ABCS HEALTH SCIENCES

ORIGINAL ARTICLE

OPEN ACCESS

Time trends of avoidable deaths in Brazil, 1996 to 2019

Stefanie Lievore Cruz[1], Arthur Carvalho[1], Camila Gonçalves Santos[1], Natália Oliveira de Souza[1], Tatiana Feltmann Alves[2], Leonardo Ferreira Fontenelle[3]

[1]Universidade Vila Velha (UVV) - Vila Velha (ES), Brazil
[2]Unidade de Atenção à Saúde da Criança e do Adolescente, Hospital Universitário Cassiano Antonio de Moraes, Universidade Federal do Espírito Santo (UFES) – Vitória (ES), Brazil
[3]Departamento de Medicina Social, Centro de Ciências em Saúde, UFES – Vitória (ES), Brazil

ABSTRACT

Introduction: The known achievements of the Brazilian Unified Health System (SUS) stand out in an adverse context. This makes it necessary to examine the effect of the SUS on the population's health, using indicators such as deaths by avoidable causes. **Objective:** To describe the time trends of mortality from avoidable causes in Brazil and to compare them to those of non-avoidable causes. **Methods:** Ecological time-series study with official mortality data, during years 1996-2019, in the age group 5-74 years. Time trends in mortality were estimated as the annual percent reduction in mortality rates, and the impact of the SUS was calculated as the difference in trend between avoidable (immunopreventable, infectious and noncommunicable diseases, maternal and external causes) and non-avoidable causes. The analyses consisted of multivariable binomial regression models, by quadrennium. **Results:** Death rates for each avoidability group remained stable or declined throughout the study period. The probability of a positive impact was greater than 90% for immunopreventable diseases throughout the study period; infectious diseases in 1996-2003 and 2016-2019; noncommunicable diseases in 1996-2003 and 2008-2019; maternal causes in 1996-1999; and external causes in 1996-2007. This probability was less than 10% for maternal deaths in 2016-2019; and external causes in 2008-2015. **Conclusion:** The SUS has had a positive impact in reducing deaths from immunopreventable, infectious and noncommunicable diseases in Brazil, although not so much for maternal and external causes.

Keywords: Unified Health System; underlying cause of death; mortality, premature; Brazil; time series studies.

INTRODUCTION

Created just over 30 years ago, the Brazilian Unified Health System (SUS) innovated by encompassing health care, health promotion and health surveillance. The SUS is the largest national health system in the world in terms of population covered and has achieved a number of milestones throughout its history, such as the Family Health Strategy[1] and the fight against smoking[2].

These achievements stand out in an adverse context. As reviewed by Santos[3], the lack of financial autonomy of municipalities has compromised the sharing of management between federal, state and municipal levels; the discourse of fiscal austerity has undermined the universality of the right to health; and both old political practices and inefficiency of public management have remained.

How to cite this article: Cruz et al. Time trends of avoidable deaths in Brazil, 1996 to 2019. ABCS Health Sci. 2024;49:e024213 https://doi.org/10.7322/abcshs.2022104.2362

Received: Jul 24, 2022
Revised: Dec 07, 2022
Approved: Feb 25, 2023

Corresponding author: Leonardo Ferreira Fontenelle - Departamento de Medicina Social, Centro de Ciências em Saúde, Universidade Federal do Espírito Santo - Avenida Marechal Campos, 1468 – Nazareth - CEP: 29047-105 – Vitória (ES), Brazil – E-mail: leonardof@leonardof.med.br

Funding: UVV (scholarship to AC, SLC)
Declaration of interests: nothing to declare

These major challenges make it necessary to examine the effectiveness of the health system. According to a literature review conducted by Malta & Duarte[4], deaths from avoidable causes can be used to construct indicators of the quality of health care. Avoidable deaths are those "totally or partially prevented by the effective healthcare measures available (or accessible) at a given time and place"[4]. No health system could repeal the "iron law" of epidemiology that those who are born must die[5]. However, effective health systems must be able to reduce the mortality rate of their population from avoidable causes, for example, compared to historical rates in the same population.

There are two lists of avoidable causes of deaths due to interventions of the SUS: one for children under 5 years of age and another for people aged 5 to 74 years[6-8]. Both lists are categorized by the mechanism of avoidability. In the case of people aged 5 to 74 years, the avoidable causes of death were grouped into[6-8]: 1) Reducible by immunoprevention actions – hereafter referred to as "immunopreventable"; 2) Reducible by adequate health promotion, prevention, control and care actions for diseases of infectious causes – hereafter "infectious diseases"; 3) Reducible by adequate health promotion, prevention, control and care actions for noncommunicable diseases – hereafter "noncommunicable diseases"; 4) Reducible by adequate actions of prevention, control and care of causes of maternal death – "maternal causes"; and 5) Reducible by adequate intersectoral actions of health promotion, prevention and care of external causes (accidental and violence) – "external causes". Completing the list are ill-defined and non-avoidable causes of death[6-8].

Three national studies examined time trends in deaths from avoidable causes in Brazil. Preceding the national list, but drawing from the same framework, the first study found a decline in under-one mortality from 1983-1992 to 1993-2002, attributing it partially to "changes in the availability of and access to health services brought about by the reorganization of the Brazilian health care system"[9]. The second study documented a decline in avoidable deaths in children under one year of age during the years 1997 to 2006 (except for antenatal-related infant deaths), while non-avoidable deaths remained stable[10]. Finally, the third study also reported a decline in avoidable deaths, but now among people aged 5-69 years, during the years 2000-2013[11]. In the latter study, the decline in the mortality rate from avoidable causes (1.6% per year) was very close to the decline in non-avoidable causes (1.4% per year), which could suggest that most of the improvement in mortality was not, in fact, due to the health system.

Considering the possibility that the effectiveness of the SUS has decreased in recent years, this study aimed to describe time trends in mortality from avoidable causes in the Brazilian population aged 5 to 74 years, and to compare these time trends with those of non-avoidable causes.

METHODS

This ecological time-series study used official mortality and population data obtained in February 2021 through TabNet (currently https://datasus.saude.gov.br/informacoes-de-saude-tabnet/ a Web application that is provided by the Brazilian Ministry of Health. The annual number of deaths in Brazil was obtained from the Mortality Information System (SIM). Population size was obtained from projections, censuses and population counts provided by the Brazilian Institute of Geography and Statistics (IBGE). The research did not undergo prior ethical approval because it only used aggregate, publicly available data.

Data were included from 1996, when SIM first used the 10th edition of the International Statistical Classification of Diseases and Related Health Problems, until 2019, the last year with available data when this study was conducted. Deaths were restricted to those occurring from 5 to 74 years of age, as the respective list of avoidable causes was used[6,8]. The SIM itself categorized the underlying causes of death into five groups of preventable causes (immunopreventable; infectious diseases; noncommunicable diseases; maternal causes; external causes), in addition to ill-defined and non-avoidable causes, according to the national list[6,8].

For each recommended age group (5 to 9, 10 to 19, 20 to 39, 40 to 59, and 60 to 74 years)[4] and sex (male, female), deaths attributed to each group of causes were described using proportional mortality (deaths from that group of causes divided by total deaths) and mortality rate (deaths from that group of causes divided by the population). Both were standardized directly by sex and five-year age group, using the 2010 Brazilian Population Census as the standard. Even in the case of maternal mortality, both sexes and all age groups were included.

Time trends in mortality were estimated as the annual percentage reduction in mortality rates. Following the proposal of Niti and Ng[12], the impact of the health system on mortality was calculated as the reduction (annual percentage) in the rate of avoidable deaths minus the same reduction in the rate of non-avoidable deaths. Impact values greater than zero indicate that the health system is effectively contributing to the reduction in avoidable deaths. Both the annual percentage reduction and the impact were calculated separately for each quadrennium, from 1996-1999 to 2016-2019.

Annual percentage reductions were calculated as 100% * (1 - RR), where RR is the ratio of one year's mortality rate to the previous year's mortality rate. Rates were estimated with negative binomial regressions, adjusted for age group and sex. There was one regression model for each group of causes of death (five groups of avoidable, one of ill-defined, and one of non-avoidable causes). The regression models had an uninformative prior distribution for the intercept, and a flat prior distribution for the other coefficients. The prior distribution for the intercept was normal, with a mean of -11.5 and a standard deviation of 5, implying an 83%

probability that mortality was between 0.001 and 1000 deaths per 100,000 population per year.

For the sake of numerical stability, the regression model for maternal deaths was restricted to women aged 10-59 years. Therefore, there were two regression models with deaths not clearly avoidable as the outcome. The model restricted to women aged 10-59 years was used as a comparison for maternal deaths, while the model including all age groups and sexes was used as a comparison for other preventable causes and ill-defined causes. All regression models were fitted using R 4.0.4, Stan 0.26.1, brms 2.14.4, and CmdStanR 0.3.0.

Sex and age were unknown for rare deaths throughout the study period as well as for a tiny portion of the population in 1996-1999. These missing data were not included in this study.

RESULTS

During the study period, the Brazilian population aged 5 to 74 increased from 138.1 million people in 1996 to 189.4 million in 2019. The median age also increased, from 26.6 years in 1996 to 33.7 years in 2019.

Similarly, the annual number of deaths increased from 565.1 thousand deaths in 1996 to 750.0 thousand in 2019. In total, there were 15.7 million deaths, most of which occurred in males (63.9%) and people aged 60-74 years (43.8%).

Most deaths (71.2%) were due to avoidable causes. This proportion was higher among males (73.0%) and persons aged 20 to 39 years (80.1%) (Table 1). Noncommunicable diseases were the largest group of avoidable causes of death (43.7% of all deaths), followed by external causes (18.5%). The other three groups of avoidable causes accounted for proportions ranging from 8.7% to 0.1%. Ill-defined causes accounted for 8.1% of all deaths.

These proportions remained fairly stable throughout the study period, with one notable exception (Figure 1). Ill-defined causes of death started in 1996 accounting for 12.6% of deaths, above infectious diseases (8.8%), and ended in 2019 accounting for 5.5% of deaths, below infectious diseases (9.5%). The proportion of ill-defined causes of death decreased mainly around the year 2005, with a corresponding increase in the other groups of causes of death.

The overall mortality rate was 402.5 deaths per 100,000 people. Males had a higher mortality rate than females in every group of causes except maternal causes (Table 2). Similarly, the mortality rate increased across age groups for most cause groups, except for maternal causes and external causes, both of which peaked at 20-39 years.

The mortality rate decreased or remained relatively stable for all groups of causes of death during the study period (Figure 2). The decrease in the mortality rate from noncommunicable diseases was the most notable and consistent, given that this group accounted for the majority of deaths.

Proportionally, however, the largest reduction occurred in mortality from ill-defined causes (Table 3). This was the only group for which there was almost certainly (probability greater than 99.9%) a positive impact during all six periods, even though the estimated annual percentage reduction varied substantially.

Mortality from immunopreventable diseases had the largest annual percentage reduction among the avoidable causes of death (Table 3). In absolute terms, however, the time trend appears to be mostly flat (Figure 2), as this group represents only 0.1% of all deaths (Table 1).

The greatest reduction in deaths from ill-defined causes occurred in the 2004-2007 quadriennium (Figure 2). Thus, the mortality rate from other groups of causes of death did not decrease as much during this period as during the others (Table 3).

There was more uncertainty (i.e. wider uncertainty intervals) in the estimated reduction in deaths due to non-avoidable causes during the 2004-2007 and 2008-2011 quadrenniums (Table 3). As a consequence, there was less certainty about the positive impact of the health system on preventable deaths.

Because maternal deaths accounted for fewer deaths than most other groups, the annual percentage reductions in their mortality rate had some of the widest uncertainty intervals (Table 3).

There does not appear to have been a positive impact on deaths from external causes during the last three quadrenniums (Table 3). During the 2008-2011 and 2012-2015 quadrenniums, a

Table 1: Proportional mortality by sex, age group, and avoidability of the underlying cause of death in Brazil, 1996–2019

Characteristic	Immunopreventable		Infectious		Noncommunicable		Maternal causes		External causes		Ill-defined causes		Non-avoidable	
	thousands	%	thousands	%	thousands	%	thousands	%	thousands	%	thousands	%	thousands	%
Sex														
Female	4	0.1	527	9.3	2,871	50.8	42	0.7	399	7.1	452	8.0	1,360	24.0
Male	11	0.1	828	8.3	3,968	39.6	0	0.0	2,494	24.9	810	8.1	1,897	19.0
Age group (years)														
5 a 9	0	0.0	14	13.0	11	10.2	0	0.0	38	35.2	9	8.3	36	33.3
10 a 19	1	0.2	35	5.7	41	6.7	6	1.0	401	65.8	32	5.3	93	15.3
20 a 39	4	0.1	283	10.2	440	15.8	32	1.1	1,474	52.9	184	6.6	371	13.3
40 a 59	7	0.1	487	9.2	2,482	46.8	4	0.1	712	13.4	457	8.6	1,150	21.7
60 a 74	4	0.1	536	7.8	3,865	56.3	0	0.0	267	3.9	580	8.5	1,607	23.4
Total	16	0.1	1,355	8.7	6,839	43.7	42	0.3	2,893	18.5	1,262	8.1	3,257	20.8

Source: Brazilian Ministry of Health, Mortality Information System.

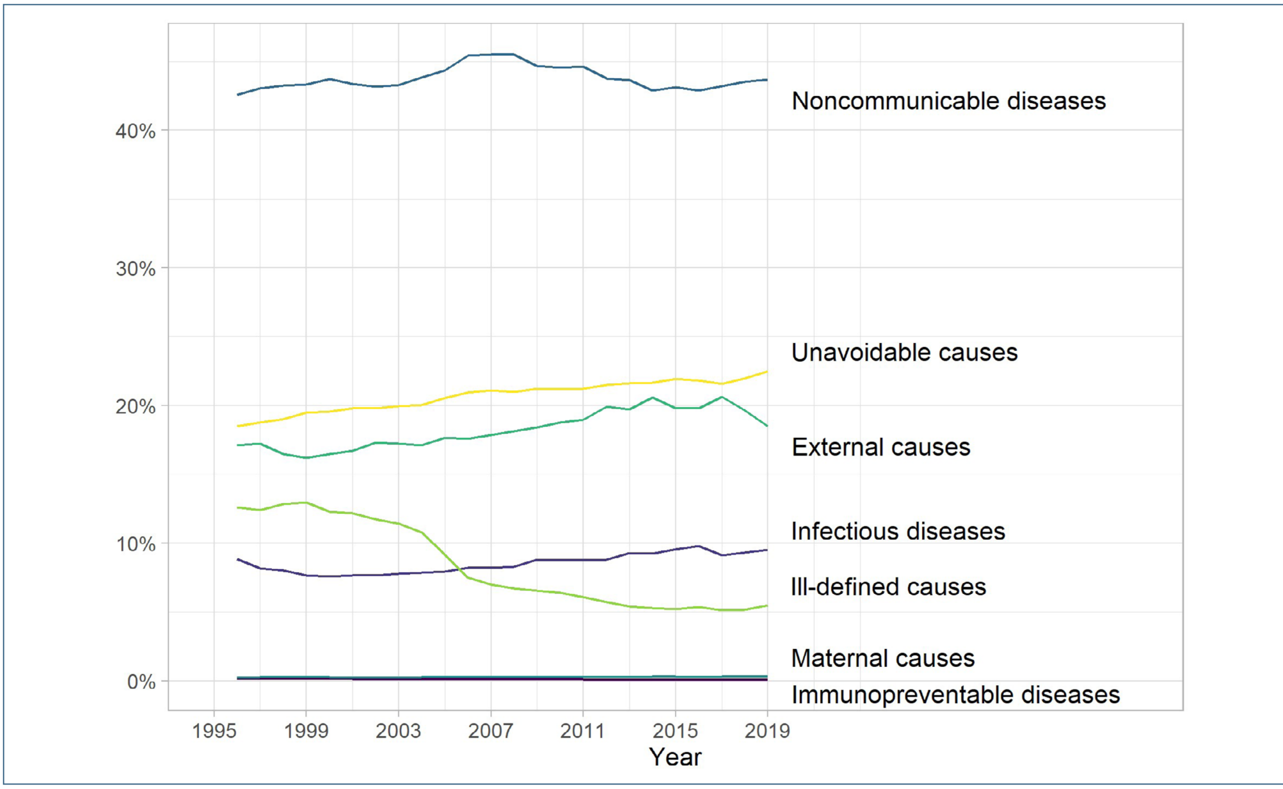

Figure 1: Standardized proportional mortality by avoidability of the underlying cause in Brazil, 1996–2019

Table 2: Standardized death rate (per 100 thousand population) by sex, age group, and avoidability of the underlying cause of death in Brazil, 1996–2019

Characteristic	Immunopreventable	Infectious	Noncommunicable	Maternal causes	External causes	Ill-defined causes	Non-avoidable
Sex							
Female	0.2	26.2	147.3	2.1	19.9	25.4	68.7
Male	0.6	42.2	205.7	0.0	126.9	44.7	97.3
Age group (years)							
5 a 9	0.1	3.6	2.7	0.0	9.3	2.1	9.1
10 a 19	0.1	4.2	4.9	0.7	48.4	3.9	11.2
20 a 39	0.3	19.5	29.7	2.1	99.6	12.8	25.0
40 a 59	0.7	50.9	264.9	0.4	74.7	52.4	121.6
60 a 74	1.3	156.5	1,178.4	0.0	79.9	194.8	483.0
Total	0.4	34.1	176.2	1.0	72.9	35.0	82.9

Source: Brazilian Ministry of Health, Mortality Information System.

modest increase seemed more likely than a decrease. During the years 2016-2019, there appears to have been a reduction, but at a similar rate to deaths from non-avoidable causes, with only an 87.4% probability of a positive impact.

DISCUSSION

After the study period of Malta et al.[11], both avoidable and non-avoidable deaths continued to decrease in Brazil. Deaths from noncommunicable diseases, immunopreventable diseases and, perhaps, infectious diseases are decreasing more sharply than those from non-avoidable causes, suggesting that the health system is having a positive impact on the health of the population. In the case of maternal and external causes of deaths, however, this impact is not as clear.

The use of official data requires caution in the interpretation of the results of this study due to underreported or ill-defined deaths. Underreported deaths were not corrected as in Malta et al. [11] because the correction factor was only available until 2013, and deaths from ill-defined causes were not redistributed as in Malta et al.[11] because the present study emphasized the comparison between avoidable and non-avoidable deaths[12].

Another limitation of official data is that they do not differentiate the source of the impact. Despite the universal aspect of the SUS, private health insurance (*planos de saúde*) in Brazil mostly duplicates healthcare covered by the SUS[13], and privately insured

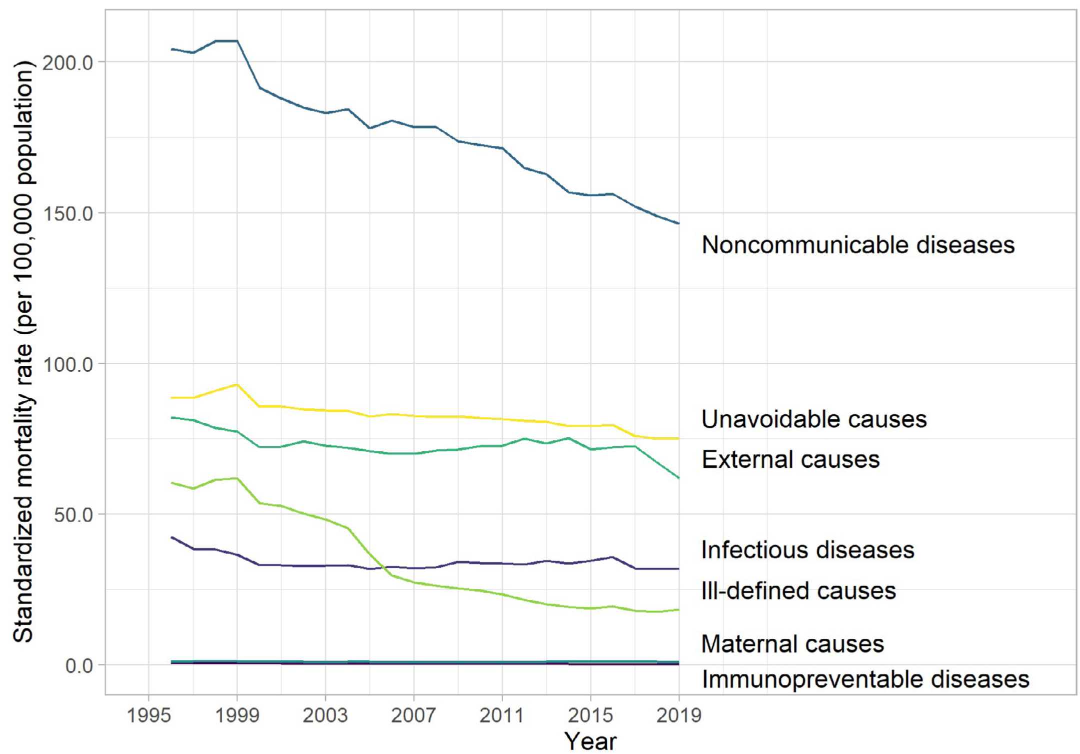

Figure 2: Standardized mortality rate by avoidability of the underlying cause in Brazil, 1996–2019

people rely preferentially on their private health insurance's provider network[14]. Thus, the time trends observed in this study reflect a mix of the impact of the SUS and private health insurance. It can expected, however, that the impact of the SUS explains most of the observed time trends, because most people in Brazil do not have private health insurance, and the national list was tailored to technology available through the SUS.

Another potential limitation is the long duration of the study period[6]. The program "Reduction of the percentage of deaths due to ill-defined causes of death" clearly achieved the expected result in the 2004-2007 quadrennium and, to a lesser extent, 2008-2011[15]. The reduction in ill-defined causes created an apparent deceleration in the decline of deaths from other groups of causes. For this reason, the study period was divided into quadrenniums, each with its own time trends.

Immunopreventable deaths have the largest annual percentage reduction among avoidable causes in all quadrenniums, and account for only 0.1% of all deaths. This reduction in mortality reflects the high vaccination coverage rates and the decline in the incidence of immunopreventable diseases in recent decades[16]. In addition, the annual reduction in immunopreventable diseases from 2008 to 2019 will be even sharper when the national list of avoidable causes is updated to reflect newly incorporated vaccines. Since 2007, the National Immunization Program has gradually incorporated the meningococcal conjugate C vaccine, 10-valent pneumococcal, influenza, varicella, hepatitis A and HPV (human papilloma virus)[16], not counting vaccines for SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) in 2021. Some of the respective diseases were not considered immunopreventable in the national list, and others were not included at all[6,8].

Deaths from infectious causes are declining at about the same rate as those from noncommunicable diseases. However, since deaths from infectious causes account for less than 10% of deaths (which in itself is an important achievement), the absolute annual reduction is smaller than that for noncommunicable diseases. As a result, the percentage of deaths from infectious causes is increasing slightly. These mixed results (decreasing mortality rate but increasing proportional mortality) contrast with a series of clear successes accumulated by the SUS in controlling many infectious diseases, such as HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome), schistosomiasis and Chagas disease[17]. This is because pneumonia accounts for two-thirds of all avoidable deaths from infectious diseases, according to Malta et al.[11]. Although vaccines exist for some causes, most cases of pneumonia in adults have no identifiable etiologic agent[18] and control measures such as contact tracing and treatment and isolation of mild cases are not routinely employed or even feasible. As a result, avoiding deaths from pneumonia has depended primarily on people having timely access to effective health care.

Table 3: Time trends of the mortality rate by quadrennium and avoidability of the underlying cause in Brazil, 1996–2019

Period	Group of causes of death	Annual reduction (%)		Probability of positive impact *
		Estimate	95% UI	
1996–1999	Immunopreventable diseases	5.47	(4.87; 6.11)	> 99.9
	Infectious diseases	3.23	(2.82; 3.62)	> 99.9
	Noncommunicable diseases	1.51	(1.33; 1.69)	> 99.9
	Maternal causes	1.91	(1.27; 2.52)	> 99.9
	External causes	1.76	(1.46; 2.06)	> 99.9
	Ill-defined causes	7.08	(6.66; 7.48)	> 99.9
	Unavoidable causes	0.57	(0.37; 0.77)	
2000–2003	Immunopreventable diseases	4.07	(3.04; 5.08)	> 99.9
	Infectious diseases	1.74	(1.05; 2.39)	> 99.9
	Noncommunicable diseases	0.45	(0.16; 0.74)	93.2
	Maternal causes	0.39	(-0.62; 1.38)	76.1
	External causes	0.70	(0.22; 1.18)	97.2
	Ill-defined causes	8.93	(8.30; 9.57)	> 99.9
	Unavoidable causes	0.13	(-0.19; 0.46)	
2004–2007	Immunopreventable diseases	1.77	(-0.86; 4.39)	94.8
	Infectious diseases	0.76	(-0.89; 2.37)	92.5
	Noncommunicable diseases	-0.31	(-1.04; 0.37)	68.8
	Maternal causes	0.06	(-2.56; 2.59)	77.1
	External causes	0.53	(-0.72; 1.77)	93.3
	Ill-defined causes	10.32	(8.74; 11.78)	> 99.9
	Unavoidable causes	-0.58	(-1.36; 0.21)	
2008–2011	Immunopreventable diseases	5.60	(2.97; 8.18)	> 99.9
	Infectious diseases	-0.22	(-1.84; 1.46)	22.1
	Noncommunicable diseases	1.34	(0.66; 1.99)	95.0
	Maternal causes	0.26	(-2.22; 2.72)	40.1
	External causes	-0.52	(-1.71; 0.68)	8.5
	Ill-defined causes	2.12	(0.45; 3.84)	96.0
	Unavoidable causes	0.49	(-0.28; 1.24)	
2012–2015	Immunopreventable diseases	5.01	(3.91; 6.10)	> 99.9
	Infectious diseases	0.90	(0.27; 1.55)	81.5
	Noncommunicable diseases	1.39	(1.11; 1.66)	> 99.9
	Maternal causes	-0.13	(-1.10; 0.88)	11.7
	External causes	-0.07	(-0.56; 0.42)	1.5
	Ill-defined causes	3.61	(2.93; 4.26)	> 99.9
	Unavoidable causes	0.58	(0.26; 0.87)	
2016–2019	Immunopreventable diseases	3.79	(3.13; 4.47)	> 99.9
	Infectious diseases	1.29	(0.90; 1.67)	99.1
	Noncommunicable diseases	1.26	(1.09; 1.43)	> 99.9
	Maternal causes	0.14	(-0.48; 0.71)	3.8
	External causes	0.97	(0.68; 1.26)	87.4
	Ill-defined causes	2.74	(2.34; 3.16)	> 99.9
	Unavoidable causes	0.77	(0.58; 0.95)	

Mortality rates were adjusted by age group and gender. UI, uncertainty interval. * "Positive impact" was defined as larger reduction than that of unavoidable causes of death.

Recently, however, the pandemic of COVID-19 (coronavirus disease 2019) has brought to the attention of the health sector the importance of airborne aerosol (rather than ballistic droplets or contaminated surfaces) for the transmission of respiratory diseases[19]. Recognizing that respiratory diseases are airborne has important implications for the engineering of indoor environments[20], and may lead to better regulations and standards[21], allowing health surveillance to control airborne diseases just as today it controls waterborne and foodborne ones. In the long term, such a "paradigm shift" may result in a more pronounced reduction in deaths from pneumonia and other infectious diseases.

Deaths from noncommunicable diseases have the largest absolute reduction among all causes of death and are (with immunopreventable diseases) one of the groups with the greatest certainty of a positive impact from the health system. The results of this study agree with estimates of the Global Burden of Disease, and confirm the achievements of the Strategic Action Plan to Tackle Noncommunicable Diseases, which articulates health promotion, health surveillance and health care[22]. Brazil is an international leader in fighting smoking and promoting healthy eating[2,23], has expanded its health surveillance to combat non-communicable diseases[24], and the expansion of the Family Health Strategy has also helped to reduce mortality from this group of avoidable causes[25].

From 2015 to 2017, following the establishment of a 20-year fiscal austerity plan, Malta et al.[26] identified an increase in risk factors for noncommunicable diseases in Brazil, and Malta et al.[27] identified an increase in deaths from this group. Inspecting the year-on-year variation in the present study confirms this increase in deaths from 2015 to 2017, but also shows a further reduction from 2017 to 2019. In addition, the annual percentage reduction in the 2016-2019 quadrennium was similar to that in the 2012-2015 quadrennium.

The Brazilian health system does not seem to have had a positive impact on maternal deaths during the 2012-2015 and 2016-2019 quadrenniums. In these latter years, the present study found a stabilization of maternal deaths, as described by Leal et al.[28] instead of the decline in 2000-2013 described by Malta et al.[11] This interruption of the decline cannot be attributed to the establishment of universal investigation of deaths of women of reproductive age, since the maternal component of the national list of avoidable deaths does not include indirect obstetric causes of maternal death[4,8] (non-obstetric conditions that have been aggravated by pregnancy).

This lack of a positive impact is absurd, as maternal deaths are considered highly avoidable[29]. Furthermore, fertility in Brazil is declining[28], which in itself should reduce maternal deaths relative to population size. Previous research found low-risk births to often receive unnecessary interventions and half of women not to receive all recommended interventions during delivery[30]. Cesarean births are remarkably common in Brazil, having increased from 40% in 1995 to 55% in 2015[28]. Although much more common in private health care (85%), cesarean births are also excessive in the SUS (36%)[30]. In the absence of a clinical indication, the choice for cesarean delivery is complex and involves concerns about the quality of health care and even obstetric violence [31]. Maternal near misses are more common in public hospitals (compared to private ones), when care is funded by the SUS, or when the parturient has to seek more than one hospital before being admitted[32]. There is much room for improvement in obstetric care in Brazil, and achieving such improvements has proved difficult.

Deaths from external causes declined slightly more than those from non-avoidable causes in 2016-2019, and remained stable in 2012-2015. Looking at subgroups of external causes of death, Souza et al.[33] found that accidental deaths declined in Brazil by about one-third from 1990 to 2015, while deaths from suicide or interpersonal violence declined by only 5%. For ages 10-24, Malta et al.[34] found no increase in suicide from 1990 to 2019 (both sexes), while deaths from interpersonal violence increased from 58 to 79 deaths per 100,000 in males. It is interesting to note that Figures 2 and 3 of that study[34] showed a downward inflection in total mortality in males at ages 15-24 after the year 2015. The *Atlas da Violência* 2021[35] report also describes such an inflection for homicides for the population as a whole, and identifies a number of reasons. The report attributes this decline in homicides to various state-level security policies created between 2000 and 2011, the 2003 firearms regulation (*Estatuto do Desarmamento*) and, perhaps more specifically, an armistice between criminal factions[35]. Because most deaths from external causes are intentionally inflicted, intersectoral peace-promoting policies stand a better chance to reduce avoidable deaths than interventions specific to the health system.

In summary, the SUS has had a positive impact on reducing deaths from immunopreventable, infectious and noncommunicable diseases in Brazil, although not as much for maternal deaths and external causes. In the coming years, the effectiveness of the health system could be further improved through the continued strengthening of primary health care and the incorporation of evidence-based therapeutic and diagnostic resources. In addition, childbirth care should be greatly improved, with universal access to humane and safe health services. Additionally, interpersonal violence and indoor air quality could greatly benefit from intersectoral health promotion, resulting in greater prevention of deaths from external and infectious causes. On the other hand, political instability, fiscal austerity and the COVID-19 pandemic are potential threats to the effectiveness of the health system.

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