

What do children aged 5 to 14 years die from in the state of Rio de Janeiro, Brazil? Trend analysis of the period 2000-2019

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Abstract *This study investigated the magnitude and trends of cause-specific mortality among children 5 to 14 years of age in the state of Rio de Janeiro (RJ) from 2000 to 2019. We performed an ecological study, using data from the Mortality Information System (MIS). We calculated mortality rates per 100,000 children by chapters, groups, and categories of causes of death (ICD-10). Trends were estimated by joinpoint regression. Mortality rates among children aged 10 to 14 years were higher than those among children 5 to 9. The five leading causes of death were the same in both age groups, but they ranked differently. The two leading ones were external causes and neoplasms (31% and 15% among children aged 5 to 9 years; 45% and 11% among children aged 10 to 14 years). Among children 5 to 9 years, the mortality trend showed an annual decline (8%) from 2011 to 2015. Among children aged 10 to 14 years, the annual decline was 1.3% from 2000 to 2019. Mortality due to external causes decreased in both age groups, except for the category “Assault by unspecified firearm” (boys, 10 to 14 years) and “Unspecified drowning and submersion” (boys, 5 to 9 years). Mortality caused by neoplasms remained steady in both age groups. Infectious and respiratory diseases decreased differently between the two groups. Most causes of death are preventable or treatable, indicating the need for health and intersectoral investments.*

Key words *Cause of death, Children, Age-specific mortality rates, Time series*

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Introduction

Until recently, mortality among children aged 5 to 14 years did not receive the same attention as that of children under 5 years, despite an estimated number of one million annual deaths in the former group. This lack of attention has resulted in an important gap in knowledge on child health¹³. In recent years, rates among children 5 to 14 years have not decreased as much as those of children under 5 years. Between 2000 and 2016, the relative decrease of deaths among children aged 1 to 11 months, 1 to 4 years, 5 to 9 years and 10 to 14 years was respectively 50%, 59%, 40% and 13% worldwide⁴.

Causes of death are diverse or of various sizes among different age groups and geographic regions, depending on the socioeconomic level and political scenario⁴. In 2016, the global leading causes of death among children aged 1 to 4 years were lower respiratory infections, diarrhea, malaria, injuries and drowning. Among those aged 5 to 9 years, the five leading causes were diarrhea, lower respiratory infections, injuries, traffic accidents and malaria. In the 10-14 age group, leading causes included injuries, traffic accidents, HIV/AIDS, drowning and lower respiratory infections. This description is mainly influenced by the epidemiological profiles of Africa and Asia, which show the highest number of deaths and whose leading causes are infections⁴. In Latin America, traffic accidents predominate among the 5-9 age group, followed by drowning, interpersonal violence, collective violence/legal intervention and respiratory infections. The major causes among the 10-14 age group included interpersonal violence, congenital anomalies, lower respiratory infections, drowning and traffic accidents⁴.

In Brazil, few studies have examined these age groups. The “Inter-agency Group for Child Mortality Estimation” by the United Nations (UN-IGME) estimated a 50% reduction in mortality rates among the 5-14 age group from 1990 to 2019, which decreased from 4 to 2 per 1,000 children in Brazil, which still corresponds to 7,000 deaths per year³. According to an analysis by the Brazilian Ministry of Health (MoH)⁵, in 2006, land accidents ranked first among both sexes, followed by drowning. Among boys, physical attacks and lymphatic neoplasms ranked third and fourth respectively and, among girls, pneumonia and lymphatic neoplasms. In 2014, the first two positions included land accidents and assaults (homicides) in both sexes. The other

causes remained the same among girls. Regarding boys, neoplasms and pneumonia came next⁵. Another MoH publication reveals a drop in mortality from preventable causes in both groups (5 to 9 and 10 to 14 years) and in both sexes from 2010 to 2017⁶.

Fadel *et al.*⁷ showed that external causes predominated among boys and were the second leading cause of death among girls in Brazil in 2016. Noncommunicable diseases were the leading cause among girls⁷.

To address the crucial lack of knowledge on mortality in older children and considering how essential knowledge on the causes of death is to support preventive actions and to tackle the lack of studies on this age group, this study aimed to investigate the magnitude and the trend in time of mortality among groups of children aged 5 to 9 and 10 to 14 years according to sex and leading causes in the state of Rio de Janeiro from 2000 to 2019.

Methods

We conducted an ecological study on the time trend of mortality and its leading causes among children aged between 5 and 14 years living in the state of Rio de Janeiro (RJ), according to age group (5-9 and 10-14 years) and sex from 2000 to 2019.

We obtained mortality data from the Mortality Information System (MIS) made available by Rio de Janeiro’s State Health Department⁸. Population data were obtained from two censuses (2000 and 2010) and from estimates for subsequent years performed by the Interagency Health Information Network (Ripsa), which were also made available by Rio de Janeiro’s Health Department⁹. Based on these data, we calculated proportional mortality by causes and mortality rates per 100,000 children according to chapters, groups and categories of the International Statistical Classification of Diseases and Related Health Problems – 10th revision (ICD-10). The Joinpoint regression method was used to analyze the trend of mortality rates by cause, sex and age group from 2000 to 2019, as it identifies trend changes (inflection points) and adjusts linear trends on a logarithmic scale¹⁰. The annual percentage change (APC) and respective 95% confidence intervals were estimated as well. Models were evaluated with and without autocorrelation term. The Monte Carlo permutation method was used as statistical test for adjustment.

To enable the performance of disaggregated analyses by groups and categories, only causes that accounted for at least 100 deaths during the analyzed period were included in the trend analysis. Considering that in a period of 20 years, events occurred that resulted in excessive mortality, such as disasters and epidemics, isolated points showing atypical values (outliers) were identified and investigated. Trend analyses were performed with and without outliers (replaced by the mean of mortality coefficients at $t-1$ and $t+1$). In such situations, both trends are presented.

This study is part of a research titled “Causes of death among children aged 5 to 14 years in European, Latin American and Asian countries”. It was approved by the Research Ethics Committee of the Medical School of the Fluminense Federal University (UFF), decision number 3.250.608 of April 08, 2019.

Results

In the last two decades, there were 14,707 deaths among children aged 5 to 14 years in the state of Rio de Janeiro: 8,935 (61%) among male children and 8,495 (58%) among children aged 10 to 14 years. Mortality rates among the 10-14 age group were higher than those among the 5-9 age group during the analyzed period of time (Table 1).

The five leading causes of death, as per ICD-10 chapters, were the same in both age groups, but they ranked differently. The two leading causes of death in both age groups were external causes and neoplasms, i.e., 31% and 15% in the 5-9 age group and 45% and 11% in the 10-14 age group. Among children aged 5 to 9 years, the other three causes were infectious-parasitic, respiratory and nervous system diseases, each of which accounted for approximately 10%. In the 10-14 age group, they ranked as follows: nervous system diseases (9%), respiratory system diseases (around 6%) and infectious-parasitic diseases (around 6%). Ill-defined causes were registered in 6% of deaths in each age group (Graph 1).

Mortality rates of external causes among young adolescents were approximately twice as high as those of children aged 5 to 9 years and higher among males in both age groups (Table 1). Among external causes, the category with the highest mortality of the 5-9 age group in both sexes was “Pedestrian traumatized in unspecified accidents”, i.e., run over by unspecified vehicle. Among male children, the second cause was “Unspecified drowning and submersion”; among

females, the second cause was “Accident involving an unspecified motor vehicle”. In the 10-14 age group, the main external cause was “Assault by unspecified firearm”, representing virtually one fourth of the deaths in this chapter, followed by being run over by vehicle and drowning. Both sexes showed a similar pattern, except for the third rank of females, which was “accident caused by vehicle” (data not shown in table). Approximately 75% of deaths from external causes in this age group occurred in males (Table 1).

Regarding neoplasms, their magnitude was similar in both age groups (total mortality rate about 4 per 100,000). “Malignant neoplasm of the brain” was the most frequent cause of death in both age groups, followed by “Lymphoid leukemia” and “Myeloid leukemia” which together exceeded brain neoplasms (Table 1).

Infectious and parasitic diseases showed a total rate of 2.8 per 100,000 among children aged 5-9 years and 2.1 per 100,000 among children aged 10-14 years. In both age groups and genders, the category “Other sepsis” was the most frequent one, followed by “Meningococcal infection” in the 5-9 age group and HIV in the 10-14 age group (Table 1).

Deaths caused by diseases of the respiratory system showed rates of 2.5 and 2.2 per 100,000 in the 5-9 and 10-14 age groups, respectively. The leading category was “Pneumonia caused by unspecified microorganisms”, which accounted for 55% of all deaths in this chapter, i.e., 616 deaths among children aged 5 to 14 years in the last two decades.

Diseases of the nervous system were the fifth leading cause of death in the 5-9 age group (2.5/100,000) and the third one in the 10-14 age group (3.0/100,000). Among these, the main categories were cerebral palsy and other brain disorders, both of which showed low absolute numbers of annual deaths, ranging from 6 to 25 deaths (data not shown).

In the 5-9 age group, time trend of total mortality rates was volatile and showed a significant annual decline (8%) from 2011 to 2015. Males showed an annual decline of 1.2% from 2000 to 2012 and of 8.4% from 2012 to 2015; in females, rates remained steady (Table 2). The trend of mortality from external causes showed variations, i.e., two periods of decrease (2000-2008 and 2011-2015) that alternated with periods of stability. In males, there was a decreasing trend during the full time period. In females, stability predominated. There was an important increase in the number of deaths in 2011, which was due

Table 1. Mortality – absolute numbers (total rates per 100,000) by age group (5 to 9 years and 10 to 14 years), chapters and main categories of the ICD-10, state of Rio de Janeiro, 2000 to 2019.

Age group/causes by chapters and main categories	Boys	Girls	Total
5 to 14 years	8935 (36,6)	5770 (24,5)	14707 (30,7)
5 to 9 years	3579 (29,9)	2632 (22,9)	6211 (26,5)
Chapter 20 – external causes	1238 (10,4)	690 (6,0)	1928 (8,2)
V09 – Pedestrian injured in unspecified accidents	210 (1,8)	80 (0,7)	290 (1,2)
W74 – Unspecified drowning and submersion	84 (0,7)	33 (0,3)	117 (0,5)
V89 – Accident with an unspecified motor vehicle	67 (0,5)	43 (0,4)	110 (0,5)
Chapter 2 – Neoplasms	529 (4,4)	423 (3,7)	952 (4,1)
C71 – Malignant neoplasm of the brain	138 (1,2)	130 (1,1)	268 (1,1)
C91 – Lymphoid leukemia	137 (1,1)	79 (0,7)	216 (0,9)
C92 – Myeloid leukemia	46 (0,4)	35 (0,3)	81 (0,3)
Chapter 1 – Certain infectious and parasitic diseases	353 (3,0)	294 (2,6)	647 (2,8)
A41 – Other septicemias	107 (0,9)	80 (0,7)	187 (0,8)
A39 – Meningococcal infection	73 (0,6)	75 (0,7)	148 (0,6)
Chapter 10 – Diseases of the respiratory system	328 (2,7)	270 (2,3)	598 (2,5)
J18 – Pneumonia due to unspecified microorganism	184 (1,5)	160 (1,4)	344 (1,5)
J98 Other respiratory disorders	34 (0,3)	20 (0,2)	54 (0,2)
Chapter 6 – Diseases of the nervous system	357 (3,0)	237 (2,1)	594 (2,5)
G93 – Other brain disorders	92 (0,8)	74 (0,6)	166 (0,7)
G80 – Cerebral palsy	86 (0,7)	42 (0,4)	128 (0,5)
Chapter 18 – Ill- defined	194 (1,6)	171 (1,5)	365 (1,6)
R99 – Other ill- defined and unspecified causes	176 (1,5)	154 (1,3)	330 (1,4)
10 to 14 years	5356 (43,1)	3138 (26,1)	8495 (34,7)
Chapter 20 – External Causes	2741(22,1)	1045 (8,7)	3786 (15,5)
X95 – Assault by other and unspecified firearm discharge	738 (5,9)	163 (1,4)	901 (3,7)
V09 – Pedestrian injured in unspecified accidents	228 (1,8)	109 (0,9)	337 (1,4)
W74 – Unspecified drowning and submersion	166 (1,3)	36 (0,3)	202 (0,8)
Chapter 2 – Neoplasms	529 (4,4)	423 (3,3)	952 (3,9)
C71 – Malignant neoplasm of the brain	124 (1,0)	91 (0,8)	215 (0,9)
C91 – Lymphoid leukemia	122 (1,0)	69 (0,6)	191 (0,8)
C92 – Myeloid leukemia	83 (0,7)	53 (0,4)	136 (0,6)
Chapter 6 – Diseases of the nervous system	384 (3,1)	345 (2,9)	729 (3,0)
G80 – Cerebral palsy	95 (0,8)	93 (0,8)	188 (0,8)
G93 – Other brain disorders	83 (0,7)	75 (0,6)	158 (0,6)
Chapter 10 – Diseases of the respiratory system	302 (2,4)	228 (1,9)	530 (2,2)
J18 – Pneumonia due to unspecified microorganism	169 (1,4)	103 (0,9)	272 (1,1)
J98 – Other respiratory disorders	26 (0,2)	25 (0,2)	51 (0,2)
Chapter 1 – Certain infectious and parasitic diseases	280 (2,3)	222 (1,8)	502 (2,1)
A41 – Other septicemias	103 (0,8)	56 (0,5)	159 (0,7)
B20- 24 – Human immunodeficiency virus disease	51 (0,4)	49 (0,4)	100 (0,4)
Chapter 18 – Ill- defined	326 (2,6)	218 (1,8)	544 (2,2)
R99 – Other ill-defined and unspecified causes	289 (2,3)	198 (1,6)	487 (2,0)

Source: Sistema de Informações sobre Mortalidade (SIM), Instituto Brasileiro de Geografia e Estatística (IBGE) and Rede Interagencial de Informações de Saúde (Ripsa).

to an increase of the “Cataclysmic storm victims” category. Replacing the atypical value of 2011 with the calculated mean value has not resulted in any considerable change in trends (Table 2).

Neoplasms remained steady throughout the analyzed period in all categories (Table 2).

A high outlier was observed in 2008 among infectious and parasitic diseases due to the

“Dengue hemorrhagic fever” category. Mortality rates of the total number of children and of males decreased throughout the period and remained stationary in females. The trend analysis with outliers replaced by the mean value showed a constant decline in all groups throughout the period. However, decline was more important among boys (Table 2).

Diseases of the respiratory system showed a decline in total mortality, but not when disaggregated by sex. Mortality rates of diseases of the nervous system remained steady. There was a drop in the number of ill-defined causes in the analyzed time period (Table 2).

The 10-14 age group, both sexes, showed a steady decline in total mortality from 2000 to 2019 (Table 3). An annual decline of approximately 3% was found in external causes in all categories throughout the period. There were no differences between the original results and those without outliers (Table 3). Among the main categories of causes of death, a stable pattern was found in mortality from gunshot wounds in males. In males, categories with a decrease in mortality included “run over” and “drowning” and in females “shooting with a firearm” and “run over” (Table 4).

“Mortality from neoplasms” remained steady throughout the analyzed period in the total age group and in both sexes, just as “diseases of the nervous system” (Table 3). Diseases of the respiratory system remained steady among males and

females, but regarding the total number of children, a slight and permanent annual decreasing trend of 1.2% was found throughout the analyzed period (Table 3).

Mortality rates from infectious diseases showed an increase in the first half of the analyzed period and a decrease in the second half. Similar to what happened among children aged 5-9 years, atypical values were found in 2008 that were also related to “Dengue hemorrhagic fever”. After smoothing these peak values, the trend became stationary, except for a declining trend in males for a short period of three years (2016-2019) (Table 3). Ill-defined causes showed a declining trend in the period, except in males from 2014 to 2019, when they had a stationary trend.

No significant autocorrelation of errors was detected in any of the Joinpoint regression models of the historical series.

Discussion

The last two decades showed a 35% reduction in the number of deaths among children aged 5 to 14 years in the state of Rio de Janeiro. That figure gets close to the estimates of 36% (World) and 38% (Latin-America) for the 2000-2018 period¹¹. The proportional distribution of these deaths between the two age groups varies according to the development level of countries. In the state of Rio de Janeiro, 58% of deaths occurred in the 10-14

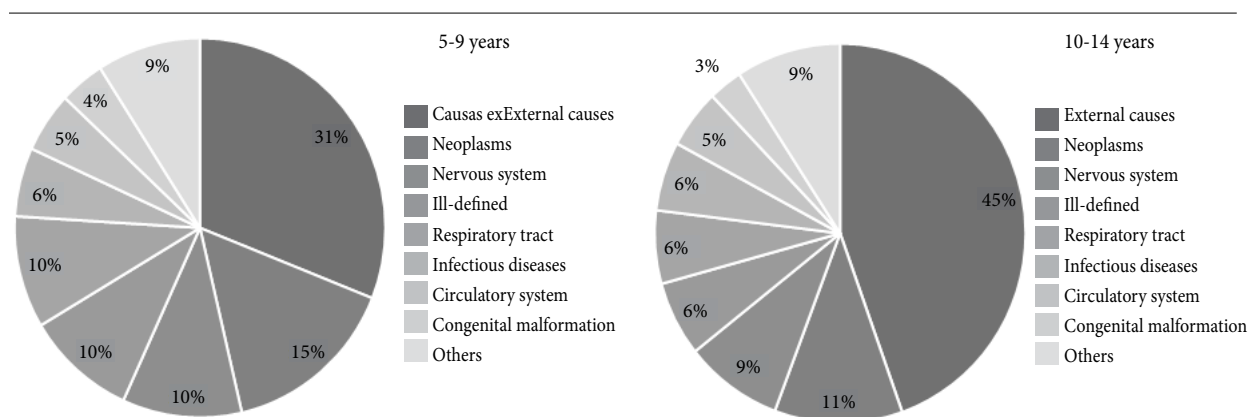


Figure 1. Proportional distribution of causes of death, by ICD-10 chapter, state of Rio de Janeiro, 2000-2019, according to age group.

Table 2. Trends in mortality rates (per 100,000) by sex and leading causes (ICD-10 chapters), age group 5 to 9 years, state of Rio de Janeiro, 2000-2019.

Leading causes of death by sex	Period	APC	Confidence interval 95%	Trend
<i>All causes</i>				
Total	2000-2011	-0.7	-1.3; 0.1	Stationary
	2011-2015	-8.0	-12.1; -3.6	Decreasing
	2015-2019	0.8	-2.1; 3.8	Stationary
Male	2000-2012	-1.2	-1.6; -0.7	Decreasing
	2012-2015	-8.4	-15.8; -0.3	Decreasing
	2015-2019	-1.4	-4.0; 1.3	Stationary
Female	2000-2011	0.3	-1.8; 1.2	Stationary
	2011-2015	-9.7	-19.2; 1.0	Stationary
	2015-2019	4.4	-2.7; 12.0	Stationary
<i>External causes of morbidity and mortality (Chapter XX)</i>				
Total	2000-2008	-3.3	-5.9; -0.6	Decreasing
	2008-2011	11.7	-13.4; 44.2	Stationary
	2011-2015	-21.3	-30.7; -10.6	Decreasing
	2015-2019	4.9	-2.4; 12.8	Stationary
Male	2000-2019	-4.9	-6.4; -3.4	Decreasing
Female	2000-2011	2.4	-1.1; 6.0	Stationary
	2011-2015	-20.4	-38.4; 2.8	Stationary
	2015-2019	7.8	-8.4; 26.7	Stationary
<i>External causes of morbidity and mortality (Chapter XX) – analysis with outlier replacement</i>				
Total	2000-2011	-1.6	-3.3; 0.1	Stationary
	2011-2015	-13.8	-24.1; -2.0	Decreasing
	2015-2019	2.1	-5.9; 10.6	Stationary
Male	2000-2019	-5.0	-6.8; -4.1	Decreasing
Female	2000-2011	0.9	-2.5; 4.5	Stationary
	2011-2015	-17.7	-36.3; 6.4	Stationary
	2015-2019	6.8	-9.2; 25.6	Stationary
<i>Neoplasms (Chapter II)</i>				
Total	2000-2019	-1.4	-2.8; 0.0	Stationary
Male	2000-2019	-1.3	-3.2; 0.7	Stationary
Female	2000-2017	-1.5	-3.6; 0.6	Stationary
<i>Certain infectious and parasitic diseases (Chapter I)</i>				
Total	2000-2019	-3.6	-5.9; -1.3	Decreasing
Male	2000-2019	-4.2	-6.3; -2.1	Decreasing
Female	2000-2019	-3.3	-6.4; 0.0	Stationary
<i>Certain infectious and parasitic diseases (Chapter I) – analysis with outlier replacement</i>				
Total	2000-2019	-3.4	-5.1; -1.8	Decreasing
Male	2000-2019	-4.1	-5.9; -2.3	Decreasing
Female	2000-2019	-3.0	-5.3; -0.6	Decreasing
<i>Respiratory system diseases (Chapter X)</i>				
Total	2000-2019	-1.8	-3.4; -0.1	Decreasing
Male	2000-2019	-2.6	-5.5; 0.3	Stationary
Female	2000-2019	-1.4	-3.7; 1.0	Stationary
<i>Nervous system diseases (Chapter VI)</i>				
Total	2000-2019	0.1	-1.0; 1.2	Stationary
Male	2000-2019	0.7	-0.6; 2.0	Stationary
Female	2000-2008	-0.9	-2.8; 1.0	Stationary
<i>Ill-defined symptoms, signs (Chapter XVIII)</i>				
Total	2000-2019	-4.5	-5.4; -3.2	Decreasing
Male	2000-2008	-3.8	-5.5; -2.1	Decreasing
Female	2000-2019	-5.3	-8.2; -2.3	Decreasing

Source: Sistema de Informações sobre Mortalidade (SIM), Instituto Brasileiro de Geografia e Estatística (IBGE) and Rede Interagencial de Informações de Saúde (Ripsa).

Table 3. Trends in mortality rates (per 100,000) by sex and leading causes (ICD-10 chapters), age group 10 to 14 years, state of Rio de Janeiro, 2000-2019.

Leading causes of death by sex	Period	APC	Confidence interval 95%	Trend
<i>All causes</i>				
Total	2000-2019	-1.3	-1.9; -0.8	Decreasing
Male	2000-2019	-1.5	-2.3; -0.7	Decreasing
Female	2000-2019	-1.2	-1.9; -0.4	Decreasing
<i>External causes of morbidity and mortality (Chapter XX)</i>				
Total	2000-2019	-2.9	-3.8; -2.0	Decreasing
Male	2000-2019	-2.8	-3.8; -1.9	Decreasing
Female	2000-2019	-3.0	-4.5; -1.6	Decreasing
<i>External causes of morbidity and mortality (Chapter XX) – analysis with outlier replacement</i>				
Total	2000-2019	-2.9	-3.8; -2.0	Decreasing
Male	2000-2019	-2.8	-3.8; -1.9	Decreasing
Female	2000-2019	-3.0	-4.5; -1.6	Decreasing
<i>Neoplasms (Chapter II)</i>				
Total	2000-2019	0.0	-0.8; 0.9	Stationary
Male	2000-2019	0.3	-0.7; 1.4	Stationary
Female	2000-2017	-0.6	-1.6; 1.2	Stationary
<i>Nervous system diseases (Capítulo VI)</i>				
Total	2000-2019	1,4	-0,0; 3,0	Estacionária
Masculino	2000-2019	1,5	-0,5; 3,5	Estacionária
Feminino	2000-2019	1,3	-0,6; 3,1	Estacionária
<i>Respiratory system diseases (Chapter X)</i>				
Total	2000-2019	-1.2	-2.3; -0.1	Decreasing
Male	2000-2019	-0.7	-2.5; 1.2	Stationary
Female	2000-2019	-1.6	-4.4; 1.2	Stationary
<i>Certain infectious and parasitic diseases (Chapter I)</i>				
Total	2000-2010	7.5	1.2; 14.1	Increasing
	2010-2019	-10.1	-16.2; -3.5	Decreasing
Male	2000-2011	5.8	0.3; 11.5	Increasing
	2011-2019	-10.4	-17.8; -2.4	Decreasing
Female	2000-2008	13.5	0.7; 29.7	Increasing
	2008-2019	-10.0	-17.1; -2.2	Decreasing
<i>Certain infectious and parasitic diseases (Chapter I) – analysis with outlier replacement</i>				
Total	2000-2019	-1.1	-2.9; 0.7	Stationary
Male	2000-2016	1.3	-0.7; 3.4	Stationary
	2016-2019	-24.4	-41.8; -1.7	Decreasing
Female	2000-2019	-1.5	-4.7; 1.7	Stationary
<i>Ill-defined symptoms, signs (Chapter XVIII)</i>				
Total	2000-2019	-3.3	-4.8; -1.7	Decreasing
Male	2000-2008	-9.9	-16.3; -3.0	Decreasing
	2014-2019	12.2	-4.3; 31.4	Stationary
	2014-2019	-16.8	-29.3; -2.0	Decreasing
Female	2000-2019	-5.0	-7.0; -2.8	Decreasing

Source: Sistema de Informações sobre Mortalidade (SIM), Instituto Brasileiro de Geografia e Estatística (IBGE) and Rede Interagencial de Informações de Saúde (Ripsa).

Table 4. Trends in mortality rates (per 100,000) of the most frequent categories of external causes by age group and sex, state of Rio de Janeiro, 2000-2019.

Main categories of death according to age group and sex	Period	VPA (95%CI)	Trend
5 to 9 years			
Male			
V09 Pedestrian injured in unspecified accidents	2000-2019	-11.3 (-13.3; -9.1)	Decreasing
W74 – Unspecified drowning and submersion	2000-2019	-2.9 (-6.1; 0.4)	Stationary
V89 – Accident with an unspecified motor vehicle	2000-2007	-17.5 (-26.1; -7.9)	Decreasing
	2007-2019	8,3 (3,5; 13,3)	Crescente
Female			
V09 Pedestrian injured in unspecified accidents	2000-2019	-23.5 (-28.3; -17.8)	Decreasing
V89 – Accident with an unspecified motor vehicle	2000-2019	-10.7 (-16.3; -4.8)	Decreasing
10-14 years			
Male			
X95 Assault by other and unspecified firearm discharge	2000-2005	5.1 (-5.7; 17.0)	Stationary
	2005-2008	-25.4 (-60.0; 39.1)	Stationary
	2008-2019	1.6 (-1.4; 4.8)	Stationary
V09 Pedestrian injured in unspecified accidents	2000-2019	-7.9 (-11.7; -4.0)	Decreasing
W74 Unspecified drowning and submersion	2005-2009	-4.1 (-7.1; -1.1)	Decreasing
Female			
X95 Assault by other and unspecified firearm discharge	2000-2013	-8.8 (-13.4; -3.8)	Decreasing
	2013-2016	41.6 (-48.1; 286.3)	Stationary
	2016-2019	-44.9 (-67.1; -10.1)	Decreasing
V09 Pedestrian injured in unspecified accidents	2000-2019	-10.7 (-14.0; -7.2)	Decreasing

Source: Sistema de Informações sobre Mortalidade (SIM), Instituto Brasileiro de Geografia e Estatística (IBGE) and Rede Interagencial de Informações de Saúde (Ripsa).

age group, which matches the profiles of developed countries¹¹.

As for the proportional distribution of causes of death, the state of Rio de Janeiro shows a pattern that closely matches the Latin American⁴ and Brazilian⁵⁻⁷ ones. Most deaths were due to external causes, which remained at the top of the list throughout the analyzed period, although they decreased over time, except in girls aged 5 to 9 years. Mortality rates of most causes were higher in males in Brazil, but not in other countries such as India and China⁷.

In the 5-9 age group, pedestrian accidents were the main category of external causes. As in other risk situations, there are gender differences in the behavior of pedestrians, even in children¹². Boys accounted for higher death rates than girls, but rates decreased in both sexes. Since the leading category is “unspecified accident conditions”, it was not possible to suggest which interventions could have successfully reduced deaths. Deaths caused by traffic accidents are generally related to commuting to school, population density, traf-

fic speed, the presence of traffic guards and the monitoring of children by parents or caregivers¹³. There is a consensus that children under 10 years of age need supervision to cross streets until they fully develop that skill^{14,15}. On the other hand, regulatory traffic safety laws could effectively reduce traffic deaths¹⁶, especially in terms of speed control and the prohibition of driving under the influence of alcohol (“Dry Law”) and may have at least partially contributed to reduce mortality, especially in this age group.

Drowning, which showed steady rates among boys in the state of Rio de Janeiro, has recently received increased attention from the WHO, since it is a frequent cause of death associated with the lack of adult supervision and protective measures^{17,18}. A cost-effective preventive measure would be increasing investments in early childhood education (day care centers / schools) to ensure safe environments while parents are at work. Mandatory swimming lessons would be an additional preventive measure, but they are difficult to implement¹⁷. Broader measures to reduce

deaths caused by traffic accidents and drownings need to be defined by a National Plan in a multisectoral way that involves parents and family members.

The 10-14 age group showed higher mortality rates from external causes than the 5-9 age group, which were predominantly related to violence. "Assaults by firearm" was the main cause category and did not decrease significantly among boys, corroborating Brazil's "portrait of wounded adolescences"¹⁹. A project by the State Security Department of the state of Rio de Janeiro to implement Pacification Police Units (PPU) in communities contributed to a considerable decrease in the rates of lethal violence²⁰. However, no temporal synchronicity was found between the implementation of that program as of 2009 and the reduction of mortality rates in boys aged 10 to 14 years, who are the most affected ones by this type of violence. There was no evidence of decline in the years following the implementation of the project, nor was there any increase in recent years after the project failed and shooting rates increased. Behavior of homicides has been discussed in the state of Rio de Janeiro^{21,22} and apparently, there has been a decline as a result of the implementation of both PPUs and other public security measures, but analyses only consider the general population. The 10-14 age group might not be as susceptible to that kind of programs as the older age groups that include subjects aged 15 years of age and over.

The replacement of the mortality rate from external causes by the mean value of the rates from 2009 to 2011 for both ages in 2011 did not considerably affect its trend, though the junction point of 2008 disappeared. The peak in 2011 was due to the high number of deaths classified as victims of cataclysmic storms (ICD-10: X37). Carmo and Anzawa²³ mention a total of 858 deaths in this ICD-10 category in the state of Rio de Janeiro, an extremely high number when compared to the average of 5 deaths per year (1996-2010) and they relate that increase to a huge disaster in Rio's Mountain Region caused by climatic events.

Neoplasms were the second leading cause of death among children aged 5 to 14 years, reflecting the Brazilian profile according to which cancer among children, adolescents and young adults is the second leading cause of deaths in general and the leading cause of deaths from diseases²⁴. A comparative study among four developing countries (Brazil, China, India and Mexico) showed that neoplasms were among the three leading causes of death among children aged 5 to

14 years in Brazil, China and Mexico⁷. Our result matches the one described in the literature, according to which leukemias and brain tumors are the most common types of cancer in children²⁴⁻²⁸. In general, pediatric neoplasms may not be prevented or identified by screening. However, most of them can be cured and their treatment is cost-effective in any scenario^{29,30}. Morbidity and mortality caused by childhood cancer reflect profound inequalities, according to a country's level of development^{26,27}. In developed countries with better access to services and treatment, more than 80% of pediatric neoplasms can be cured. In low- and middle-income countries, this proportion lies between 15% and 45%²⁹. There is also a difference in the temporal trend of mortality: annual drops of 2% to 3% are seen in countries such as Japan and Australia, while rates are stable or show a minimal decrease in Latin America²⁷. In the state of Rio de Janeiro, mortality rates from neoplasms (2000-2019) remained steady, suggesting that interventions are not effective enough, neither in terms of access nor in quality of therapeutic care. Early diagnosis and access to quality treatment are factors that directly impact chances of getting cured. Therefore, reducing pediatric cancer mortality rates in the state requires general access to treatment, adoption of modern chemotherapy protocols, supportive measures against treatment toxicity and advances in radiotherapy and diagnostics techniques^{29,30}. These measures depend on public policies and decentralization of pediatric oncology treatment and hospitalization services³¹. Another important aspect concerns cancer information systems. According to the Pediatric Oncology Forum of Rio de Janeiro, the Population-Based Cancer Registration System was only implemented in the state capital from 2019³². Information systems are an important factor for the continuous improvement of the quality of care and for supporting informed decisions and public policies.

In Brazil, deaths from infectious and parasitic diseases among children and young adults dropped between 2000 and 2010, resulting in increased life expectancy³³. The mortality profile of the state of Rio de Janeiro, where infectious and parasitic diseases are responsible for 10% of deaths of children aged between 5 and 9 years and for 6% of deaths of children between 10 and 14 years, comes close to the profile of developed regions of the world. Meningococcal infections stood out among children aged 5 to 9 years and the disease caused by HIV among children aged 10 to 14 years. An excessive increase in mortality

ty rates occurred in 2008 mainly in the male 5-9 age group, which was caused by dengue hemorrhagic fever. Replacing the atypical value of 2008 with the three-centric mean of the mortality coefficients eliminated the changes in the trend of mortality from infectious and parasitic diseases and made them stationary. Malhão *et al.*³⁴ not only observed an excessive mortality caused by dengue fever among children under 15 years residing in the Metropolitan Region of Rio de Janeiro, but also detected an excessive mortality rate caused by infectious diseases that are part of its differential diagnosis.

Lower respiratory diseases and infections cause a major health impact and rank among the leading causes of death worldwide³⁵. In the state of Rio de Janeiro, pneumonia caused by unspecified microorganisms killed 616 children aged 5 to 14 in the last decades, accounting for 55% of deaths in the respiratory disease group. Immunization is essential to control most respiratory infections. Development and implementation of vaccines against *Streptococcus pneumoniae* (pneumococcus) and *Haemophilus influenza B* are important tools to prevent pneumonia, just as the influenza vaccine, which is highly effective in its prevention³⁵. These vaccines are part of the National Immunization Program and are distributed by the Brazilian Public Health System. However, vaccination coverage has been decreasing since 2018 in Brazil³⁶. In our study, this group of causes ranked fourth and fifth among the causes of death in children aged 5-9 and 10-14 years, respectively. Mortality rates in both males and females remained steady over time, but when both genders were considered together, rates decreased. In 2009, there was an increase in the number of deaths, probably due to the influenza A (H1N1) pandemic that affected Brazil³⁷. Due to the low number of deaths, especially when disaggregated by categories, trend analyses become unstable, limiting their interpretation. Nevertheless, it remains essential to monitor both the Severe Acute Respiratory Syndrome mortality trend and the direct and indirect impact of COVID19 on mortality in the coming years to be able to quickly implement prevention and control measures.

Nervous system diseases were the fifth leading cause of death in the 5-9 age group and the third one in the older group. A study on children and adolescents in Rio Grande do Sul covering a time period from 2000 to 2014 identified diseases of the nervous system as the third leading cause of death in both age groups and both sexes³⁸. In our study, “cerebral palsies” were the second main category of causes of mortality in this group of causes among children aged 5 to 9 years and the first one among children aged 10 to 14 years. This suggests a migration that might be due to therapeutic care progress that led to a decrease in perinatal mortality and resulted in an increased survival rate of these children³⁹. Mortality rate of these causes remained stable in both age groups throughout the entire period of time we analyzed. However, the small number of deaths limits trend analyses and their interpretation.

Knowing and understanding the distribution and trends of the leading causes of death are essential for health managers to plan actions and public policies aimed at improving health conditions. In addition, they allow the identification of gaps and priorities and the elaboration of interventions in a multisectoral way, not only by health authorities but also by other sectors authorities such as public security, culture and education.

The vast majority of causes of mortality in the 5-14 age group are either preventable or treatable. Safety laws that address behavioral risk factors such as driving under the influence of alcohol, speed control, seat belt use, early identification, updated and quality treatments for major childhood cancer types, as well as appropriate and universal vaccination and antimicrobial treatment to fight infectious and parasitic diseases may reduce the deaths of these children in a comprehensive, equitable and fast way. The decrease in mortality from ill-defined causes found in the analyzed period may contribute to better targeting preventive measures. Additionally, we need to qualify the certification of causes of death with undefined or incomplete diagnoses, which are not very useful in public health⁴⁰.

Collaborations

C Boschi-Pinto and HGR Curvello contributed to the study conception and design, data analysis and interpretation, writing and critical review of the manuscript. SC Fonseca and PL Kale worked on data analysis and interpretation, writing and critical review of the manuscript. JCC Guimarães worked on data analysis and interpretation. H Kawa contributed in the critical review of the manuscript. All authors approved the final version of the manuscript and are responsible for all aspects of it, including ensuring its accuracy and integrity.

Financing

JCC Guimarães is a CNPQ scholarship holder – scholarship for Scientific Initiation – PIBIC-UFF (Process 121012/2021-2).

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Article presented 29/12/2021

Approved 12/08/2022

Final version presented 14/08/2022

Chief editors Romeu Gomes, Antônio Augusto Moura da Silva

