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Excess of deaths during COVID-19 pandemic in Mato Grosso, Brazil

Excesso de mortes durante a pandemia de COVID-19 em Mato Grosso, Brasil

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Abstract *This article aims to estimate the excess of deaths in the years 2020 and 2021 in Mato Grosso state, in the state capital and in the countryside, according to gender and age group. Data was extracted from DATASUS/Ministry of Health website for the period from 2015 to 2020 and from the website of the State Department of Health - Data Warehouse System (DW) for 2021. Non-fetal deaths by natural causes of residents in Mato Grosso were analyzed and the analyses were broken down into countryside and state capital (Cuiabá). The variables selected were age group, gender, month of occurrence, and underlying cause of death. Excess mortality was calculated using generalized additive quasi-Poisson model adjustments with correction for overdispersion. A 30% excess of deaths was identified in 2020, with the state capital recording the highest estimate, in older age groups, and between the months of July and September. In 2021, the expected number of deaths was 57% higher, with the double in the younger age groups in the countryside. The study showed different demographic profiles of excess deaths in the years 2020 and 2021 during COVID-19 pandemic and distinct patterns between countryside and state capital, suggesting inequalities that may have caused impact on different risks.*

Key words *Mortality, COVID-19, COVID-19 pandemic, Excess mortality rate, SARS-CoV-2, Infectious diseases*

Resumo *O objetivo deste artigo é estimar o excesso de óbitos nos anos de 2020 e 2021 no estado de Mato Grosso, na capital do estado e no interior, segundo sexo e faixa etária. Os dados foram extraídos do site do DATASUS/Ministério da Saúde para o período de 2015 a 2020 e do site da Secretaria de Estado da Saúde – Sistema Data Warehouse (DW) para 2021. Óbitos não fetais por causas naturais de residentes no Mato Grosso foram analisados e as análises foram divididas em interior e capital do estado (Cuiabá). As variáveis selecionadas foram: faixa etária, sexo, mês de ocorrência e causa básica do óbito. O excesso de mortalidade foi calculado usando ajustes generalizados do modelo aditivo quase-Poisson com correção para superdispersão. Identificou-se um excesso de 30% de óbitos em 2020, com a capital do estado registrando a maior estimativa, nas faixas etárias mais avançadas, e entre os meses de julho e setembro. Em 2021, o número esperado de óbitos foi de 57% superior, sendo o dobro nas faixas etárias mais jovens do interior do estado. O estudo mostrou diferentes perfis demográficos de excesso de óbitos nos anos de 2020 e 2021 durante a pandemia de COVID-19 e padrões distintos entre interior e capital do estado, sugerindo desigualdades que podem ter impactado em diferentes riscos.*

Palavras-chave *Mortalidade, COVID-19, Excess mortality rate, SARS-CoV-2, Doenças infecciosas*

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Introduction

COVID-19 pandemic is so far deemed to be the major health challenge of this century. After one year and four months of the pandemic, Brazil has accumulated 19,917,855 cases and 556,370 deaths, ranked second in the world in the accumulated number of deaths[1]. The state of Mato Grosso, in the central region of the country, recorded the second highest COVID-19 mortality rate in the country on July 17, 2022, with 14,795 deaths (425 deaths/100,000 habitants). The lack of national and integrated planning among the federation entities and the unfavorable political scenarios are among some of the factors that strongly affected the pandemic and its impact on the country's mortality[3].

Excess deaths are typically defined as the difference between the observed numbers of deaths in specific time periods and expected numbers of deaths in the same time periods[4]. The analysis of the excess number of deaths is an alternative way to estimate the epidemic's severity, representing the unexpected deaths in a given period and based on the mortality rate recorded in previous years. During a pandemic, excess deaths can be caused either directly by the disease or indirect due to other causes, as a consequence of the overburdening of the health system, population fear of seeking out medical care for sudden illnesses, as well as by the measures required to control the spread of the disease and are closely linked to the country's demographic and social and economic profile and may also present inequalities within the same country and between population groups, according to known risk factors for the worsening of the disease[5,6]. In addition, it should consider the consequent long-term effects of COVID-19, a recent study with preliminary data from the 2021 National Mortality System death records, showed that more than 2,900 deaths were caused by post-COVID-19 conditions in Brazil[7].

The first case of COVID-19 registered in Mato Grosso was confirmed in March of 2020, with the first death registered in early April of same year. Estimates from a seroepidemiological survey carried out between September and October 2020 showed the prevalence of 12.5% of antibodies against SARS-CoV-2, which would represent a number of cases 77% higher than officially registered[8]. In the first wave of the disease in 2020, the maximum number of cases was recorded in July, with weeks of maximum occupancy of the number of beds, in 2021, the second wave again caused the collapse of the Health System, with a queue of waiting for ICU beds between March and May[9]. In addition, through the same survey, it was found that 40% of cases were asymptomatic[10] and more than half of the population reported having used ivermectin to prevent COVID-19[11], medicine included in the COVID Kit adopted by the state government and distributed to cases diagnosed in the Unified Health System[12], even without having efficacy against COVID-19.

In this context, considering the number of deaths caused by the COVID-19 pandemic in the country and as Mato Grosso is one of the states with the highest mortality rate due to the disease, we hypotheses that there was an excess of death due natural causes in this state during the two first year of the pandemic. Therefore, the purpose of this study is to analyze the exceeding number of deaths during COVID-19 pandemic in the state in the years 2020 and 2021.

Methodology

The study was conducted using death data from the Mortality Information System extracted from DATASUS/Ministry of Health website for the years 2015 to 2020 (https://datasus.saude.gov.br/mortalidade-desde-1996-pela-cid-10) and from the website of the State Department of Health – Data Warehouse (DW) System, for 2021, as these are not available on the Ministry of Health website. All the data obtained on May 11, 2022. The 2015-2020 data are considered finalized by the Ministry of Health, and data from 2021 are available for public access, but on a preliminary basis. Natural causes were considered to be those classified in chapters I to XVIII of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). Non-fetal deaths of residents in Mato Grosso were analyzed and the analyses were broken down into countryside and state capital (Cuiabá). The variables selected were: age group, gender, month of occurrence, and underlying cause of death. COVID-19 deaths were classified according the guidelines of the Health Surveillance Department of the Ministry of Health, encoding B34.2 for deaths whose underlying cause was COVID-19 in Brazil.

Mortality rate by COVID-19 (per 100,000 inhabitants) was calculated for Mato Grosso, Cuiabá and interior. The estimates population obtained from the Department of Informatics of the Unified Health System. Mortality rates were

standardized by age, using the direct method, considering the Brazilian population.

The mortality data observed during the years 2015-2019, were used to obtain a prediction of the expected number of deaths in 2020 and 2021. The prediction of the number of expected deaths, according to age group (0-19; 20-39; 40-59; 60-69; 70-79; 80+), gender (female; male) and trimester (January-March; April-June; July-September; October-December) was obtained through generalized additive quasi-Poisson model adjustments with correction for overdispersion. Age group, gender, trimester, and year of occurrence were considered as predictors in the respective models for Mato Grosso, Cuiabá, and the countryside. The year of occurrence variable was adjusted in a non-parametric way (spline), to capture possible non-linear trends in mortality over the assessed period. The excess of death estimate was calculated using the ratio between the number recorded in 2020 and 2021 and the expected number of deaths in a non-pandemic scenario (2015-2019), the results were presented in percentages, accompanied by their respective 95% confidence intervals (95%CI) and statistical significance was considered by not including the null value in the 95%CI. The analyses were performed in R software, version 3.6.4 (http://www.r-project.org) with package mgcv (Mixed GAM Computation Vehicle with Automatic Smoothness Estimation).

This research is linked to the research project Monitoring COVID-19 in Mato Grosso, approved by the Ethics Committee of the Mato Grosso State University (Opinion number: 4.602.628 of March 20, 2021). The signature of a consent document was waived, since the data used was not identified by name and had public access, as established by the resolution of the National Health Council No. 510, dated April 7, 2016.

Results

In 2020, 20,246 deaths were recorded due to natural causes for people residing in Mato Grosso, with 5,450 more deaths than the average for 2015 to 2019 (14,796). In 2021, 25,249 deaths, 70% higher the number of deaths for this period.

In 2020 and 2021, the mortality rate due to COVID-19 in Mato Grosso was 126.3/100,000 inhabitants and 266.5/100,000 inhabitants, respectively, where the state capital recorded the highest rates when compared to the countryside in both periods. Men had higher mortality rates when compared to women. The age distribution shows the growth of mortality rates with increasing age, however differently between the state capital and the countryside. In the countryside, both in 2020 and 2021, mortality rates in the elderly aged 60 to 69 years are higher than those aged 70 to 79, while the opposite is seen in the state capital. In all age groups the mortality rate is higher in the state capital, highlighting the difference in rates in the 70 to 79 age group when compared to the countryside (Table 1).

By analyzing the monthly distribution of deaths from natural causes, it is possible to see stability in the number of deaths over the years from 2015 to 2019 (Figure 1). In 2020, as from June we witnessed a growth, and consequently an excess of deaths, which continues until September when compared to the same months in the previous five years. In 2021, between January and June, the excess of deaths is even more expressive, with March and April being the months that stood out the most. We point out that the first death from COVID-19 in residents of Mato Grosso occurred on April 4, 2020.

The excess deaths, in relative terms, were similar in all genders in both years. Among children and adolescents, there is no significant excess of deaths in the capital, but in the state and interior there lower than expected numbers of deaths in 2020, a pattern that differs from that observed in 2021there were no significant excess of deaths for the state, capital, and countryside (Table 2). In 2020, when evaluated the age groups, the highest growth was recorded both in the state and in the countryside, among the elderly aged 60 to 69 years and 80 years and over, and in the state capital for age groups 60 to 69 years (60%) and 70 to 79 years (52%). In 2021, the excess deaths are most noticeable in all age groups, except 0 to 19 years old; the highest growth is seen in adults aged 40 to 49 in the state (95%), in the countryside (91%), and in the state capital (113%).

When assessing the distribution of deaths over the trimester of 2020, it is noteworthy that between July and September there was double the number of deaths recorded in the average of the previous five-year period in the state capital. In 2021, the first trimester (January to March) recorded twice as many deaths in the countryside of the state (136%), and, in the state capital, the excess of deaths was higher between April and June (Table 2).

The excess of deaths from natural causes between age groups is distinct when comparing

Table 1. Deaths and Mortality Rate (100,000 inhabitants) by COVID-19. Mato Grosso, countryside and state capital in 2020 and 2021.

	2020			2021		
	Mato Grosso	Interior	Cuiabá	Mato Grosso	Interior	Cuiabá
Deaths by covid-19	4,454	3,274	1,180	9,397	7,012	2,385
MR* by covid-19	126.31	112.57	190.99	266.49	241.10	386.02
MR* by covid-19**	132.21	118.33	215.06	273.81	248.35	422.62
Sex						
Female	97.99	83.55	169.06	216.18	190.13	344.42
Male	155.41	142.86	211.91	318.01	294.08	425.71
Age group						
0 - 19	2.66	2.85	1.71	2.76	2.74	2.84
20 - 39	19.16	17.62	26.37	69.76	66.10	86.92
40 - 59	134.45	121.99	190.09	367.67	343.72	474.61
60 - 69	454.49	410.50	633.67	919.11	835.19	1260.92
70 - 79	444.36	349.56	1420.13	786.60	626.44	2435.19
80+	1953.63	1798.40	2632.20	2808.48	2540.98	3977.81

* MR: Mortality Rate; ** Standardized by population of Brazil.

Source: Authors.

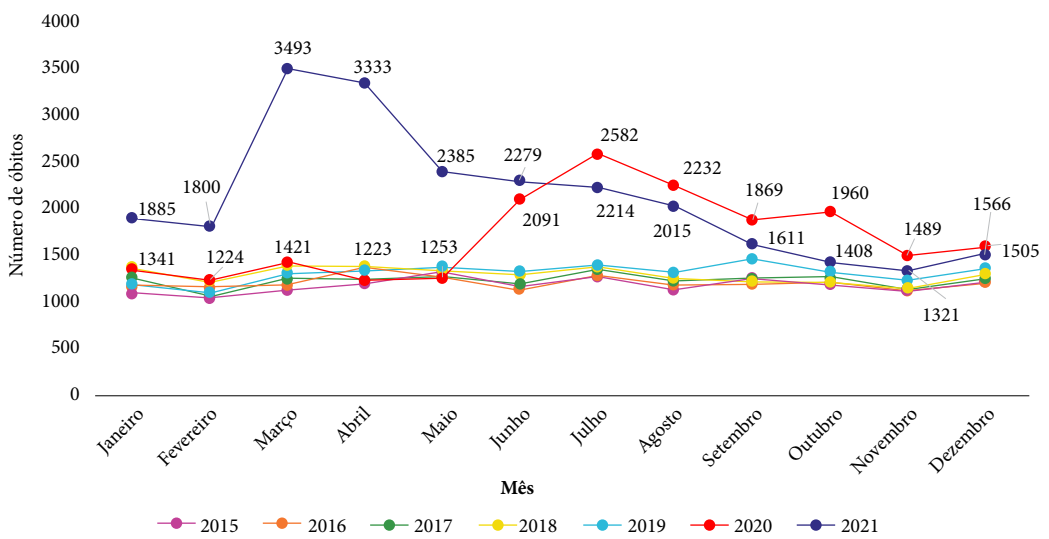

Figure 1. Number of deaths* according to month of occurrence. Mato Grosso, 2015 to 2021.

Natural causes (chapters I to XVIII, ICD-10).

Source: Authors.

female and male in 2020 (Table 3). The largest growth in females was seen in seniors aged 80 and over for the state (52%), countryside (47%), and state capital (69%). Among males, the highest growth was in seniors aged 60 to 69 in the state (46%), in the countryside (39%), and in the state capital (77%), and in adults (40 to 59) in the state (41%) and in the countryside (37%), and in the age group 20 to 39 in the state capital (60%). Noteworthy is the reduction in deaths among children and adolescents for the state and countryside in 2020, for males only. July through September were the months that showed the highest growth in deaths in all genders, being the most significant

Table 2. Excess of deaths from natural causes in 2020 and 2021, according to sex, age group and month of occurrence. Mato Grosso, countryside and state capital.

	Mato Grosso		Interior		Capital	
	O/E (n)	% Growth (95CI%)	O/E (n)	% Growth (95CI%)	O/E (n)	% Growth (95CI%)
2020						
General	20,246/15,785	28 (16; 44)	15,791/12,714	24 (12; 40)	4,455/3,071	45 (20; 84)
Sex						
Female	8,356 /6,613	26 (14; 42)	6,394 /5,207	23 (10; 38)	1,962 /1,398	40 (16; 78)
Male	11,890 /9,172	30 (17; 46)	9,397 /7,507	25 (13; 41)	2,493 /1,673	49 (23; 89)
Age group						
0 - 19	894 /1,097	-18 (-27; -7)	724 /932	-18 (-22; -11)	170 /167	2 (-18; 34)
20 - 39	1,139 /930	22 (9; 36)	913 /764	19 (7; 36)	226 /167	36 (10; 76)
40 - 59	4,381 /3,346	31 (18; 47)	3,400 /2,656	28 (15; 44)	981 /688	43 (18; 80)
60 - 69	4,148 /3,047	36 (23; 52)	3,175/2,439	30 (17; 46)	973 /608	60 (33; 102)
70 - 79	4,582 /3,519	30 (17; 46)	3,555 /2,844	25 (13; 40)	1,027 /676	52 (26; 91)
80+	5,102 /3,846	33 (20; 49)	4,024 /3,079	31 (18; 46)	1,078 /766	41 (17; 77)
Month						
Jan-Mar	3,983 /3,917	2 (-8; 14)	3,178 /3,165	0 (-10; 13)	805 /753	7 (-12; 35)
Apr-Jun	4,566 /3,937	16 (4; 30)	3,505 /3,174	10 (-1; 24)	1,061 /763	39 (15; 76)
Jul-Sep	6,682 /3,956	69 (52; 90)	5,110 /3,183	60 (45; 80)	1,572 /773	103 (68; 157)
Oct-Dec	5,015 /3,975	26 (14; 42)	3,998 /3,193	25 (13; 41)	1,017 /782	30 (7; 65)
2021						
General	25,249/15,813	57 (23; 128)	19,832/ 12,815	55 (19; 122)	5,417/ 2,998	81 (15; 322)
Sex						
Female	10,592 /6,625	60 (23; 128)	8,192/3,662	56 (20; 124)	2,400 /1,364	76 (12; 311)
Male	14,657 /9,188	59 (23; 127)	11,640 /5,281	54 (18; 120)	3,017 /1,633	85 (17; 331)
Age group						
0 - 19	976 /1,098	-11 (-32; 28)	833 /940	-11 (-32; 29)	143 /163	-12 (-44; 111)
20 - 39	1,722 /649	85 (42; 165)	1,381 /770	79 (37; 158)	341 /163	109 (33; 398)
40 - 59	6,546 /2,349	95 (50; 179)	5,115 /2,677	91 (47; 174)	1,431/671	113 (36; 397)
60 - 69	5,280 /2,140	73 (33; 147)	4,079 /2,458	66 (27; 137)	1,201 /593	102 (29; 371)
70 - 79	5,371 /2,473	52 (17; 117)	4,222 /2,867	47 (13; 111)	1,149/660	74 (11; 305)
80+	5,354 /2,702	39 (7; 98)	4,202 /3,103	35 (4; 94)	1,152 /748	54 (-2; 258)
Month						
Jan-Mar	7,178 /3,924	83 (41; 161)	5,443 /3,190	71 (31; 144)	1,735 /735	136 (50; 451)
Apr-Jun	7,997/3,943	103 (56; 189)	6,383 /3,199	99 (53; 185)	1,614 /744	117 (38; 406)
Jul-Sep	5,840 /3,963	47 (13; 110)	4,619 /3,208	44 (11; 106)	1,221 /754	62 (3; 278)
Oct-Dec	4,234 /3,982	6 (-18; 52)	3,387 /3,217	5 (-19; 50)	847 /764	11 (-29; 159)

O: observed; E: expected; 95CI%: confidence interval of 95%.

Source: Authors.

in males, in the state (72%), in the countryside (62%), and in the state capital (114%).

In 2021, the excess of deaths occurred in even more expressive figures when compared to 2020 and in younger age groups (Table 4). Among males, the largest growth was in adults aged 40 to 49, in the state (107%) and countryside (101%), but in adults aged 20 to 39 years and state capital (144%). Adults women aged 40 to 59 recorded the highest growth in deaths in the state and in the countryside, while in the capital the highest excess of deaths was among elderly (60 to 69 years old) with 90% growth. April to June were the months with the highest excess of deaths.

Discussion

In Mato Grosso, the deaths registered in 2020 exceeded 27% of the expected deaths, with high-

Table 3. Excess of deaths from natural causes among men and women, according to age group and month. Mato Grosso, countryside and state capital, 2020.

	Mato Grosso		Interior		Capital	
	O/E (n)	% Growth (95CI%)	O/E (n)	O/E (n)	% Growth (95CI%)	O/E (n)
Female						
Age group						
0 - 19	407 /459	-11 (-21; 1)	332 /382	-13 (-22; 0)	75 /76	-2 (-21; 30)
20 - 39	436 /389	12 (0; 27)	356 /313	14 (1; 29)	80 /76	5 (-14; 37)
40 - 59	1,635 /1,402	17 (5; 31)	1,253 /1,088	15 (4; 29)	382 /313	22 (1; 54)
60 - 69	1,567 /1,277	23 (11; 38)	1,180 /999	18 (6; 32)	387 /277	40 (16; 76)
70 - 79	1,866/1,474	27 (14; 42)	1,417 /1,165	22 (10; 36)	449 /308	46 (21; 84)
80+	2,445 /1,611	52 (37; 70)	1,856 /1,261	47 (33; 65)	589 /349	69 (40; 113)
Month						
Jan-Mar	1,688 /1,641	3 (-7; 16)	1,310 /1,296	1 (-9; 14)	378 /343	10 (-9; 40)
Apr-Jun	1,850/1,649	12 (1; 26)	1,380 /1,300	6 (-5; 19)	470 /347	35 (12; 71)
Jul-Sep	2,732 /1,657	65 (48; 85)	2,061/1,304	58 (42; 78)	671 /352	91 (58; 141)
Oct-Dec	2,086 /1,665	25 (13; 41)	1,643 /1,308	26 (13; 41)	443 /356	24 (3; 58)
Male						
Age group						
0 - 19	487 /637	-23 (-31; -13)	392 /551	-28 (-37; -19)	95 /91	4 (-16; 37)
20 - 39	703 /540	30 (16; 48)	557 /451	23 (10; 40)	146 /91	61 (31; 109)
40 - 59	2,746 /1,944	41 (27; 59)	2,147 /1,568	37 (23; 54)	599 /375	60 (32; 102)
60 - 69	2,581 /1,771	46 (32; 63)	1,995 /1,440	39 (25; 55)	586 /331	77 (47; 123)
70 - 79	2,716 /2,045	33 (20; 49)	2,138 /1,679	27 (15; 43)	578 /368	57 (30; 98)
80+	2,657 /2,235	19 (7; 33)	2,168 /1,818	19 (8; 33)	489 /417	17 (-3; 47)
Month						
Jan-Mar	2,289 /2,276	1 (-9; 13)	1,868 /1,868	0 (-10; 12)	427 /411	4 (-14; 32)
Apr-Jun	2,701 /2,287	19 (7; 33)	2,125 /1,874	13 (2; 27)	591 /416	42 (18; 80)
Jul-Sep	3,913/2,299	72 (55; 93)	3,049 /1,879	62 (46; 82)	901 /421	114 (77; 171)
Oct-Dec	2,898 /2,310	27 (14; 42)	2,355 /1,885	25 (12; 40)	574 /426	35 (11; 71)

O: observed; E: expected; 95CI%: confidence interval of 95%.

Source: Authors.

er estimates in the state capital, in the older age groups, and between the months of July and September. In 2021, this excess occurred in even more expressive figures, when compared to 2020, being approximately 55% higher the expected amount in state and countryside and 81% higher in capital, with emphasis on younger age groups.

Previous studies analyzed the excess mortality during the pandemic in Cuiabá, capital of Mato Grosso[13,14]. Santos et al.[15] showed that Mato Grosso was one of the three Brazilian states with the most excess deaths, therefore indicating a heavier impact of the pandemic in these states. For the authors, the lower purchasing power of these populations, implying reduced social distance practices, including remote home-based work, may be one of the explanations for the higher excess of deaths in these locations[15].

The results of this study are like other national studies when considering the finding of excess of deaths in 2020, however, the magnitude is different according to the period considered. In Belo Horizonte, the excess of deaths was estimated at 16.1% until October 2020, and it was higher in the most vulnerable areas of the city[16]. Silva et al.[3], when assessing excess mortality from March to May 2020 in the capital cities and in other municipalities of the country, found only 33 deaths beyond the expected for the state capital of Mato Grosso, and no excess deaths in the countryside of the state. For 2021, the excess of deaths estimated was higher than in 2020 in Mato Grosso, but so far there have been no studies assessing this estimate in Brazil.

The excess of deaths was higher in the state capital compared to all the municipalities in the

Table 4. Excess of deaths from natural causes among men and women, according to age group and month. Mato Grosso, countryside and state capital, 2021.

	Mato Grosso		Interior		Capital	
	O/E (n)	% Growth (95CI%)	O/E (n)	O/E (n)	% Growth (95CI%)	O/E (n)
Female						
Age group						
0 - 19	429 /460	-7 (-29; 34)	376 /384	-2 (-25; 41)	53 /74	-29 (-55; 72)
20 - 39	690 /390	77 (36; 154)	565 /315	79 (37; 158)	125 /74	69 (7; 302)
40 - 59	2,511 /1,404	79 (38; 155)	1,942/1,096	77 (36; 154)	529 /305	86 (18; 335)
60 - 69	2,108 /1,279	65 (27; 135)	1,594 /1,007	58 (22; 127)	514/270	90 (21; 344)
70 - 79	2,298 /1,477	55 (20; 122)	1,765 /1,174	50 (15; 115)	533 /300	77 (13; 313)
80+	2,556 /1,614	58 (22; 126)	1,950 /1,271	53 (18; 119)	606 /340	78 (13; 314)
Month						
Jan-Mar	3,060/1,644	86 (43; 166)	2,285/ 1,306	75 (34; 151)	775/ 334	131 (47; 441)
Apr-Jun	3,293/1,652	99 (53; 184)	2,583/ 1,310	97 (51; 182)	710/ 339	109 (33; 389)
Jul-Sep	2,437/1,660	47 (13; 109)	1,904/ 1,314	45 (11; 107)	533/ 343	55 (-1; 262)
Oct-Dec	1,802/1,668	8 (-17; 54)	1,420/ 1,317	8 (-17; 54)	382/ 347	10 (-30; 157)
Male						
Age group						
0 - 19	547 /638	-14 (-34; 23)	457 /555	-18 (-37; 19)	90 /89	1 (-36; 143)
20 - 39	1,032 /541	91 (46; 174)	816 /455	79 (37; 158)	216 /89	144 (54; 480)
40 - 59	4,035 /1,947	107 (59; 196)	3,173 /1,580	101 (54; 187)	862 /366	136 (50; 450)
60 - 69	3,172 /1,773	79 (38; 155)	2,485 /1,451	71 (32; 145)	687 /323	112 (35; 394)
70 - 79	3,073 /2,048	50 (15; 114)	2,457 /1,693	45 (11; 108)	616 /359	71 (9; 299)
80+	2,798 /2,238	25 (-4; 78)	2,252 /1,832	23 (-5; 76)	546 /407	34 (-15; 212)
Month						
Jan-Mar	4,118/2,280	81 (39; 158)	3,158/ 1,883	68 (29; 140)	960/ 401	140 (52; 460)
Apr-Jun	4,704/2,291	105 (58; 193)	3,800/ 1,888	101 (54; 188)	904/ 406	123 (42; 420)
Jul-Sep	3,403/2,302	48 (14; 111)	2,715/ 1,894	43 (10; 105)	688/ 411	67 (6; 291)
Oct-Dec	2,432/2,314	5 (-19; 50)	1,967/ 1,900	3 (-20; 48)	465/ 416	12 (-29; 161)

O: observed; E: expected; 95CI%: confidence interval of 95%.

Source: Authors.

countryside of the state. One possible explanation is that different behavior in the state was seen in the speed of COVID-19 spread among municipalities; the first case recorded occurred in the Baixada Cuiabana Health Region, which includes the two most populous municipalities in the state, Cuiabá and Várzea Grande[17]. COVID-19 pandemic spread with the movement and interaction of people, and large cities share transportation networks, economic and social activities, which contribute to increased movement and interaction between people between and within cities. A study conducted in the United States showed that large metropolitan areas had higher infection and mortality rates, and that connectivity between cities was more important than population density in spreading COVID-19 pandemic[18]. In Brazil, the first deaths occurred almost exclusively in the metropolitan areas, and as the pandemic spread, it reached municipalities of 100 thousand and 500 thousand inhabitants, and despite the internalization, the deaths were concentrated in the big cities[19]. According to Nicolelis et al.[20], in the country's capital cities, there has been a "boomerang effect", which is characterized by the flow of infected people from the capital cities to the countryside, and then back to the capital cities, which concentrate the hospital care and intensive care units.

Regarding the difference between genders, the debate about the extent to which the biological expressions of gender, gender-linked biology

interact and interfere for exposure, susceptibility and health outcomes is not recent in the scientific literature[21]. For COVID-19, speculation has focused on both social aspects of gender (e.g., higher likelihood of smoking and less hand washing among men compared to women) and biological susceptibility (e.g., related to sex hormones)[9,22].

This study showed no significant difference in excess mortality between men and women, which differed from other studies, both international[23,24] and national[3,17,25], in which excess deaths were more significant among men. On the other hand, the age profile of excess deaths among men and women is distinct in 2020 in the population under analysis, with a reduction of deaths in children and adolescents only among men, and the excess of deaths was more expressive among elderly women (aged 80 or more and aged 70 to 79 years), and, among men, this excess was higher among the elderly aged 60 to 69 years and adults aged 40 to 59 years. These results are similar to the findings of Fernandes et al.[26] in São Paulo, with an excess of deaths for men aged 45 years and older, and for women aged 60 to 79 years only.

Regarding age groups, in 2020 inequalities in mortality were more apparent in people over the age of 40 compared to younger people, and this is an expected result, since it is known that lethality by COVID-19 is higher with advancing age[27]. However, studies in Brazil have shown that in the first months of 2021, during the second wave of the pandemic in the country, there was a change in the profile of severe cases and deaths, with a more expressive increase among young and middle-aged individuals when compared to the elderly[28,29]. This is consistent with what was found in this study where the excess deaths were higher among adults compared to the elderly in 2021, where the excess deaths among 20 to 69 year old was between 73% and 95% and among the elderly 80 years and older was 39%. This profile may have been influenced by the start of vaccination for the older age groups and patients with comorbidities that aggravate the disease, highlighting the importance of the prioritization of these groups in Brazil.

The reduction in deaths among male children and adolescents in 2020 in the state has been found in other studies and can be explained by the longer time that this population stayed at home with the suspension of school classes[17,30]. When breaking down into state capital and countryside, this reduction was seen only for the latter.

The months of highest excess of deaths in the state for both 2020 and 2021 are consistent with the waves of highest number of cases, hospitalizations, and deaths caused by COVID-19 in the state. The ICU bed occupancy rate in July 2020 was over 90%, with subsequent waiting lines for ICU beds in the state being recorded for several weeks. The same occurred between March and May 2021, which possibly hindered the appropriate care to the population requiring health services not only for COVID-19, but for other diseases and morbidities, consequently increasing the number of preventable deaths[9,31].

In this study, we analyzed only natural causes of death, once data from 2021 are available as preliminary basis. But it should be highlighted as a limitation because did not capture the reductions that may have occurred in deaths from external causes.

It is important to highlight the challenges in recording deaths caused by COVID-19, especially in the first months of cases of the disease, since the underreporting of cases due to the scarcity of testing may have influenced the real cause of death, as well as the proportion of cases that may have been recorded as being caused by some comorbidity, even if the person had COVID-19[32]. In May 2020, the Brazilian Ministry of Health published guidelines for coding the causes of death in the context of COVID-19, in which it standardized its registration in part I of the certificate (basic cause - disease or morbid condition that directly caused the death), composing the logical sequence of events recorded by the physician. For cases of deaths caused by other diseases or accidents in cases of individuals with COVID-19, the guidance is that if the certifier considers COVID-19 to have aggravated or contributed to the death, he or she may report it in part II of the certificate[33]. Therefore, the standardization of the records for feeding the Mortality Information System may have avoided mistakes in the certification of suspected or confirmed COVID-19 deaths.

Conclusion

This study showed the profile of excess deaths according to gender and age group in Mato Grosso during the COVID-19 pandemic, identifying different profiles at different times of its confronting in 2020 and 2021. Distinct patterns of excess deaths were also unfolded between countryside and the state capital, suggesting inequalities that may have caused impact in different risks for these populations. This highlights the impor-

tance of monitoring excess deaths at the regional or state level, considering stratifications such as those analyzed in this study, capable of assessing the discrepant effects of the pandemic on population subgroups.

Collaborations

LR Oliveira, AP Muraro: study design and manuscript writing; ACS Andrade: statistic analysis, study design and manuscript writing; MS Cecconello, MC Lalucci: manuscript writing. All authors revised the manuscript and approved its final submitted version.

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