the possibility of a child born in one of the studied maternities having died in a different city, births included in the SINASC database for the studied maternities were cross-referenced with the SIM database for the whole state of Santa Catarina.

We obtained the expected number of deaths among the population of the Florianópolis region (Florianópolis, São José, Palhoça, and Biguaçu) from the SIM registry. After obtaining the final number of detected deaths, we calculated the differential loss during pairing as the difference or proportion between expected and detected deaths.

We calculated the number and proportions of births and deaths during the first year of life according to birthweight category, period of birth, and type of maternity ward. The same calculations were performed for births and deaths of babies born weighing under 2,000 g. Survival functions (95% confidence intervals) were calculated using the Kaplan-Meier method,[7] stratified according to weight category, four-year period, and type of maternity. To test the difference between curves for each category, we used the Log-Rank test.[7] Crude and adjusted analyses of the proportional hazards ratios were carried out using Cox regression, taking into account weight category, period of birth, and type of maternity. Calculations were done for all births, for babies born weighing under 2,000 g, for babies who died in the first year, and for babies who died in the first 60 days of life. Data were analyzed using the Stata 9 statistical package.

We abided by all norms stated in Resolution 196/96 of the National Ethics Committee (Comissão Nacional de Ética em Pesquisa – CONEP) pertaining to the confidentiality of data.

RESULTS

Between 1999 and 2006, SINASC recorded 90,350 births in Florianópolis and São José. We excluded from the analysis 26 records with birthweight under 500 g, 51 that lacked birthweight information, 90 records pertaining to home births, 14 to births that took place on the way to the hospital, and 16 that lacked information on place of birth. We analyzed the remaining 90,153 birth records (99.8%).

The SIM database for the state of Santa Catarina contained 10,019 records of deaths of children under one year of age in the period. Pairing this data to SINASC data yielded 1,053 records of deaths taken place in the state of Santa Catarina among babies delivered in hospitals in Florianópolis and São José.

The differential loss of SIM records linked to SINASC records was 15.0%, ranging from 18.7% in the first four-year period (1999-2002) to 10.1% in the second (2003-2006).

Survival decreased significantly in lower birthweight categories. There was a slight reduction in the number of births, though without survival difference, between the two periods. Babies born in private hospitals had significantly higher survival. When only babies born weighing under 2,000 g were analyzed, there was a proportional increase in lower-birthweight babies a significant increase in survival in 2003-2006 when compared to 1999-2002. Greater survival was observed among babies born in private hospitals (Table 1).

Survival functions according to birthweight categories, periods and types of maternity wards among lower-birthweight babies (< 2,000 g) are presented in Figure 1.

Crude analysis of the hazards ratio of mortality (Cox regression) showed a significant increase in risk the lower the birthweight category. Risk was constant in the two periods, and there was a significant difference according to type of hospital. In crude analysis, being born in the teaching or general hospitals emerged as a

[c] Secretaria de Estado de Saúde de Santa Catarina. Downloads. Base de Dados Sinasc e SIM. [cited 2008 Oct 16] Available from: http://www.saude.sc.gov.br/

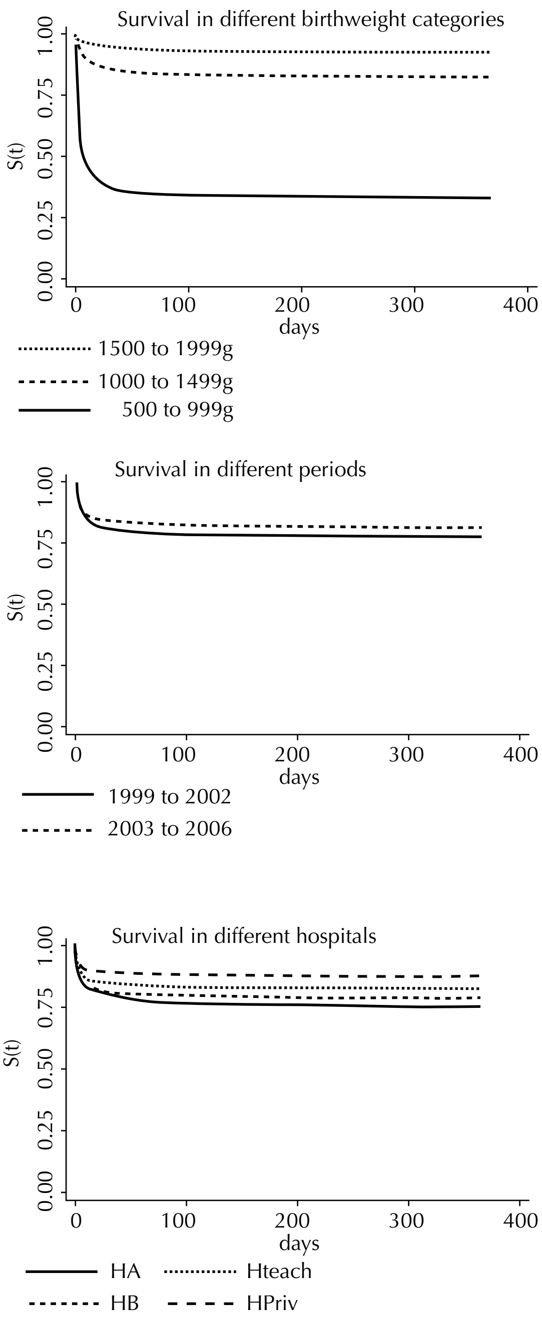

Figure 1. Probability of Kaplan-Meier survival in the first year of life among children born weighing under 2,000 g, according to selected variables. Cities of Florianópolis and São José, Southern Brazil, 1999-2006.

risk factor for mortality, whereas being born in a private hospital was a protective factor. Adjusted analysis did not alter the effects of birthweight and period. After adjustment, being born either in the teaching or in private hospitals was found to be a protective factor against mortality in the first year of life (Table 2).

Crude analysis of lower-birthweight babies showed a significant reduction in survival as birthweight category decreased and a reduction in the risk ratio in 2003-2006 when compared to 1999-2002. Being born in the teaching or in private hospitals was found to be protective against death in the first year. Adjusted analysis did not alter the pattern of increased risk with decreasing weight, and protective effects of being born in the second period or in any hospital other than HA (Table 3).

Frequency, survival function, and Cox regression analysis of weight (total and under 2,000 g), period, and hospital of birth were repeated for death and censured at 60 days. These results were virtually identical to those obtained for all lower-birthweight babies and are therefore not presented.

There was a significant difference between the two periods (log-rank, p=0.025) in the manner in which the survival curve decelerates in the 500 to 999 g group. More deaths were observed during the first day of life among babies born in 2003-2006, and this trend is reversed for subsequent periods. On the second and seventh days, the probabilities of the two curves are virtually superimposed, followed by an increase in this difference. After 28 days (neonatal period), the difference in survival in the two periods becomes evident (Figure 2).

DISCUSSION

The survival rate of 98.8% in the first year of life is equivalent to an infant mortality coefficient of 12‰ in Florianópolis and São José between 1999 and 2006, which can be considered as low when compared to national and international standards.[10]

In the present study, we did not observe a significant decrease in infant survival between the two four-year periods; however, survival increased among babies born weighing under 2,000 g in these periods.

The international literature describes a decrease in mortality among babies with lower birthweight and gestational age.[22] This reduction was found to be significant in the first half of the 1990's, becoming stabilized after that.[11] The Brazilian literature confirms this increase in survival among lower-birthweight groups, but not the later stabilization.[6]

Greater survival among lower-birthweight groups was not sufficient to significantly increase infant survival, partly due to the increase in prevalence of low-birthweight babies. Similar phenomena have also been described in the United States[19] and in other Brazilian regions, such as Pelotas, also in Southern Brazil.[21]

Survival among lower-birthweight groups is lower in the present study than in the United States between 1990 and 2002 (85% among children weighing less

Table 1. Number of births and deaths and probability of survival according to birthweight category, period of birth, and hospital. Cities of Florianópolis and São José, Southern Brazil, 1999-2006.

Variable	Births	Deaths	Survival		p-value
	n	n	S (t)	95%CI	
Total births	90,153	1,053	98.8	98.8;99.9	
Birthweight category (g)					
2,500 or more	82,678	389	99.5	99.5;99.6	
2,000 to 2,499	4,732	104	97.8	97.3;98.2	
1,500 to 1,999	1,547	126	91.9	90.4;93.1	< 0.001
1,000 to 1,499	751	135	82.0	79.1;84.6	
500 to 999	445	299	32.8	28.5;37.2	
Period					
1999 to 2002	45,139	535	98.8	98.7;98.9	0.634
2003 to 2006	45,014	518	98.8	98.8;98.9	
Hospital					
HA	30,011	367	98.8	98.7;98.9	
HTeach	12,307	186	98.5	98.3;98.7	< 0.001
HB	32,816	439	98.7	98.5;98.8	
HPriv	15,019	61	99.6	99.5;99.7	
Babies < 2000g	2,743	560	79.6	78.0;81.1	
Period					
1999 to 2002	1,274	284	77.7	75.3;79.9	0.029
2003 to 2006	1,469	276	81.2	79.1;83.1	
Hospital					
HA	810	198	75.6	72.5;78.4	
HTeach	672	115	82.9	79.8;85.5	< 0.001
HB	1,014	216	78.7	76.1;81.1	
HPriv	247	31	87.5	82.6;91.0	

than 1,500 g)[11] and in Australia in 1997 (73% among babies weighing less than 1,000 g).[19] Both these surveys were conducted within neonatal intensive care units. Survival is expected to be higher in populations of such units, followed by hospital-based studies, and lowest in population-based studies.[16,20]

A comparison of the present hospital-based study with Brazilian cohorts of subjects born after 1999 shows that the 63.7% survival found among babies with birthweight under 1,500 g in Florianópolis and São José is greater than that found in maternities in Fortaleza, Northeastern Brazil (49%)[8] and similar to that reported in a population-based study from Pelotas (62%).[4] The 91.1% survival estimated for babies born weighing under 2,500 g in the present study (6,811 survivals in 7,457 under-2,500 g births) was similar to that observed in Goiânia, Center-Western Brazil (87.5%),[12] and higher than that found in Campos, Southeastern Brazil (75.2%).[15]

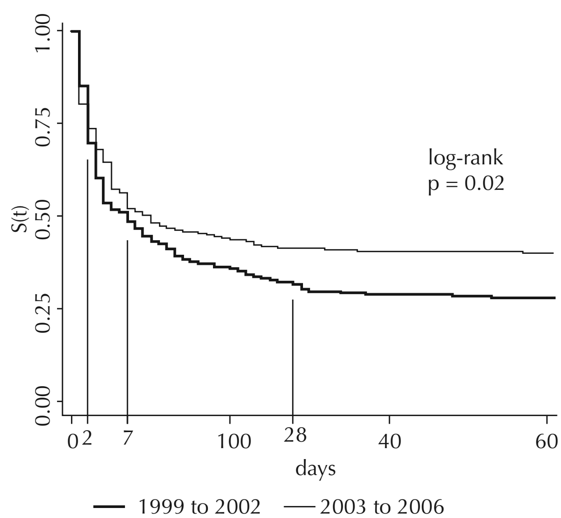

Figure 2. Probability of survival in the first 60 day of life among children born weighing 500-999 g. Cities of Florianópolis and São José, Southern Brazil, 1999-2006.

Table 2. Crude and adjusted Cox regression analysis and proportional hazards ratio for deaths of children under one year of age, according to selected variables. Cities of Florianópolis and São José, Southern Brazil, 1999-2006.

Variable	Crude analysis			Adjusted analysis		
	PHR	95%CI	p	PHRa	95%CI	p
Birthweight category (g)						
2.500 or more	1			1		
2.000 to 2.499	4.7	3.8;5.8	<0.001	4.6	3.7;5.8	< 0.001
1.500 to 1.999	18.1	14.8;22.1		17.8	14.6;21.8	
1.000 to 1.499	42.2	34.7;51.3		41.3	33.9;50.3	
500 to 999	248.8	213.6;289.9		241.9	207.3;282.4	
Period						
1999 to 2002	1		0.634	1		0.058
2003 to 2006	1.0	0.9;1.1		0.9	0.8;1	
Hospital						
HA	1			1		
HTeach	1.2	1;1.5	< 0.001	0.8	0.7.0.9	< 0.001
HB	1.1	0.9;1.3		1.0	0.8;1.1	
HPriv	0.3	0.3;0.4		0.4	0.3;0.6	

PHR: proportional hazards ratio, crude; PHRa: proportional hazards ratio adjusted for weight category and period and hospital of birth.

Survival and hazards ratio among the whole sample remained unchanged across the entire study period, in both crude and adjusted analysis. For lower birthweight categories (< 2,000 g), these parameters increased in the second period, in both in crude and adjusted analysis. These findings are in agreement with the national and international literature.[1,6,11,19,21]

In crude analysis, being born in a private hospital was shown to be a protective factor, whereas being born in a teaching hospital was a risk factor. The lower survival rate found in the teaching hospital in crude analysis was related to this hospital's propensity to provide care to risk populations, especially low-birthweight babies. After adjustment for birthweight, the direction of the association for this hospital was inverted, being born in the teaching hospital becoming a protective factor.

Differences in survival between hospitals may be a consequence of the quality of care provided or of the population under study.[3,8] The equipment in the three public facilities studied is of similar complexity, quantity, and quality, and the three hospitals tend to populations with similar characteristics. Therefore,

Table 3. Crude and adjusted Cox regression analysis and proportional hazards ratio for deaths of children under one year of age with birthweight < 2,000 g, according to selected variables. Cities of Florianópolis and São José, Southern Brazil, 1999-2006.

Variable	Crude analysis			Adjusted analysis		
	PHR	95%CI	p	PHRa	95%CI	p
Birthweight category (g)						
1,500 to 1,999	1		< 0.001	1		< 0.001
1,000 to 1,499	2.3	1.8;3.0		2.4	1.8;3.0	
500 to 999	13.0	10.5;16.1		13.0	10.6;16.1	
Period						
1999 to 2002	1		0.031	1		0.03
2003 to 2006	0.8	0.7;1		0.8	0.7;1	
Hospital						
HA	1			1		
HTeach	0.7	0.5;0.9	< 0.001	0.7	0.5;0.8	0.007
HB	0.9	0.7;1.1		0.8	0.7;0.97	
HPriv	0.5	0.3;0.7		0.6	0.4;0.9	

PHR: proportional hazards ratio, crude; PHRa: proportional hazards ratio adjusted for weight category and period and hospital of birth.

differences in survival seem not to be related to these characteristics. The literature describes a difference in survival between hospitals (“hospital effect”) for similar birthweight and gestational age groups, even after adjustment for conditions upon admission.[1,2,20]

Survival curves in the first year of life are not easily comparable, given their relative scarcity in the literature, the different bases used (populational, hospital, and neonatal intensive care units), and the use of different exclusion criteria (with or without malformations, for instance), weight categories, and times to the outcome (neonatal, hospital discharge, 90 or 120 days post-delivery, or first year of life).[9]

The survival function curves of the different weight groups indicate a higher number of deaths during the first days of life. Moreover, these curves reveal differences in terms of probability of survival between different groups throughout the first year of life, each curve showing a different inflection point. The comparison of curves for babies under 1,000 g, in two periods, at seven and 28 days post-delivery (early neonatal and neonatal periods, respectively) partially reflect the differences in survival among these groups. One can question whether the classical division of observation periods is the most adequate, given that preterm birth and other pregnancy and delivery-related causes are the major determinants of infant mortality.

The scientific literature contains an abundance of evaluations of infant survival according to weight group or gestational age; however, few studies analyze survival using survival or actuarial curves. Curve-based mortality/survival seems to provide a more thorough evaluation of the data, capable of outlining a scenario for intervention planning.[9,13,22]

One limitation of the present study is the use of birthweight as a proxy for gestational age. This choice was due to the better quality of birthweight data in SINASC when compared to gestational age data.[10] Another limitation is the fact that database linking resulted in lower loss of deaths in the second four-year period, probably due to the progressive increase in data completeness and quality. Differences in survival between the two periods may thus be greater than that detected.

We conclude that there was an improvement in survival of babies born weighing under 2,000 g during the studied period, in addition to a difference in survival according to birthweight. The effect of improved survival among these birthweight categories seems not to have had an impact on infant mortality due to the increased prevalence of low-birthweight babies. Hospital of birth has a significant effect on probability of survival. Therefore, it will be important to identify the best and worst practices in an attempt to increase survival and improve health care indicators.

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