Life-threatening conditions at birth: an analysis of causes of death and survival estimate for under-five children in live birth cohorts

Ameaça à vida ao nascer: uma análise das causas de morte e estimativa de sobrevida de menores de cinco anos em coortes de nascidos vivos

Amenaza para la vida al nacer: un análisis de las causas de muerte y estimación de supervivencia de menores de cinco años en cohortes de nacidos vivos

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Abstract

Despite the reduction in under-five mortality, the causes are still mostly avoidable, and survival may be compromised by life-threatening conditions at birth. The study estimated the burden of life-threatening conditions at birth, neonatal near miss, and mortality, with an emphasis on avoidable causes, as well as under-five survival in live birth cohorts. This was a retrospective cohort study of live birth in the city of Rio de Janeiro, Brazil (2012-2016). The databases from the Brazilian Information System on Live Births and the Brazilian Mortality Information System were linked. Pragmatic criteria were used to define life-threatening conditions and near miss. Deaths were classified according to the Brazilian list of causes of avoidable deaths. Morbidity and mortality and survival indicators were estimated (Kaplan-Meier). Of the 425,505 live birth, 2.2% presented life-threatening conditions at birth. The under-five, infant and neonatal mortality rates were 0.01, 0.06, and 14.97 per 1,000 person-days, respectively. Avoidable, unclearly avoidable, and ill-defined causes accounted respectively for 61%, 35%, and 4% of the deaths. The risk of death from avoidable causes attributable to life-threatening conditions at birth was 97.6%. Survival was lower in newborns with life-threatening conditions compared to those without life-threatening conditions. The pragmatic criteria for life-threatening conditions determined the profile of proportional mortality by causes of death according to the three groups of causes in the Brazilian list of causes of avoidable deaths. Life-threatening conditions at birth increases the risk of morbidity and mortality in under-five children and raises the discussion on vulnerability and the need for care for these children and social support for their families.

Healthcare Near Miss; Child Mortality; Survival Analysis; Cause of Death

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Introduction

The targets of the *Sustainable Development Goals* (SDGs) include the reduction of mortality in under-five children to less than 25 per 1,000 live births, reduction of neonatal mortality to less than 12 deaths per 1,000 live births, and elimination of avoidable deaths in newborns and under-five children, from 2016 to 2030 [1,2]. Before the deadline, Brazil reached the target of the *Millennium Development Goals* (MDGs) to reduce mortality in under-five children by two-thirds by 2015 [3].

The same pattern was true in the city of Rio de Janeiro, Brazil (Departamento de Informática do Sistema Único de Saúde – DATASUS. Informações de saúde. Estatísticas vitais. http://www2.datasus. gov.br/DATASUS/index.php?area=0205, accessed on 09/Jul/2018), (Secretaria Municipal de Saúde do Rio de Janeiro. Sistemas de informação em saúde. http://tabnet.rio.rj.gov.br/, accessed on 30/Jun/2018). Although the under-five and neonatal mortality rates in the city of Rio de Janeiro were already below the targeted levels by 2016 (14.9 and 8.3 per thousand live births, respectively), the causes of death are still mostly avoidable (http://tabnet.rio.rj.gov.br/, accessed on 30/Jun/2018). The fact that other Latin American countries like Cuba and Costa Rica had under-five mortality rates in 2016 of 5.3 and 10.6 per thousand live births, respectively, reinforces the potential for further reduction of under-five mortality in Brazil [1,2].

Various Brazilian studies have shown that the principal causes of under-five death are avoidable by health innterventions [4,5,6,7,8]. In the Pelotas birth cohorts (Rio Grande do Sul State), the persistence of infant mortality rates from avoidable causes was attributed to maternal socioeconomic and biological disadvantages, associated with the increase in preterm births [6].

Considering that prematurity and asphyxia at birth are complications heavily associated with neonatal deaths [7,9,10], conditions at birth based on gestational age, birthweight, and five-minute Apgar score have been shown as markers of life-threatening conditions at birth. These markers, called pragmatic criteria, singly [11,12] or jointly comprise the clinical, laboratory, and management criteria [13,14,15], various definitions of near miss, or severe neonatal morbidity: newborns with life-threatening conditions that survived the neonatal period. The occurrence of life-threatening conditions at birth and cases of neonatal near miss present increased risk of under-five death when compared to children born without life-threatening conditions. There are still few studies that have estimated the probability of death or survival in childhood among newborns with life-threatening conditions, or particularly among cases of neonatal near miss [16].

This study estimated the burden of life-threatening conditions at birth, neonatal near miss, and mortality, with an emphasis on avoidable causes, as well as under-five survival, in live birth cohorts in the city of Rio de Janeiro, from 2012 to 2016.

Methods

This was a retrospective cohort study of singleton liveborn children living in the city of Rio de Janeiro from 2012 to 2016 (n = 426,867). We opted not to include newborns from multiple pregnancies since they present differentiated morbidity and mortality risks. The study population's maximum follow-up period was five incomplete years after birth (starting on January 1, 2012, and ending on December 31, 2016). Five-year follow-up was only possible for live births from the 2012 cohort.

The data sources were the Brazilian Information System on Live Birth (SINASC) and the Brazilian Mortality Information System (SIM) of the Rio de Janeiro Municipal Health Department. The birth and death databases were initially linked by the number on the Certificate of Live Birth in the two databases, and in case of missing information in this field, probabilistic linkage was used. The proportion of linked death and birth records was 85.7%.

Newborns were classified as presenting life-threatening conditions if they met at least one of the pragmatic criteria for neonatal near miss [14]: birthweight less than 1,500g, gestational age less than 32 weeks, and five-minute Apgar less than seven. Newborns with life-threatening conditions that survived the neonatal period (0 to 27 days) were classified as cases of neonatal near miss. The analysis excluded 0.3% of records with inconsistencies between birthweight and gestational age.

Deaths from zero to five incomplete years were classified according to the brazilian list of avoidable causes, consisting of three groups of causes of death: avoidable, unclearly avoidable, and ill-defined. The group of avoidable causes consists of seven subcategories according to the type of intervention [17].

We calculated the proportion of liveborn infants with life-threatening conditions at birth. For the 2012 cohort, the disease burden of newborns with life-threatening conditions and survivors of the neonatal period was measured by the neonatal near miss rate (NNMR: number of neonatal near miss cases per 1,000 live births). We calculated the ratio between deaths and cases of neonatal near miss.

The risks of death (probability of death), both total and according to life-threatening conditions at birth, were calculated by the actuarial method, adjusted for losses [18], by age groups, per thousand: neonatal mortality (quotient between deaths from 0 to 27 days and number of live births, or life table root) and post-neonatal mortality (quotient between deaths from 28 to 364 days and the number of live births), with survivors of the previous age bracket who were one, two, three, and four complete years old. The relative risk of death according to life-threatening conditions at birth was calculated by age.

We calculated the infant mortality rate (IMR), neonatal mortality rate (NMR), and under-five mortality rate (UFMR) per 1,000 live births only for the 2012 birth cohort (which presented five incomplete years of follow-up). Considering all the birth cohorts as a single dynamic cohort with different follow-up times from 2012 to 2016, we calculated the NMR, IMR, and UFMR per 100,000 person-days. The under-five mortality rate was also calculated according to the Brazilian list of avoidable causas (three groups), both total and comparing live births with and without life-threatening conditions. The principal specific causes of death were described (groupings from the International Classification of Diseases – 10th revision – ICD-10), by groups and subgroups of Brazilian list of avoidable causas. The attributable risk (AR) or etiological fraction was calculated according to life-threatening conditions for each group of avoidable causes, and the proportional attributable fraction (%AR) from life-threatening conditions, considering the under-five mortality rate per 100,000 person-days. Considering that the data were obtained from health information systems with excellent coverage in the state of Rio de Janeiro (DATASUS. Consolidação do Sistema de Informações sobre Nascidos Vivos – 2011. http://tabnet.datasus.gov.br/cgi/sinasc/Consolida_Sinasc_2011, accessed on 20/Mar/2017), (DATASUS. Consolidação do Sistema de Informações sobre Mortalidade – 2011. http://tabnet.datasus.gov.br/cgi/sim/Consolida_Sim_2011.pdf, accessed on 20/Mar/2017) and thus representative of the population, we can infer that the %AR can be interpreted as the population %AR [19].

The Kaplan-Meier method was used for analysis of the survival curves [18] of liveborn infants with and without life-threatening conditions. Log-rank statistic was used to test the difference between the survival curves.

The study is an integral part of the research project *Neonatal Near Miss, Deaths, and Under-Five Survival: Analysis of Live Birth Cohorts in the City of Rio de Janeiro*, approved by the Institutional Review Boards of the Institute of Studies in Collective Health, Federal University of Rio de Janeiro (protocol n. 2.105.885), and the Rio de Janeiro Municipal Health Department (protocol n. 2.218.098).

Results

The birth cohorts totaled 425,505 live births. We classified 419,357 live births according to with versus without lifethreatening conditions at birth, of which 2.2% presented at least one pragmatic criterion of risk of death, and 3,820 evolved to under-five death, corresponding to a rate of 0.01 per 1,000 person-days (Table 1). The under-five mortality rate, infant mortality rate, neonatal mortality rate, and neonatal near miss rate for the 2012 birth cohort were, respectively, 12.0, 10.6, 6.7, and 20.1 per 1,000 live births. The ratio between near miss and neonatal deaths was 3:1.

Table 2 shows the risks of death (probabilities of death adjusted for losses to follow-up) according to life-threatening condition per 1,000 survivors of the previous age bracket. Newborns with life-threatening conditions presented higher risk of death than those without life-threatening conditions at all ages, especially in the neonatal period, and a reduction of 18.6% in the probability of survival up to five incomplete years. Independently of history of life-threatening conditions, the risk of death decreased with age (Table 2).

Table 1

Health indicators in live births. City of Rio de Janeiro, Brazil, 2012-2016.

Morbidity and mortality indicators	Live birth cohorts	
	2012 *	2012-2016 **
Number of live births	82,639	419,357
Neonatal mortality rate	6.7	14.97
Infant mortality rate	10.6	0.06
Under-five mortality rate	12.0	0.01
Proportion of live births with life-threatening conditions	2.3	2.2
Neonatal near miss rate	20.1	-
Ratio, neonatal near miss cases/neonatal deaths	2.9	-

Sources: Brazilian Mortality Information System and Brazilian Information System on Live Births, Rio de Janeiro Municipal Health Department.
* Rates per 1,000 live births;
** Rates per 1,000 person-days.

Table 2

Risks of death per thousand survivors * according to life-threatening conditions, by age. City of Rio Janeiro, Brazil, 2012-2016.

Age	Life-threatening condition						Relative risk
	Yes (live births = 9,150)			No (live births ** = 410,270)			
	Survivors	Deaths	Risk of death	Survivors	Deaths	Risk of death	
0-6 days	9,150	982	107.5	410.207	401	1.0	107.5
7-27 days	8,137	334	144.3	408.553	346	1.8	80.2
28-364 days	7,724	336	184.9	404.008	1093	4.8	38.5
1 year	6,105	32	189.8	330.834	176	5.4	35.1
2 years	4,572	7	191.3	245.937	71	5.7	33.6
3 years	3,087	3	192.3	161.855	31	6.0	32.1
4 years	1,581	1	193.3	80.387	7	6.2	31.2

Sources: Brazilian Mortality Information System and Brazilian Information System on Live Births, Rio de Janeiro Municipal Health Department.
* Probability of death calculated by the life table actuarial method, adjusted for losses;
** Live births (life table root number).

Among deaths of under-five children, 61%, 34%, and 4% were due to avoidable causes, unclearly avoidable causes, and ill-defined causes, respectively. The pattern in the distribution of causes in the three major groups of Brazilian list of avoidable causas is repeated in the presence or absence of life-threatening conditions at birth, although the percentage values for the unclearly avoidable and ill-defined groups were higher in newborns without life-threatening conditions, while avoidable causes showed a higher percentage in the group with life-threatening conditions (Table 3). Considering only the subgroups of avoidable causes, there was a predominance of causes that were reducible by adequate prenatal care among newborns with life-threatening conditions and reducible by adequate diagnosis and treatment among newborns without life-threatening conditions.

The principal specific causes of death in the group of causes reducible by adequate prenatal care were maternal hypertensive disorders (P00.0 ICD-10) for children with life-threatening conditions at birth and maternal renal and urinary tract diseases (ICD-10 P00.1) for those without life-threatening conditions (24.9% live births with and 18.4% without live-threatening conditions) (Table 3).

In the groups of causes reducible by adequate intrapartum care, 31.5% of the deaths of children without life-threatening conditions were due to neonatal meconium aspiration (P24.0 ICD-10), fol-

lowed by neonatal aspiration, unspecified (P24.9), while two causes tied for third, intrauterine hypoxia (P20.9 ICD-10: 11%) and birth asphyxia (P21.9 ICD-10: 11%). The life-threatening conditions at birth were predominantly birth asphyxia (P21.9 ICD-10: 19.4%) and neonatal meconium aspiration (P24.0 ICD-10: 18.8%) (Table 3).

Causes reducible by immunoprevention appeared less frequently among the subgroups of avoidable causes, and the specific causes were pertussis and tuberculosis, independently of history of life-threatening conditions at birth (Table 3).

In the other groups of avoidable causes, there was no difference in the order of the principal causes according to history of life-threatening conditions at birth. Bacterial sepsis of newborn (P36 ICD-10) was the principal cause of death reducible by adequate care for the neonate (Table 3).

In addition, history of life-threatening conditions did not interfere in the order of the principal clearly avoidable and ill-defined causes of death. The former were predominantly congenital malformations (83.8% and 69.6% among those born with and without life-threatening conditions, respectively), mainly congenital cardiopathies (Q20 to Q26 ICD-10: 17.1% versus 37.1%). Other ill-defined causes, unspecified (R99 ICD-10: 77.3% versus 74.8%) were the main diagnoses in the group of ill-defined causes (Table 3).

As for risk of death, independently of the subgroup of avoidable causes, under-five mortality rates were higher among newborns with life-threatening conditions at birth when compared to those without life-threatening conditions (Figure 1). The under-five mortality rates from avoidable and unclearly avoidable causes were lower and close to those for infants without life-threatening conditions at birth.

Table 3

Absolute and relative distribution of deaths in under-five children according to the classification of avoidability of life-threatening conditions at birth. City of Rio de Janeiro, Brazil, 2012-2016.

Avoidable causes of death	Life-threatening condition						Total		
	Yes (n = 1.695)			No (n = 2.125)			(n = 3,820)		
	n	%	Rank	n	%	Rank	n	%	Rank
1. Avoidable causes	1,254	74.0	-	1,092	51.4	-	2,346	61.4	-
1.1 Reducible by immunoprevention	1	0.0	-	13	-	-	14	-	-
Tuberculous meningitis (A17.0)	1	100.0	1st	1	7.7	3rd	2	14.3	2nd
Pertussis, unspecified (A37.9)	0	0.0	-	9	69.2	1st	9	64.3	1st
Miliary tuberculosis, unspecified (A19.9)	0	0.0	-	2	15.4	2nd	2	14.3	2nd
Other tuberculosis of nervous system (A17.8)	0	0.0	-	1	7.7	3rd	1	7.1	3rd
1.2 Reducible by adequate care for woman in pregnancy and childbirth and for fetus and newborn									
1.2.1 Reducible by adequate prenatal care	638	-	-	141	-	-	779	-	-
Maternal hypertensive disorders (P00.0)	159	24.9	1st	25	17.7	2nd	184	23.6	1st
Neonatal respiratory distress syndrome (P22.0)	138	21.6	2nd	5	3.5	8th	143	18.4	2nd
Maternal renal and urinary tract diseases (P00.1)	60	9.4	3rd	26	18.4	1st	86	11.0	3rd
Early congenital syphilis, unspecified (A50.2)	31	4.9	7th	20	14.2	3rd	51	6.5	5th
1.2.2 Reducible by adequate intrapartum care	191	-	-	73	-	-	264	-	-
Birth asphyxia, unspecified (P21.9)	37	19.4	1st	8	11.0	30	45	17.0	2nd
Neonatal meconium aspiration (P24.0)	36	18.8	2nd	23	31.5	1st	59	22.3	1st
Other forms of placental separation and hemorrhage (P02.1)	34	17.8	3rd	2	2.7	80	36	13.6	3rd
Intrauterine hypoxia, unspecified (P20.9)	16	8.4	5th	8	11.0	3rd	24	9.1	4th
Neonatal aspiration syndrome, unspecified (P24.9)	3	1.6	10th	19	26.0	2nd	22	8.3	6th
1.2.3 Reducible by adequate care of the fetus and newborn	333	-	-	178	-	-	511	-	-
Bacterial sepsis of newborn (P36.9)	137	41.1	1st	59	33.1	1st	196	38.4	1st
Necrotizing enterocolitis of newborn (P77)	57	17.1	2nd	18	10.1	2nd	75	14.7	2nd
Primary atelectasis of newborn (P28.0)	18	5.4	3rd	8	4.5	40	26	5.1	3rd
Congenital pneumonia, unspecified (P23.9)	4	1.2	9th	16	9.0	3rd	20	3.9	4th

(continues)

Table 3 (continued)

Avoidable causes of death	Life-threatening condition						Total		
	Yes (n = 1.695)			No (n = 2.125)			(n = 3,820)		
	n	%	Rank	n	%	Rank	n	%	Rank
1. Avoidable causes	1,254	74.0	-	1,092	51.4	-	2,346	61.4	-
1.3 Reducible by adequate diagnosis and treatment	63	-	-	386		-	449	-	-
Pneumonia, unspecified (J18.9)	21	6.3	1st	139	78.1	1st	160	31.3	1st
Septicemia, unspecified (A41.9)	19	5.7	2nd	46	25.8	3rd	65	12.7	3rd
Acute bronchitis, unspecified (J21.9)	9	2.7	3rd	64	36.0	2nd	73	14.3	2nd
1.4 Reducible by health promotion measures linked to adequate healthcare measures	28	-	-	301	-	-	329	-	-
Respiratory risks, unspecified (W84.9)	9	32.1	1st	94	31.2	1st	103	31.3	1st
Inhalation of gastric content, site unspecified (W78.9)	4	14.3	2nd	31	10.3	2nd	35	10.6	2nd
Diarrhea and gastroenteritis of presumed infectious origin (A09)	3	10.7	3rd	24	8.0	3rd	27	8.2	3rd
2. Ill-defined causes of death	22	1.3		143	6.7		165	4.3	-
Other ill-defined causes, unspecified (R99)	17	60.7	1st	107	35.5	1st	124	37.7	1st
Conditions originating in the perinatal period, unspecified (P969)	4	14.3	2nd	31	10.3	2nd	35	10.6	2nd
Other general symptoms and signs (R68.8)	1	3.6	3rd	1	0.3	40 *	2	0.6	3rd
Respiratory arrest (R09.2)	0	0.0	-	2	0.7	3rd	2	0.6	3rd
3. Other causes (unclearly avoidable)	419	24.7	-	890	41.9	-	1.309	34.3	-
Congenital hypoplasia and dysplasia of lung (Q33.6)	38	9.1	1st	29	3.3	3rd	67	5.1	2nd
Multiple congenital malformations, not classified elsewhere (Q89.7)	31	7.4	2nd	8	0.9		39	3.0	5th
Other congenital malformations of heart, unspecified (Q24.9)	29	6.9	3rd	128	14.4	1st	157	11.9	1st
Other specified congenital malformations of heart (Q24.8)	11	2.6	9th **	41	4.6	2nd	52	4.0	3rd

Note: 1. percentages were calculated for the three groups of avoidability in relation to total deaths and for specific causes in relation to the total subgroup of avoidability; 2. presents the ranking of the three specific leading causes by subgroups of avoidability. When the three leading causes differed according to history of life-threatening conditions, other specific causes were listed that ranked higher.

Sources: Brazilian Mortality Information System and Brazilian Information System on Live Births, Rio de Janeiro Municipal Health Department.

* Tied with other and unspecified convulsions (R56.8) and other general symptoms and signs (R688). Both causes rank fourth among newborns with life-threatening conditions;

** Tied with Q03.9 and Q25.0, ranking 11th and 22nd among newborns without life-threatening conditions.

The absolute difference between the under-five mortality rates per thousand person-days according to history of life-threatening conditions at birth was 14.8 for avoidable causes, 5.6 for unclearly avoidable causes, and 0.3 for ill-defined causes. The attributable risk of under-five death from avoidable causes with history of life-threatening conditions was 97.6%, that is, for every 100 avoidable deaths among under-five children who were born with life-threatening conditions, 98 would be avoidable if this condition at birth had been prevented in the population base.

Figure 2 shows the survival curves. Survival up to five years of age was lower among children with life-threatening conditions at birth when compared to those without life-threatening conditions (p < 0.00001). The largest reduction in survival occurred close to birth, approximately 14%, considering only the neonatal period. Importantly, after 27 days of age, infants with life-threatening conditions at birth, cases of near miss, still showed a 4.6% reduction in survival, especially in the first two years of life.

Figure 1

Under-five mortality rate (UFMR) per 1,000 person-days according to avoidability in birth cohorts. City of Rio de Janeiro, Brazil, 2012-2016.
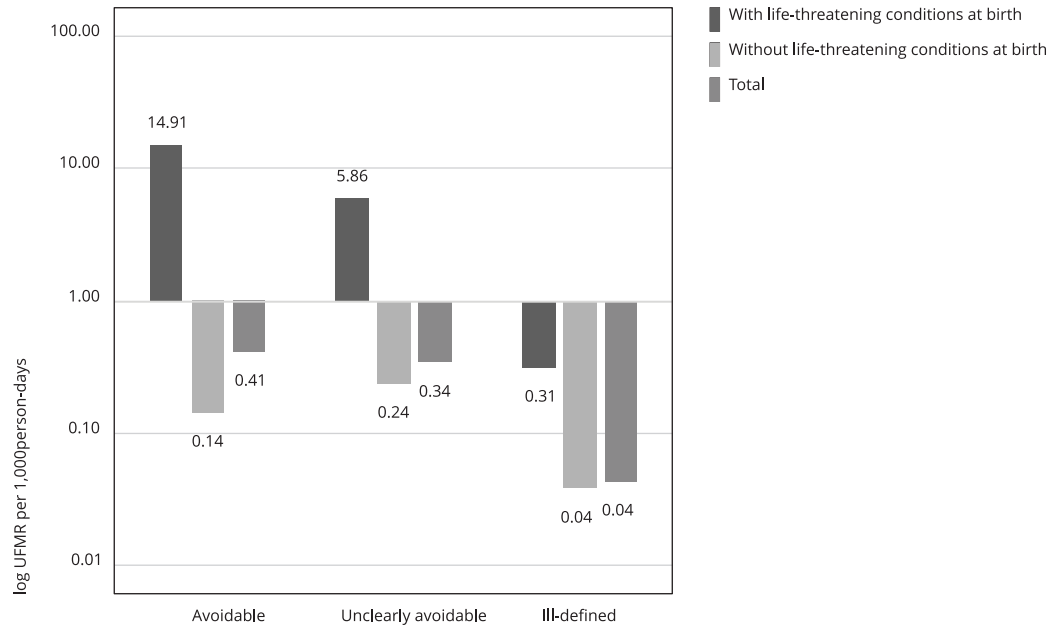
Sources: Brazilian Mortality Information System and Brazilian Information System on Live Births, Rio de Janeiro Municipal Health Department.

Figure 2

Kaplan-Meier method for estimating survival up to four years and 364 days of age in newborns with life-threatening conditions at birth in live birth cohorts. City of Rio de Janeiro, Brazil, 2012-2016.
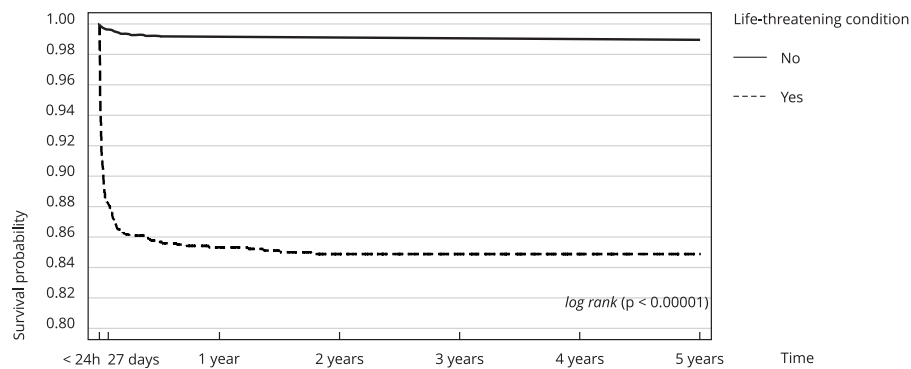
Discussion

A history of life-threatening conditions at birth reduced by 19% the probability of survival up to five incomplete years, and the principal causes of death were reducible by interventions by the Brazilian Unified National Health System (SUS).

The deaths in under-five children were mostly concentrated in early infancy, and there was thus a larger reduction in survival at earlier ages. The neonatal period is the most vulnerable period for infant deaths, accounting for approximately 55% of deaths up to five years of age in Brazil in 2015 [10]. This concentration in the neonatal period is expected when infant mortality decreases, as in developed countries [2]. In addition, the relationship between the relative risk of death by history of life-threatening conditions according to age at death indicates biological vulnerabilities in relation to life-threatening conditions at birth and age at death.

In the live birth cohorts in the city of Rio de Janeiro, deaths in under-five children were predominantly from avoidable causes. The highest concentration of deaths in the first month of life underlines the relevance of factors associated with the gestation, labor and delivery, and postpartum period for reducing under-five mortality [8]. Causes reducible by improved prenatal care are expected due to the higher frequency of very low birthweight (< 1,500g) and very premature newborns (< 32 weeks gestational age), which are pragmatic criteria for defining life-threatening conditions and are totally or partially avoidable by qualified prenatal care [5,20].

Birthweight less than 1,500g was strongly associated with neonatal death in Brazil [7]. In the world, complications of preterm birth accounted for 15.4% of deaths in under-five children and 10.5% of intrapartum complications in 2013 [21]. Neonatal survivors with very low birthweight and low gestational age show high risk of neurodevelopmental abnormalities [22]. Premature newborns, especially those with less than 32 weeks gestational age, have a higher risk of neonatal death, which persists in the post-neonatal period. There is also an important risk of long-term neurodevelopmental impairment, low stature, and noncommunicable conditions [23]. The third pragmatic criterion in the definition of life-threatening conditions, a five-minute Apgar score less than seven, indicative of asphyxia, relates essentially to conditions of intrapartum and neonatal care [5]. Among Brazilian neonates with low risk of death, perinatal asphyxia contributed to 40% of all neonatal deaths from 2005 to 2010 [10]. In the current study, among newborns with life-threatening conditions, asphyxia and intrauterine hypoxia were the second cause (reducible by adequate neonatal care) and third cause (reducible by adequate intrapartum care) of avoidable death. In this sense, the definition of life-threatening conditions, based on the presence of at least one of the pragmatic criteria, was reflected in the mortality profile by groups and subgroups of avoidable causes, but had little effect on the ranking of specific causes. The differences found here relate more to the magnitude of deaths.

In the current study, among children born with life-threatening conditions, the predominant causes were reducible by adequate prenatal and intrapartum care. Maternal hypertensive disorders were the principal causes of death reducible by adequate prenatal care, independently of history of life-threatening conditions at birth. In the decade prior to the current study, there was an upward trend in the infant mortality rate reducible by adequate prenatal care, partly due to maternal hypertensive disorders, in a study in Londrina, Paraná State, Brazil [7]. Shortcomings in prenatal care related to the management of diseases have been documented in the city of Rio de Janeiro [24,25] and are the principal determinants of avoidable deaths in the state of Rio de Janeiro [8].

The deaths of under-five children without life-threatening conditions at birth featured causes reducible by adequate health promotion and diagnostic measures, related to contextual factors, most prevalent in the post-neonatal period. Although the principal specific causes are common to children both with and without life-threatening conditions, competing risks of death in the neonatal period (which are more frequent in children with life-threatening conditions at birth) may partly explain these results.

Pertussis and tuberculosis, immune-preventable causes, are still present among deaths of under-five children. As in other subgroups of avoidable causes, they reflect gaps in the healthcare provided to under-five children [4].

Congenital cardiopathies were the principal diagnoses in the group of unclearly avoidable causes of death in the current study. In the state of Rio de Janeiro (2006-2010), and among the infant deaths

with congenital malformations, 39% presented congenital cardiopathies [26]. With improvements in healthcare during childhood, for example, congenital malformations can be expected to gain proportionally greater importance both in the neonatal period and from 1 to 59 months of age [27]. In Brazil, congenital anomalies ranked second among causes of death in under-five children in 2015 and were the leading cause of death in the states of the South, Central, and Southeast (except for Minas Gerais and Goiás) [8].

The impact of the prevention of life-threatening conditions at birth can reduce by up to 97.6% the avoidable deaths in under-five children in the city of Rio de Janeiro, assuming a causal relationship and absence of confounding (http://tabnet.datasus.gov.br/cgi/sim/Consolida_Sim_2011.pdf). In absolute numbers, this means that 1,653 under-five children would not have died if they had been born without life-threatening conditions.

The estimated survival of cases of neonatal near miss, presented in a previous publication [16], raise the discussion on vulnerability and the need for care for these children and social support for their families. The extension of survival analysis up to four complete years based on history of life-threatening conditions at birth emphasizes that the prevention of life-threatening conditions at birth is indispensable for reducing life-course morbidity and mortality.

The burden of severe disease in neonates, measured in the current study as the population-based neonatal near miss rate, was 20.1 per 1,000 live births. There are no publications with the rate's population-based calculation to make a direct comparison with our results. In the maternity hospital with the most births in the city of Rio de Janeiro, and which almost exclusively serves the local birthing demand, the neonatal near miss rate by place of birth and based on the same pragmatic definition of near miss as in our study was 28.6 per thousand live births in 2011 [12].

The study's strengths include the exclusive use of pragmatic criteria in the definition of life-threatening conditions and neonatal near miss and the calculation of indicators based on this definition in the population base (live birth cohorts by mother's place of residence), thus potentially assisting in monitoring maternal-child health in the city. The information system's quality has improved in Brazil, particularly in the SINASC [28,29]. The SIM still presents some deficiencies, but the database linkage qualifies the data and contributes to the study of infant mortality [30,31]. In the current study, besides mortality, it was possible to assess the impact of the prevention of life-threatening conditions at birth on the mortality rates in under-five children. However, the lack of linkage of some pairs, particularly for deaths from one to four years of age, may have underestimated the under-five mortality rate. Mandatory recording of the number from the Certificate of Live Birth on the Death Certificate exclusively for infant deaths (under one year of age) decreases the odds of deterministic linkage according to the number on the Certificate of Live Birth. The quality of certification of the underlying cause is important for ensuring greater trustworthiness in the classification of deaths according to the Brazilian list of avoidable causes. In this sense, investigation of deaths by health services is a good strategy, but it does not extend to deaths from one to four years of age and sometimes may also fail to reach all infant deaths. In the city of Rio de Janeiro, the proportion of infant deaths that are investigated has increased steadily, reaching 95.5% in 2016 [32].

Considering the profile of avoidable causes among newborns with life-threatening conditions, one can infer that the process that led to death is similar to that which led to the occurrence of near miss. This process can be prevented, at least partially, by improving prenatal care. The reduction in prematurity is still a challenge, but the control of hypertensive, metabolic, and infectious diseases during prenatal care can help reduce morbidity and mortality in the infant population in Rio de Janeiro.

Contributors

Additional informations

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Resumo

Apesar da redução da mortalidade na infância, as causas ainda são majoritariamente evitáveis, e a sobrevida pode estar condicionada à situação de ameaça à vida ao nascer. Foram estimadas a carga de ameaça à vida ao nascer, de near miss neonatal, e a mortalidade, com ênfase na evitabilidade, e sobrevida na infância, em coortes de nascidos vivos. Estudo de coorte retrospectiva de nascidos vivos residentes no Município do Rio de Janeiro (2012-2016). Os bancos de dados dos Sistemas de Informações sobre Nascidos Vivos e sobre Mortalidade foram relacionados. Critérios pragmáticos foram utilizados para definição ameaça à vida e near miss. Óbitos foram classificados segundo a lista brasileira de causas de mortes evitáveis. Foram estimados indicadores de morbimortalidade e a sobrevida (Kaplan-Meier). Dos 425.505 nascidos vivos, 2,2% apresentaram ameaça à vida ao nascer. As taxas de mortalidade na infância, infantil e neonatal foram, respectivamente: 0,01; 0,06 e 14,97 por 100 mil pessoas-dia. Causas evitáveis, não claramente evitáveis e mal definidas corresponderam, respectivamente, a 61%, 35% e 4% dos óbitos. O risco de morte por causas evitáveis atribuível ao nascimento com ameaça à vida foi de 97,6%. A sobrevida foi menor entre recém-nascidos com ameaça à vida, comparados àqueles sem ameaça à vida. Os critérios pragmáticos de ameaça à vida determinaram o perfil de mortalidade proporcional por causas de morte segundo os três grupos de causas da lista brasileira de mortes evitáveis. Nascer com ameaça à vida define crianças com maior risco de morbimortalidade e põe, em pauta, a discussão sobre a vulnerabilidade e as necessidades de assistência às crianças e do apoio social às suas famílias.

Near Miss*; Mortalidade da Criança; Análise de Sobrevida; Causas de Morte*

Resumen

A pesar de la reducción de la mortalidad en la infancia, las causas de fallecimiento todavía son mayoritariamente evitables y la supervivencia puede estar condicionada con la situación de amenaza para la vida al nacer. En este trabajo se estimaron la carga de amenaza para la vida al nacer, el near miss *neonatal y la mortalidad, con énfasis en la evitabilidad y supervivencia en la infancia en cohortes de nacidos vivos. Es un estudio de cohorte retrospectivo de nacidos vivos, residentes en el municipio de Río de Janeiro, Brasil (2012-2016). Se relacionaron los bancos de datos de los Sistemas de Información sobre Nacidos Vivos y sobre Mortalidad. Se utilizaron criterios pragmáticos para la definición amenaza para la vida al nacer y* near miss. *Los óbitos se clasificaron según la lista brasileña de causas de muertes evitables. Se estimaron indicadores de morbimortalidad y supervivencia (Kaplan-Meier). De los 425.505 nacidos vivos, un 2,2% presentaron amenaza para la vida. Las tasas de mortalidad en la infancia, infantil y neonatal fueron, respectivamente: 0,01; 0,06 y 14,97 por 1.000 personas-día. Las causas evitables, no claramente evitables y mal definidas, correspondieron, respectivamente, a un 61%, 35% y 4% de los óbitos. El riesgo de muerte por causas evitables atribuible al nacimiento con amenaza para la vida fue de un 97,6%. La supervivencia fue menor entre recién nacidos con amenaza para la vida, comparados con aquellos sin amenaza para la vida. Los criterios pragmáticos de amenaza para la vida determinaron el perfil de mortalidad proporcional por causas de muerte, según los tres grupos de causas de la lista brasileña de causas de muertes evitables. Nacer con amenaza para la vida define a los niños con un mayor riesgo de morbimortalidad y pone en relevancia la discusión sobre vulnerabilidad y necesidades asistenciales para los niños, así como el apoyo social a sus familias.*

Near Miss*; Mortalidade del Niño; Análisis de Supervivencia; Causas de Muerte*