TECHNICAL NOTE

Excess Mortality in Brazil: Detailed Description of Trends in Mortality During the COVID-19 Pandemic

Fatima Marinho[1], Ana Torrens[2], Renato Teixeira[2], Elisabeth França[3], Ana Maria Nogales[4], Daisy Xavier[5], Thomas Fujiwara[6]

1. Vital Strategies – Senior Technical Advisor – corresponding author – fmarinho@vitalstrategies.org
2. Vital Strategies – Technical Advisors and Research Consultants
3. Federal University of Minas Gerais (UFMG) - Associate Professor – Faculty of Medicine
4. University of Brasília (UnB) - Statistics Department
5. Federal University of Minas Gerais (UFMG) - Researcher - Epidemiology and Evaluation of Health Services Research Group – Faculty of Medicine
6. Princeton University - Associate Professor of Economics and Brazil LAB Associate Director - Department of Economics

Introduction

Why analyze excess deaths?

Measuring the specific mortality of COVID-19 has been a challenge worldwide. In many countries, limited testing availability has led to restrictive criteria for access to testing, even for symptomatic people. This makes it impossible to generalize test results, and extremely difficult to interpret COVID-19 "case" and "death" counts.[1] Considering the low number of test kits for the coronavirus that causes COVID-19 (SARS-CoV-2) in Brazil, and the difficulties in collecting, transporting and storing material for laboratory examination, there is consensus that underreporting of COVID-19 cases and deaths[2] is a reality in the country, thus making it difficult to control the epidemic.[3] Nevertheless, it is important to acknowledge that states and

1 WHO: Revealing the Toll of COVID-19: A Technical Package for Rapid Mortality Surveillance and Epidemic Response, 2020.
2 França EB, Ishitani LH, Teixeira RA, Abreu DX, Corrêa PRL, Marinho F, Vasconcelos AMN. Deaths due to COVID-19 in Brazil: how many are there and which are being identified? REV BRAS EPIDEMIOL 2020; 23: E200053.
3 Cimerman S, Chebabo A, Cunha CA, Rodriguez-Morales AJ, Deep Impact of COVID-19 in the HealthCare of Latin America: the case of Brazil, Brazilian Journal of Infectious Diseases (2020).

municipalities made an effort to buy tests and increase the testing capacity of the Public Health Laboratories, which resulted in a recent increase in testing.

The impact of pandemic diseases on population mortality is well known.[1] In addition to deaths directly associated with the disease itself and indirectly due to overcrowding in hospitals and health clinics, people with chronic diseases or acute illnesses may fear becoming infected with COVID-19 when seeking hospital care; some may also avoid care because of restrictions on movement. Therefore, observing excess mortality from all causes, or all natural causes, can lead to insights about the consequences of the epidemic on the population's health, serving to inform health managers about the ongoing patterns of viral transmission and the movements of the epidemic. Although more specific indicators are essential for good monitoring, excess all-cause mortality is a relatively simple and robust indicator, as it allows us to count the number of deaths regardless of the accuracy of the data on cause of death.

This study aims to contribute to measuring the impact of COVID-19 on mortality from natural causes, by analyzing excess deaths in Brazil's regions, states and state capitals, according to sex and age group, based on simple, systematic and updated indicators, so that general mortality can be monitored, allowing the identification of inequalities in death toll across geographic and demographic groups.

Materials and Methods

Sources of information on mortality in Brazil

In Brazil, mortality data are collected in two ways. The Civil Registry Offices (CROs) are responsible for registering deaths and issuing death certificates for legal purposes, while the Ministry of Health's Mortality Information System (SIM) compiles statistics on causes of death and is the official source for epidemiological studies on mortality in the country. Both sources use the medical certificate of cause of death, which is the standardized legal instrument for data collection, issued by the Ministry of Health, with numerical control and distribution across the country. It is on the medical certificate of cause of death that doctors attest and provide information on the cause of death.

Once completed and signed by the doctor, a copy of the medical certificate of cause of death is delivered to the deceased's family members, who then register the death in the notary office, where the data is entered into the National Association of Natural

People Registrars (ARPEN-Brasil) information system to issue the death record. This document is quite important in Brazil, as it is required for an array of bureaucratic matters such as financial transactions, entry into the inheritance process and end of employment, in addition to being mandatory for the burial of the deceased and other responsibilities.

The municipality health departments where the death took place receives a copy of the medical certificate of cause of death and the information contained is digitized in the Ministry of Health's Mortality Information System (SIM). The cause of death is then coded following the rules of the International Classification of Diseases (ICD-10). Data digitized by the municipalities are transferred to the state health departments for consistency analysis, corrections, and problem-checking of the cause-of-death coding.[4] After state-level validation, the database is transferred to the Ministry of Health for final validation through data quality control routines.[6] The Ministry of Health may request that municipalities and states provide clarifications and conduct investigations on deaths, when necessary. Information in the SIM mortality database is only released to the public after going through this process of evaluating and improving data quality, which adds quality to the information on the causes of death in the country.

Mortality trends

Comparisons between the current number of deaths and its historical average can offer insights about the impact of COVID-19 on the population and the health system. To this end, the method applied in this study was based on historical mortality data from 2015 to 2019 to estimate the expected number of deaths in 2020, per epidemiological week[5].

It should be noted that the study considered only natural causes of death (i.e. not deaths from injuries, violence, drowning, suicide, etc.), meaning that the total deaths estimated pertain to diseases. For that reason, deaths certified by the Medical Legal Institute (IML) were excluded from SIM and CR data. Since the CR provides only the place where the death occurred, the place of death listed in the SIM was adopted in

[4] Ministério da Saúde/Secretaria de Vigilância em saúde. Boletim epidemiológico 15, 2020. https://portalarquivos.saude.gov.br/images/pdf/2020/May/09/2020-05-06-BEE15-Boletim-do-COE.pdf

[5] The use of the term "week" throughout this document always refers to the concept of "epidemiological week".

this analysis, instead of the place of residence commonly used in epidemiological studies.

An exponential model was used to project the weekly numbers of deaths expected for 2020, based on the trend of historical data of deaths due to natural causes registered in the SIM from 2015 to 2019. Because the mortality rates increase annually due to population growth and aging, the use of an exponential model leads to more accurate estimates of mortality trends. The historical average method was applied only when the estimates generated values below zero, which was observed especially in low-density areas where the number of weekly deaths is small and presents high variation, with negative variations in some weeks.

The source of data used to provide the mortality observed in 2020 was the Civil Registry, available at the Civil Registry Transparency Portal, of the Civil Registry Information Center. The SIM data available for 2020 is still preliminary, and has a lower number of deaths than that registered in the same period in 2019, and is also lower than the number of deaths registered in the Civil Registry, in the most recent period, April and May.[6].

The Brazilian Institute of Geography and Statistics (IBGE) have published coverage estimates for SIM and CR.[7] This comparative analysis showed that most regions and states had less mortality underreporting in the SIM compared to the CR. The Civil Registry Offices' under-registration varied from 28% in Maranhão state to 0.46% in the Federal District in 2017. Variation in the SIM underreporting was 5.3% in Amapá and 0.32% in São Paulo states.

The number of deaths reported in the SIM was therefore considered to be the reference to correct for under-registration in the CR. The ratio of SIM to CR for location, sex, and age group, in 2019, was used as a correction coefficient and applied to the CR data for 2020.

Two capitals received different treatment to adjust the correction and maintain consistency in comparison with the historical series of previous years. In São Paulo, the CR had a higher number than the SIM, probably because the CRO did not remove all external causes of death. For this reason, only for this location, the

[6] Ministry of Health. Coronavirus epidemiological report 16 https://portalarquivos.saude.gov.br/images/pdf/2020/May/21/2020-05-19---BEE16---Boletim-do-COE-13h.pdf
[7] IBGE. Nota Técnica https://www.ibge.gov.br/estatisticas/sociais/populacao/26176-estimativa-do-sub-registro.html?edicao=26182&t=o-que-e, acessado 5 de julho de 2020

correction applied decreased the number observed in the CR (Appendix 1, Table 1). For Belo Horizonte, since the weekly deaths of CR in 2019 were considerably lower compared to 2020, the estimate for 2020 was well above the historical series when applying the standard correction. To address this situation, it was used instead the average between 2019 and 2020 of the CR.

The excess mortality was the value above the projected baseline for the respective week of 2020. Weeks with values below the projected baseline were disregarded. The level of analysis used to generate the excess mortality values was subnational, having the state and state capitals as the units of analysis, including sex and age disaggregation, considering the age groups from 0 to 59 years and 60 years or older.

To obtain the excess death rates in more aggregate levels, for the country and its regions and respective totals for sex and age range, the sum of excess mortality at the most disaggregated levels was applied. Some weeks showed values below zero and were disregarded when calculating excess. Therefore, the estimate of excess deaths, at the most aggregate levels, is not the direct difference between the sum of projected deaths and the sum of observed deaths. The final estimate of the excess mortality indicator considered the period between the week of the first confirmed death by COVID-19 in the country and the most updated data with reliable Civil Registry Offices data, from week 12 to 23 (March 15th and June 6th).

Results

2020 shows excess mortality in the country, compared to expectations

Based on historical data from the last five years, 1,200,813 natural deaths would have been expected in Brazil in 2020, an average of 23,093 deaths per week. Mortality in Brazil frequently shows a slight increase at the beginning of the year due to respiratory viruses brought from the northern hemisphere by travelers. This is followed by a greater number of deaths from May to August, peaking in June and July, as a result of the higher incidence of deaths from respiratory viruses in winter specially among the elderly and children (mainly in the South and Southeast of Brazil). The last two months of this period also present a higher incidence of deaths from circulatory diseases.

From the first death by COVID-19, registered in week 12, to week 23 (ending on June 6), there were 332,997 deaths from natural causes in the country, 62,490 deaths more than the expected for the period, which corresponds to 22% more

deaths than expected for the same period of the year. From week 12 of 2020 (starting March 15th) a consistent excess death rate is seen in the country, compared to expected rates. A drastic increase is observed from week 17, peaking in week 19, with 32% (9,057) more deaths than expected. The decline in excess death rates in the following weeks may be due to reporting delays in the country, mainly outside state capitals. (Graph 1).

The Southeast, Northeast, and North have been the most affected regions of the country

Between March 15th and June 6th (week 12 to 23), the most affected regions in Brazil were the Southeast, Northeast and North, in that order. From week 12 to 23, there were 25,883 (20%) more deaths than expected in the Southeast region. In the Northeast of the country, there were 22.860 more deaths than expected, representing 31% of excess deaths, proportionally higher than the Southeast in the same time frame. In the North region of the country, there were 10,779 more deaths than the expected amount in the same period, corresponding to a proportional mortality excess of 59% above expectation, greater than that observed in other regions of the country (Graph 2).

In the Southeast of the country, where the first imported case of COVID-19 were registered, there has been a constantly growing trend in the number of deaths since week 12, increasingly more from week 17 to peaking in week 20 with 29% (3,714) more deaths than expected for the respective week of the current year. The decline in excess deaths in the following weeks may be due to reporting delays, which means that a few more weeks are needed to verify these results (Graph 2). The states of Rio de Janeiro and São Paulo have mostly contributed to this figure, with excess deaths in the period at 43% (13,412) and 16% (10,012), respectively. While lower in population terms, the state of Espírito Santo also registered excess deaths in the period with 22% (1,125) more deaths than expected for the period (Appendices, Table 2).

The Brazilian Northeast also shows a growing trend in terms of excess mortality, which was sustained from week 12 onwards, worsened in week 17, and reached a peak of 47% (3,564) of excess deaths in week 19. The decline in excess deaths in the following weeks may be due to the delay in death registrations, which means that a few more weeks are needed to verify these results (Graph 2). The states of Ceará, Maranhão and Pernambuco registered a significant share of excess deaths in the Northeast region, followed by Alagoas and Paraíba states which, despite

having smaller populations and therefore a lower absolute number of deaths, also showed excess deaths in the period surveyed. In Ceará, Maranhão and Pernambuco, respectively, 64% (7,742), 64% (4,996), and 44% (5,732) more deaths were registered than expected for the period from March 15th to June 6th. Alagoas registered 42% (1,626) more deaths from week 12 to 23, and Paraíba had 12% (700) excess deaths during this period (Appendices, Table 2). So far, although Bahia state has not exceeded the number of deaths expected for the year, the state capital has, according to the information presented below (Appendices, Graph 10).

The North region also reported excess deaths from week 12 onwards, more significantly after week 15, quickly reaching a peak of 127% (2,187) in week 18, and finally showing an apparent downward trend in the weeks that followed. This downward trend may be due to the delay in death registrations, which means that a few more weeks are needed to verify these results (Graph 2). So far, the excess deaths in the North have been concentrated in the states of Amazonas and Pará, which reported 120% (4,423) and 56% (4,993) more deaths than expected between weeks 12 and 23, respectively. The states of Roraima, Amapá, Acre and Rondônia reported 45% (229), 44% (335), 26% (254) and 24% (417) excess deaths from weeks 12 to 23, respectively. However, the smaller population, the delay in registration, and the reduced absolute number of deaths hinder individual monitoring of the trend in these federative units (Appendices, Table 2).

Excess deaths in state capitals are proportionally higher

In the state capitals, which are home to a quarter of the Brazilian population (24%, or 50,398,367 out of a total of 210,147,125) and registered 30% of the country's deaths (360,750 out of a total of 1,187,034 deaths) in 2019, excess deaths are even higher, proportionally. Based on the previous five years, 361,352 deaths in the country's capitals would be expected in 2020, or an average of 6,949 deaths per week[8]. From week 12 of 2020 onwards, there is an increasing trend in the number of deaths in state capitals, which exceeds the number of deaths expected. This trend was accentuated in week 16, reached a peak in week 19 with 67% (5,820) more deaths than expected for the week, and declined during the following weeks, although this decrease has yet to be confirmed. Between weeks 12 and 23, there

[8] The seasonality of deaths in the state capitals follow the same patterns as that of the country as a whole

were 40,333 more deaths in the capital cities than expected for the period, which corresponds to 48% of excess deaths (Graph 3).

Although other federative units also show excess deaths compared to the expected for the current year, eight capitals are the sites of most of the total excess deaths in Brazil, namely: Rio de Janeiro and São Paulo in the Southeast region; Fortaleza, Recife, São Luís and Salvador in the Northeast; and Manaus and Belém, in the North. Between weeks 12 and 23, 56% (7,952) and 36% (6,208) of deaths above the expected average occurred in the cities of Rio de Janeiro and São Paulo, respectively. In Fortaleza and Recife, the excess death rate during the same period reached 112% (4,751) and 66% (3,346) respectively; and in São Luís and Salvador, 107% (2,308) and 56% (2,263). During the same period, the city of Manaus reported 142% (3,461) of excess deaths, and Belém reported 111% (3,242) (Appendices, Graph 10).

Deaths by age group and sex

More men than women are dying

From 2015 to 2019, an average of 52% (2,967,917 out of 5,690,917) of deaths from natural causes in the country involved males. The excess deaths observed in 2020 was higher among men compared to women. Indeed, men accounted for 26% (38,078) of excess deaths between weeks 12 and 23, while among women, this number reached 18% (24,412) during the same period (Graph 4). In the state capitals, where excess deaths were considerably higher, the rates among males and females during the same period, totaled 56% (23,488) and 39% (16,846), respectively (Graph 5).

High excess death rates are among people younger than 60 years

In the last five years, 74% (4,198,701 out of 5,690,917) of all deaths due to natural causes in Brazil involved people aged 60 years or older, on average. As expected, most of the deaths occurring in 2020 have been concentrated in this age group. Between weeks 12 and 23, a total of 44,546 (21%) deaths above the expected occurred among people 60 and older. However, those younger than 60 years old (0 to 59 years) accounted for a significant number of excess deaths in the current year, proportionally equal or even higher than in the 60-and-over age group in some locations, totaling 26% (17,943) for the under-60 age group (Graph 6). During the same period (weeks 12 to 23), in the state capitals, where the number of excess

deaths was higher, 29.502 (48%) deaths above the expected occurred among people aged 60 and older, with a similar proportion of excess deaths among people younger than 60 years (48% (10.831) more deaths than expected). In state capitals, among those under the age of 60, excess deaths from disease peaked at 62% (1,540) in week 18 (April 26 to May 2). (Graph 7).

It is important to note that the proportionally higher excess deaths in the under 60 age group have been observed, particularly in the Southeast region. In particular, the states of Rio de Janeiro and São Paulo showed the highest values, but also Espírito Santo. Between weeks 12 and 23, in the 0-59 age group, 28% (8,099) of deaths above the expected were observed in the Southeast region, that is, 10% points higher than the 60-and-over age group, which showed 18% (17,748) more deaths during the same period. In the Northeast region, the excess death rates from weeks 12 to 13 in the 0-59 age group, which totals 30% (5,863), is proportionally lower to the excess deaths rate in the 60-and over age group, which totals 32% (16,997). In the North region, excess deaths among those 60 years old and older showed 70% (8,403) more deaths for the period from week 12 to 23. That is, it remains proportionally higher than among the younger people, although the percentage of 38% (2,376) of deaths above expectations during the same period is significant among people younger than 60 years (Appendices, Graphs 9 and Table 4).

In the City of Rio de Janeiro, excess deaths in people under 60 years peaked in week 18 (May 2nd), totaling 170% of the expected number of deaths (425). This was higher than those over 60 years, which was 106% (1,075) in the same period. In the city of São Paulo, the overall increase in deaths was proportionally smaller among those under 60 years of age, but there was a greater increase of excess deaths in this age group at weeks 18 and 19. Excess death among those under 60 years old was 34% (150) and 43% (178) and among those over 60 years old it was 12% (232) and 30% (432) in those weeks. In the city of Manaus, the excess deaths was consistently greater among those over 60 years old. Nevertheless, compared to other capitals, the highest percentage in excess deaths was observed in this city; in week 17 (April 25th), an increase of 243% (178) in deaths was registered among those under 60 years old, while as increase of 368% (601) was seen in people older than 60 in the same week (Appendices, Table 5)

Discussion

Excess deaths are occurring in much of Brazil, starting around the time of the first COVID-19 death, in São Paulo on March 16th, peaking in mid-April/May and persisting until June. Another study also revealed excess deaths in state capitals in the North, Northeast, and Southeast regions[9] of Brazil. Other countries facing the COVID-19 epidemic have also experienced a higher-than-expected increase in deaths.[10]

More than 62,000 excess deaths caused by diseases were observed between March 15 and June 6. Such a phenomenon – that is, a 22%, increase in overall deaths over 12 weeks - had previously not been observed in this century. In the last respiratory virus pandemic (Influenza AH1N1 in 2009), the number of excess deaths observed was small and restricted to specific age groups,[11] while the Zika virus epidemic in 2016 increased the infant mortality rate and the number of maternal deaths,[12] without affecting the overall mortality rate significantly.

Excess deaths follow the spread of COVID-19 throughout Brazil. The epidemic presents a variety of scenarios with regional characteristics. The first COVID-19 cases occurred in the North and South, with local transmission taking place in February.[13] In the North and part of the Northeast, particularly the states of Maranhão and Ceará, which are further north, cases increased at the same time as in the states of Rio de Janeiro and São Paulo, which are located in Southeast Brazil. The virus spread rapidly in the state capitals of the North, Northeast and Southeast regions, before reaching their inland areas.[14]

[9] Freitas ARR, Medeiros NM, Vinhal-Frutuoso LC, Beckedorff AO, Martin LMA, Medeiros MM, Freitas GGS, Lemos DRQ, Cavalcanti LPG. Use of excess mortality associated with the COVID-19 epidemic as an epidemiological surveillance strategy -preliminary results of the evaluation of six Brazilian capitals. Preprint SciELO - Scientific Electronic Library Online. DOI: https://doi.org/10.1590/SciELOPreprints.442

10 Wu, J., A. McCann, J. Katz and E. Peltier. 2020. “120,000 Missing Deaths: Tracking the True Toll of the Coronavirus Outbreak.” https://www.nytimes.com/interactive/2020/04/21/world/coronavirus-missing-deaths.html. The New York Times, 23 June 2020

11 Marinho de Souza MF, Widdowson MA, Alencar AP, Gawryszewski VP, et alli. Trends in mortality from respiratory disease in Latin America since 1998 and the impact of the 2009 influenza pandemic. Bull World Health Organ 2013; 91:525–532 | doi: http://dx.doi.org/10.2471/BLT.12.116871

12 Rabello D, Vinhal L, Miranda M, Silva M, Porto D, Teixeira R, De Lamare T, Marinho F. Análise descritiva da Mortalidade materna e na Infância no brasil, 2007 a 2016. Consensus CONASS, ano VIII, número 28, julho, agosto e setembro de 2018, www.conass.org.br/consensus. ISSN 2594-939X

13 Resende PC, Delatorre E, Gräf3, Daiana Mir4, at ali. Genomic surveillance of SARS-CoV-2 reveals community transmission of a major lineage during the early pandemic phase in Brazil. This version posted June 18, 2020. doi: https://doi.org/10.1101/2020.06.17.158006 bioRxiv preprint.

[14] Candido DS, Claro IM, De Jesus JG, et alli. Evolution and epidemic spread of SARS-CoV-2 in Brazil. medRxiv preprint doi: https://doi.org/10.1101/2020.06.11.20128249.this version posted June 23, 2020.

In the Southeast, where the first death caused by COVID-19 in the country was reported, the excess deaths first hit the states of São Paulo and Rio de Janeiro, while the state of Minas Gerais as well as its capital, Belo Horizonte, saw a more recent increase. The North showed the highest rate of excess deaths, with an increase of 59% in deaths from natural causes. Among all states in that region, Amazonas and Pará had the highest number of deaths. In the Northeast region, the 31% increase in deaths related to illnesses and diseases primarily occurred in the states of Ceará, Pernambuco and Maranhão, accounting for 81% of excess deaths in the region.

The Central-West and South regions have not yet shown significant rates of excess deaths during the analyzed period, whereas the Federal District has shown a recent upward trend. Interactive dashboards with periodic updates made it possible to follow the trend of mortality in more recent periods, and from June 14th to July 4th (SE 25 to SE 27), there were 1,826 deaths in Brasília, meaning a rapid increase to 25% excess deaths above the expected in those weeks.

Men have died more than women, especially in state capitals, where excess deaths among males averaged 56%, compared to 39% of excess deaths among females. The difference between male and female rates has also been observed in other countries, according to Wenham,[15]: *"Although so far the disaggregated data by sex for COVID-19 has shown an equal number of cases between men and women, there appear to be differences in mortality and vulnerability to the disease according to sex. Emerging evidence suggests that men are dying more than women."*

Excess deaths were higher among people aged 60 years or older. However, people younger than 60 years of age showed mortality proportionally equal to those 60 and over in state capitals, or 48% higher than expected for each age group. A study on excess mortality in Portugal[16] concluded that *"It is interesting to note that no excess mortality has been found in the age group of individuals younger than 55 years. Indeed, that group has been around the average daily number of deaths seen in the past 12 years."* However, a study comparing excess mortality rates in countries found that in England, excess deaths among people aged 15 to 64 years were higher than in other countries.[17] Age and location-adjusted mortality rates show much higher rates of deaths associated with COVID-19 in locations suffering from severe

[15] Wenham C, Smith J, Morgan R, on behalf of the Gender and COVID-19 Working Group. COVID-19: the gendered impacts of the outbreak. The Lancet, V.395 March 14, 2020. https://doi.org/10.1016/ S0140-6736(20)30526-2.
[16] NOGUEIRA PJ, NOBRE MA, NICOLA PJ, FURTADO C, VAZ CARNEIRO A. Excess Mortality Estimation During the COVID-19 Pandemic: Preliminary Data from Portugal. Acta Med Port 2020 Jun;33(6):376-383.
[17] Janine Aron and John Muellbauer. Measuring excess mortality: the case of England during the Covid-19 Pandemic. INET Oxford Working Paper No. 2020-11, May 2020.

economic deprivation.[18] Health is likely to be more precarious in such areas and essential workers tend to be underpaid and more exposed to potential infections, and may live in these places in disproportionate numbers. This is particularly relevant for the age group from 15 to 64 years. The high comparative levels of excess mortality in England may also have been affected by ethnic differences in the incidence of deaths associated with COVID-19.

Proportionally, the Southeast region of Brazil had a higher rate of excess deaths among people younger than 60 years compared to those above that age group, reaching 28% and 18%, respectively. In the states of Rio de Janeiro and São Paulo, more deaths related to illness and disease occurred among people younger than 60 years, proportionally. In the City of Rio de Janeiro and São Paulo, peaks of death from all causes of disease were observed proportionally greater among the youngest. And Manaus was the city with the highest excess of deaths among those under 60 years of age when compared to other capital cities.

Factors associated with socioeconomic status, urban segregation, occupation and low remuneration, limited access to health services, and ethnicity/race can be determinant for the excess death rates among people younger than 60 years[19] in the state capitals. The lack of home infrastructure[20], especially on the outskirts of large cities, hinders measures to prevent contagion, isolate cases and contacts, facilitating the spread of the disease, increasing the risk of the poorest population. Disaggregating the data into smaller age groups may also help to better understand the pattern of excess deaths in the subpopulation.

Limitations

The estimate of excess mortality via the weekly difference between the projection of the expected value and the observed value must be redone after SIM data for the year 2020 is made available. In addition to the total number of deaths, and the use of the same source of information, from the same institution that uses standardized methods, the SIM data allows for more detailed analyzes, which include basic causes of death. On the other hand, the availability of data in a timely manner, with

[18] ONS/UK. Deaths involving COVID-19 by local area and socioeconomic deprivation: deaths occurring between 1 March and 17 April 2020", ONS.
19 Khunti K, SinghAK, Pareek M, Hanif, K. Is ethnicity linked to incidence or outcomes of covid-19? Preliminary signals must be explored urgently BMJ, 2020; 369:m1548 https://www.bmj.com/content/bmj/369/bmj.m1548.full.pdf Accessed on 23/06/2020
20 CEBES. COVID-19 e Desigualdade no Brasil. http://cebes.org.br/2020/04/covid-19-e-desigualdade-no-brasil, acesso em 5 de julho 2020

respective corrections based on the comparison with SIM data, allows a robust analysis using Civil Registry Office data.

CR data provide information on natural causes deaths based on the location where the death was registered. In the SIM, the place of death is considered. However, the place of the record is not always the same place of occurrence. Thus, there may be local differences. Concerning external causes, as the CR data do not use a single definition for the cause of death, but rather mention the diseases in the death certificate text, deaths from external causes may be included in the final database. For comparison purposes, deaths recorded by the Medical Legal Institute (in Portuguese, "Instituto Médico Legal" - IML) were excluded from the SIM. These differences can only be assessed after an analysis is made with SIM 2020 data when these data are available.

It should be noted that the difference between the date of death and data availability is heterogeneous in the country. Therefore, care must be taken when analyzing the latest weeks. According to the Civil Registry Transparency Portal, the delay is 14 days, but differences observed in regional trends show that this value is heterogeneous between states.

The calculation of the death excess mortality indicator based on local levels of age and sex is very opportune because it considers reality according to demographic profiles. However, when this level of geographic detail and time reference (week) based on sex and age is taken into account, small figures are observed and, as a result, high variability is seen, which affects the model used to calculate the projections. Specific methods for treating this type of data, such as the empirical Bayesian method,[21] may be used in a new analysis.

Conclusions

To interpret large differences in excess mortality rates between regions of a given country, we must consider the average infection rates in previous weeks and the average risk of mortality by COVID-19 in addition to the overall quality of the health care system in each location.

In this pandemic scenario, the excess deaths from natural causes in Brazil followed the higher incidence of cases and deaths caused by COVID-19.[2] This was also

[21] Marshall RJ. Mapping disease and mortality rates using empirical Bayes estimators. J R Stat Soc Ser C Appl Stat 1991; 40(2):283-94.

observed in other countries. The excess mortality has been associated with COVID-19 and with the increase in deaths from other causes.[22-23]

The North, Northeast and Southeast regions, which have higher numbers of COVID-19 cases and deaths, have shown higher rates of excess deaths, whereas the Central-West and South regions, which reported fewer cases of COVID-19 during the analyzed period (some state capitals have recent increase in number of cases), have not.

State capitals were hit hardest by excess deaths,[12] particularly: Manaus and Belém, in the North; São Luís, Fortaleza, Recife, and Salvador, in the Northeast; and Rio de Janeiro and São Paulo, in the Southeast. The population density in state capitals, crowded public transport, inequality, and precarious housing with a high concentration of individuals per household[24] have made it more challenging to achieve satisfactory levels of physical distancing.

The state capitals of the South and Central-West regions have not presented excess deaths in the period surveyed, except for the city of Cuiabá, which has shown an increase in the number of deaths caused by diseases and illnesses. However, more up-to-date analyzes already show that the country's capital, the city of Brasília, in the Central-West, has shown a recent increase in deaths caused by all diseases, with an upward trend in the month of June, which can be followed by the other capitals and states of this region.

Men died significantly more than women in all places analyzed, higher than expected for the gender difference. Studies on excess deaths and mortality from COVID have shown similar results. Biological and socioeconomic factors, as well as those related to gender, have been identified as determinants of higher male mortality[18].

Proportionally, people younger than 60 years died more than those over 60, especially in state capitals. This result suggests the need for further studies to analyze the relationship between mortality due to COVID-19, excess deaths and social factors.[22,23]

[22] Woolf SH, Chapman DA, Sabo RT, Weinberger DM, Hill L. Excess Deaths From COVID-19 and Other Causes, March-April 2020. JAMA Published online July 1, 2020

23 Wu, J., A. McCann, J. Katz and E. Peltier. 2020. “46,000 Missing Deaths: Tracking the True Toll of the Coronavirus Outbreak.” The New York Times

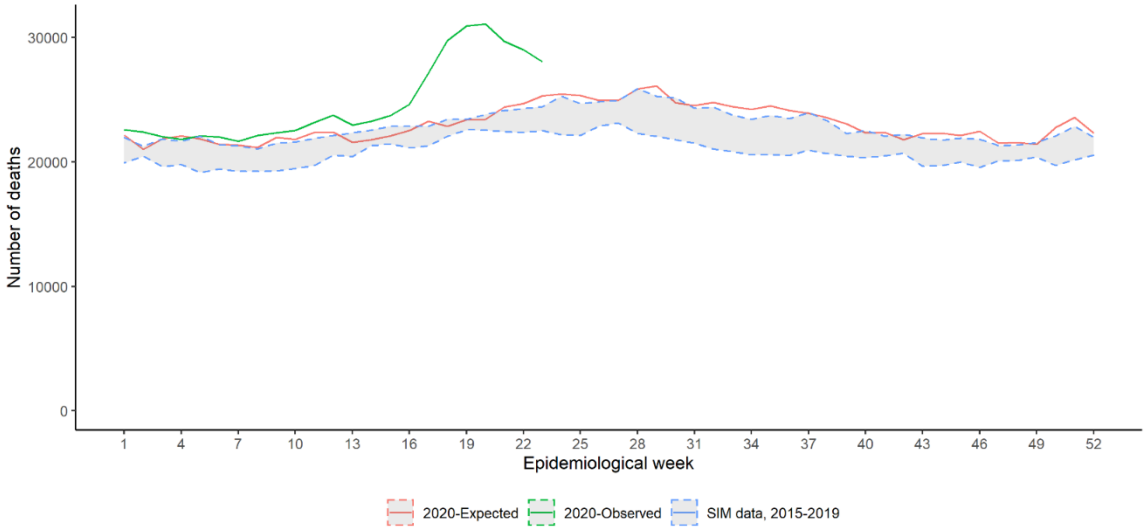
24 Maricato E. Metrópole, legislação e desigualdade. ESTUDOS AVANÇADOS 17: 48, 2003.

More than 62,000 deaths above the expected occurred in Brazil. That shows that many more people the expected have died - directly from COVID-19 or indirectly, abbreviated lives. The excess of deaths among those under 60 years old undoes the belief in the invulnerability of this group. Social determinants[25] and health services quality can have impact in this increase.

The excess of deaths can be a complementary indicator for monitoring the evolution of COVID-19 in populations and in the national territory. It is a robust indicator where updated data is available.

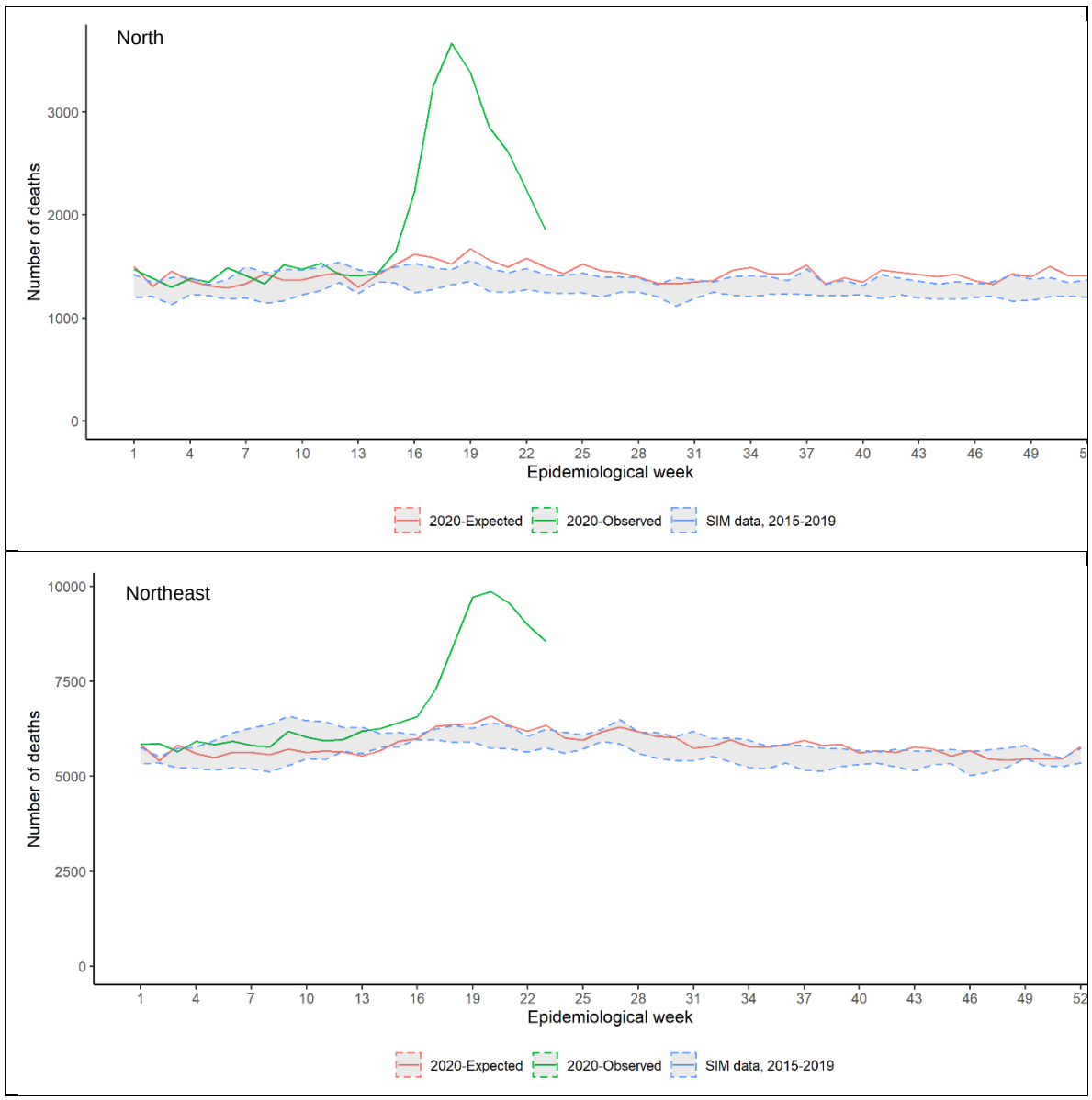
Results Graphs

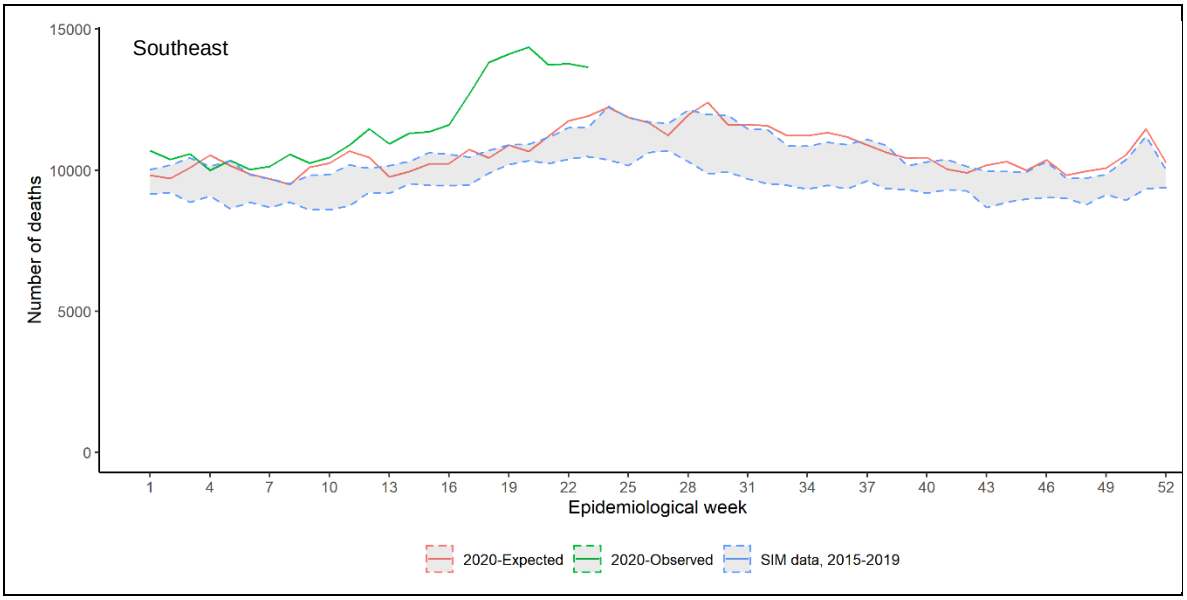
Graph 1. Total number of deaths per epidemiological week. Brazil, 2020 EW 1 to 23.



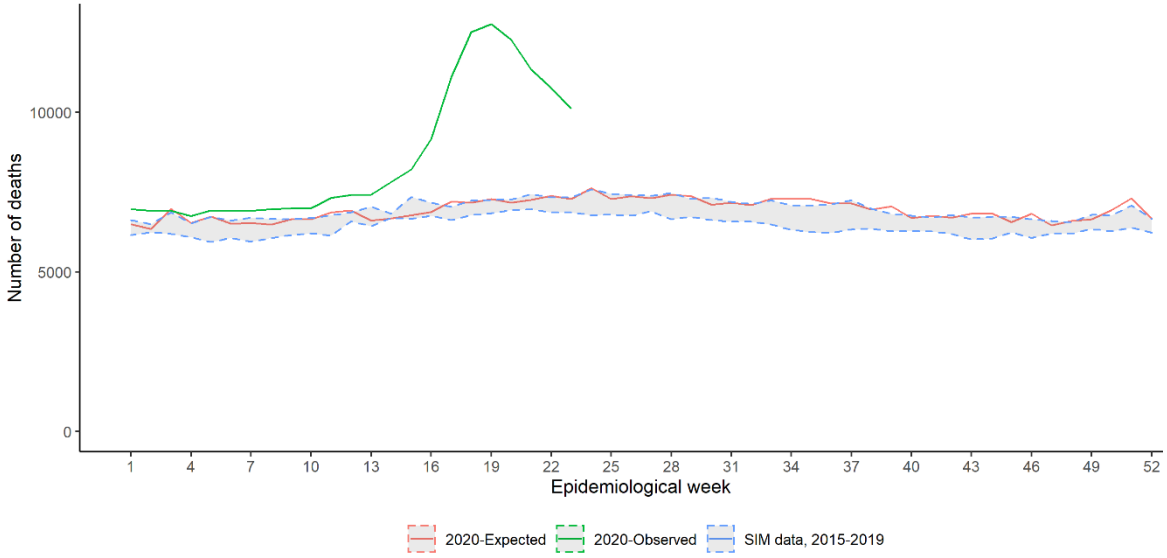
25 Baqui P, Bica I, Marra V, Ercole A, Van der Schaar M. Ethnic and regional variations in hospital mortality from COVID-19 in Brazil: a cross-sectional observational study. Lancet Global Health, July 2020. https://doi.org/10.1016/S2214-109X(20)30285-0

Graph 2. Total number of deaths per epidemiological week. North, Northeast, and Southeast regions, 2020 EW 1 to 23.

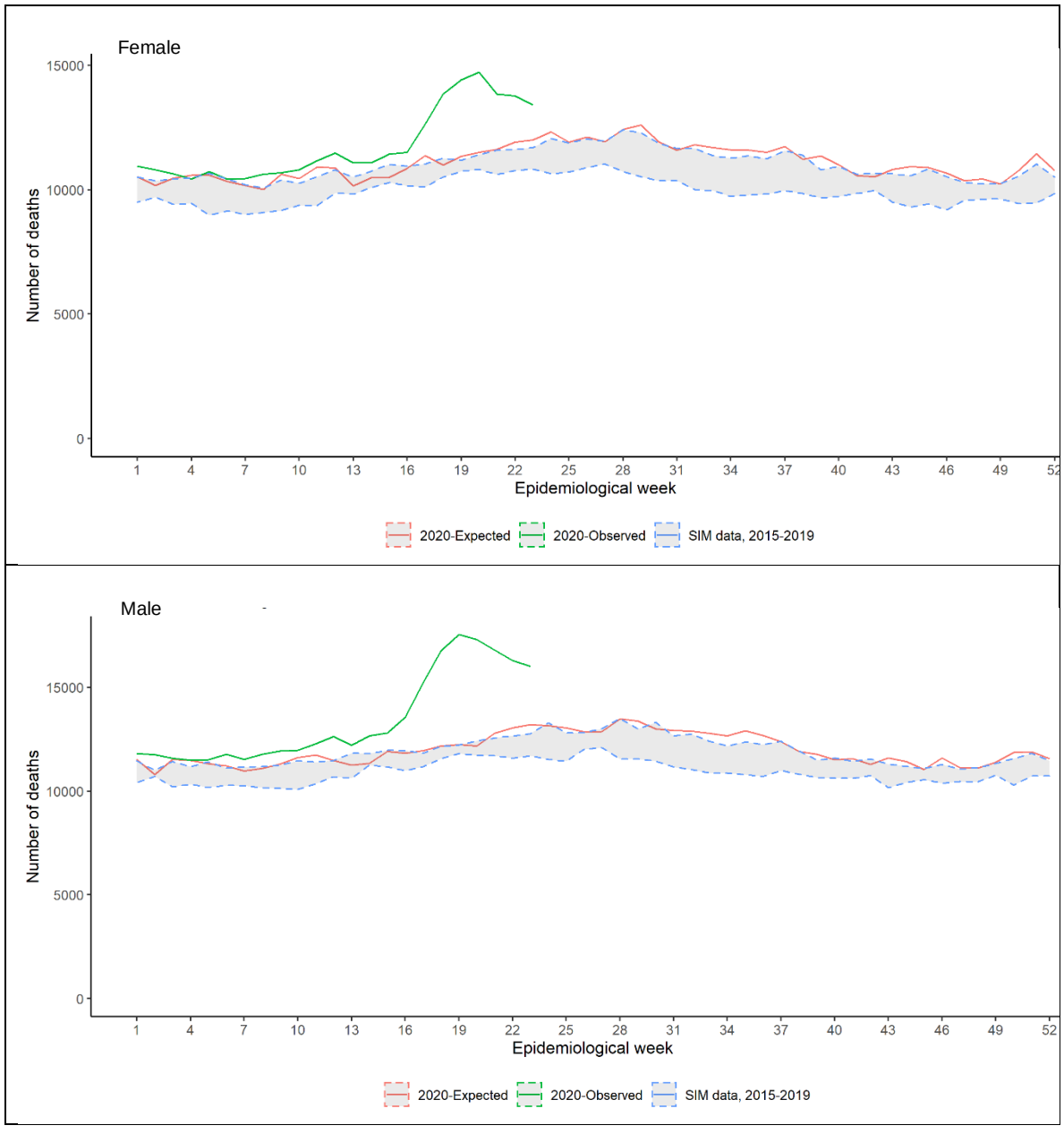




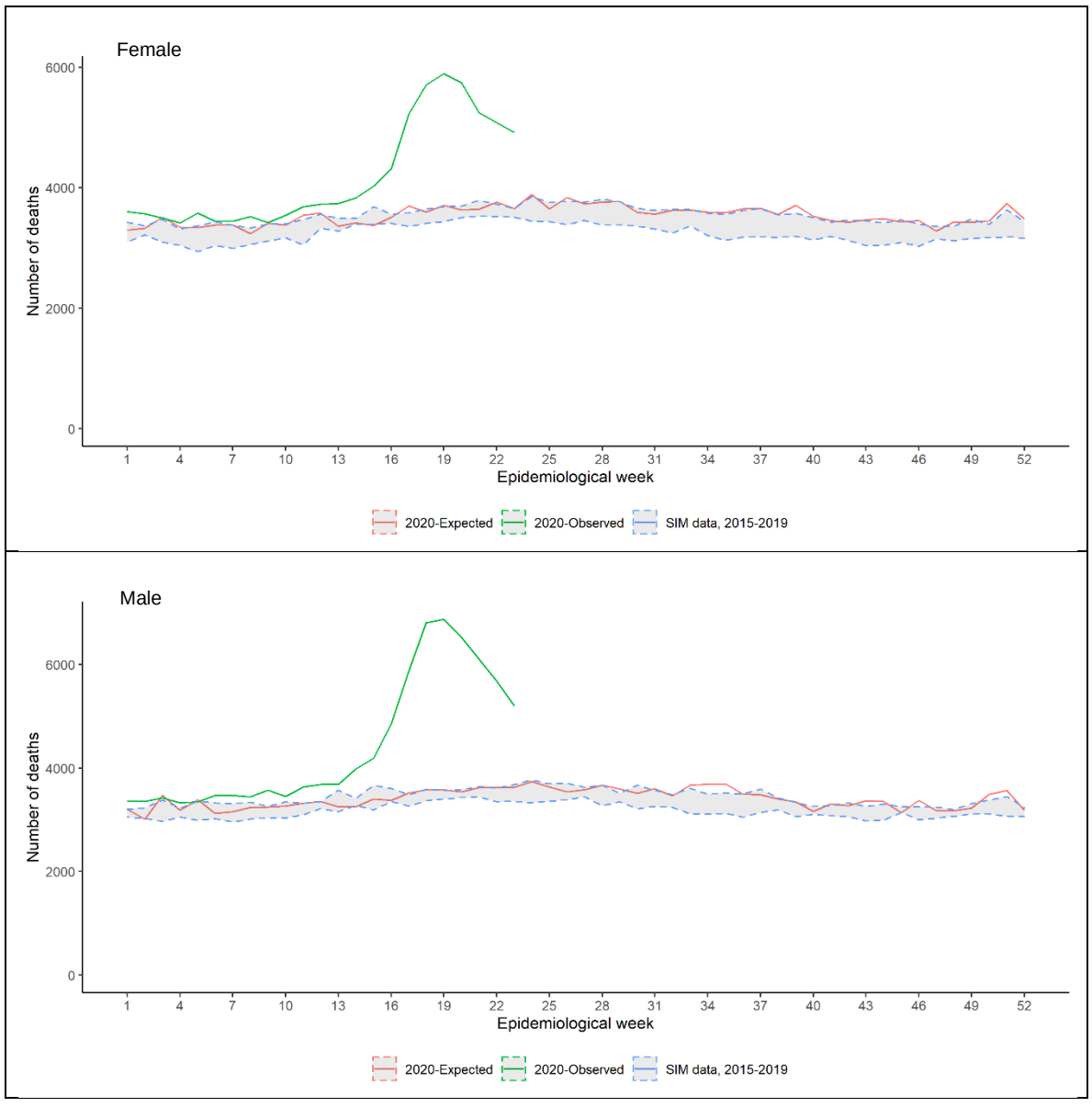
Graph 3. Total number of deaths per epidemiological week. State`s capital cities (aggregate), 2020 EW 1 to 23.



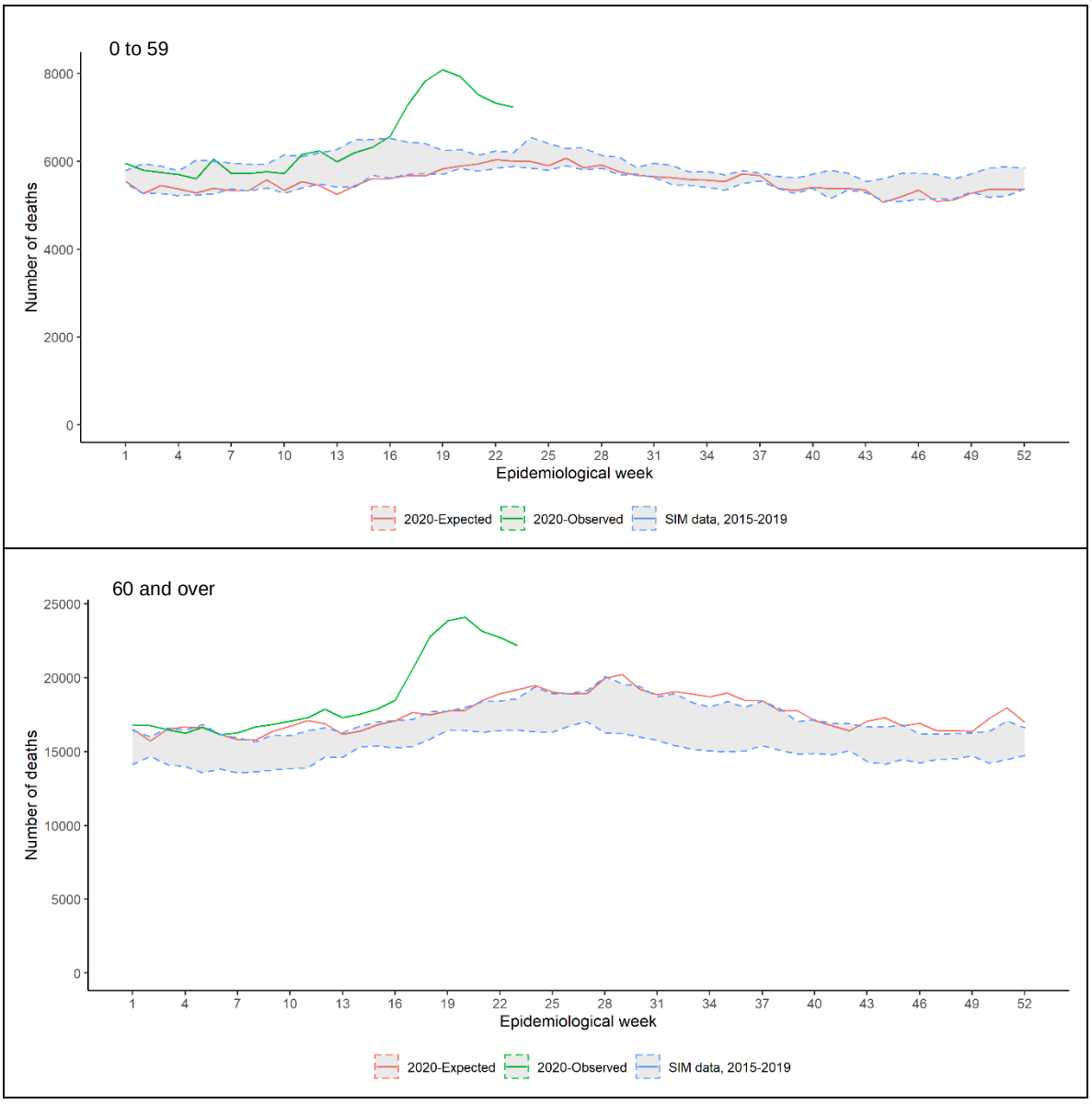
Graph 4. Total number of deaths by sex. Brazil, 2020 EW 1 to 23.



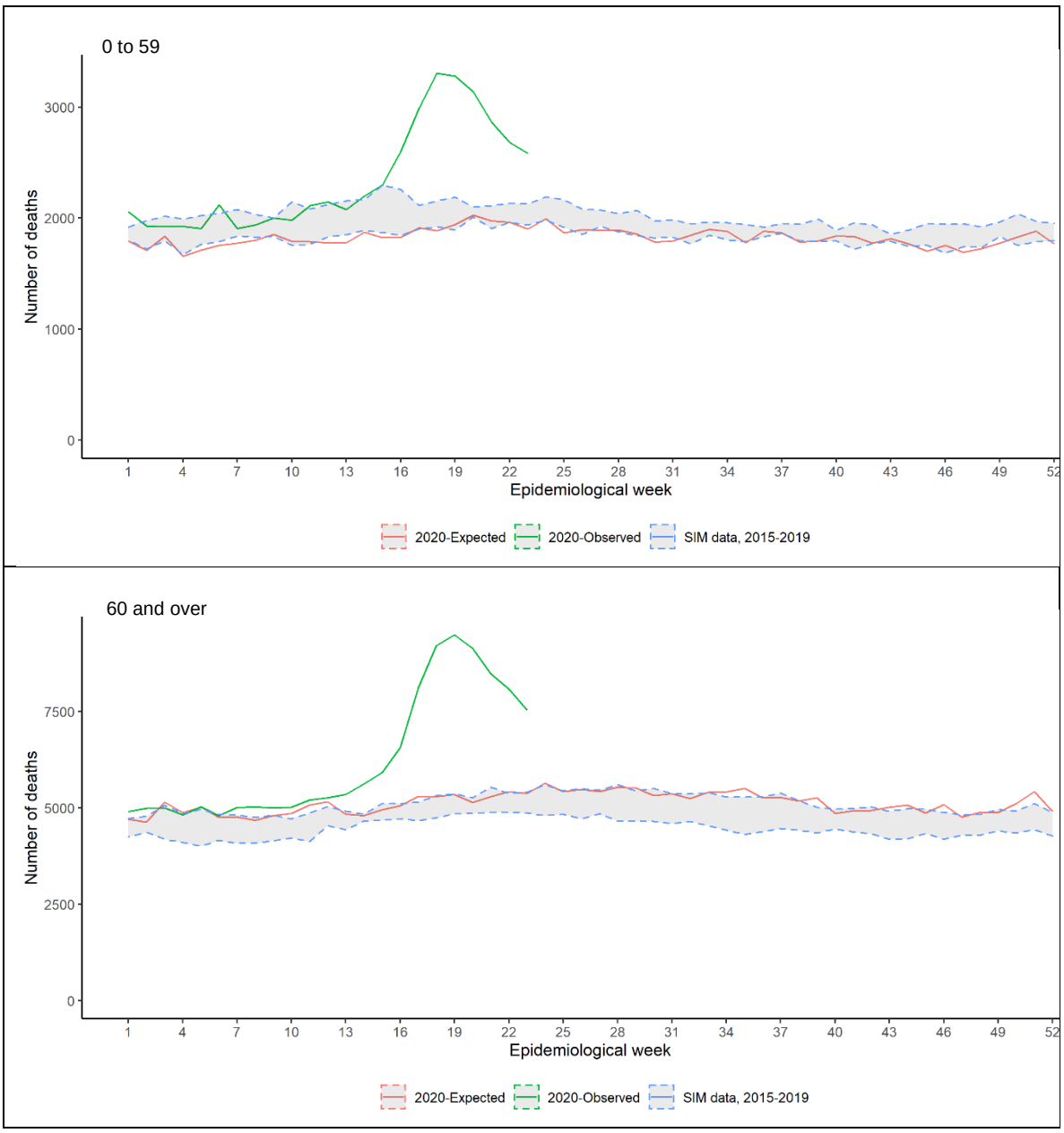
Graph 5. Total number of deaths by sex. State`s capital cities (aggregate), 2020 EW 1 to 23.



Graph 6. Total number of deaths by age group. Brazil, 2020 EW 1 to 23.



Graph 7. Total number of deaths by age group. State`s capital cities (aggregate), 2020 EW 1 to 23.



Appendices and graphs

Table 1. Civil Registry Office Correction Factor 2020. Brazil, per epidemiological week.

Epidemiological Week	CR	SIM	Correction Factor
1-4	83,815	86,873	1.04
5-8	82,194	85,875	1.04
9-12	83,148	86,869	1.04
13-16	85,253	89,363	1.05
17-20	89,421	93,677	1.05
21-24	93,805	98,313	1.05
25-28	95,512	100,508	1.05
29-32	94,956	99,311	1.05
33-36	89,834	94,566	1.05
37-40	88,640	92,257	1.04
41-44	84,860	88,076	1.04
45-48	82,531	86,050	1.04
49-52	84,365	86,784	1.03

Table 2. Excess death by state. 2020 EW 12 to 23.

States	Observed	Excess	
		n	%
North			
RO	2,025	417	24%
AC	1,128	254	26%
AM	8,068	4,423	120%
RR	683	229	45%
PA	13,712	4,993	56%
AP	904	335	44%
TO	1,480	129	8%
Northest			
MA	12,792	4,996	64%
PI	4,226	132	3%
CE	19,839	7,742	64%
RN	4,749	413	9%
PB	6,281	700	12%
PE	18,801	5,732	44%
SE	2,865	297	11%
AL	5,360	1,626	42%
BA	18,887	1,222	7%
Southest			
MG	29,664	1,334	5%
ES	6,008	1,125	22%
RJ	44,636	13,412	43%
SP	72,527	10,012	16%
South			
PR	15,325	1,026	7%
SC	8,222	321	4%
RS	17,195	547	3%
Middle West			
MS	3,392	279	8%
MT	3,360	233	6%
GO	7,594	247	3%
DF	3,274	315	10%

Table 3. Excess death by sex. Country regions and states, 2020 EW 12 to 23.

States	Female			Male		
	Observed	Excess		Observed	Excess	
		n	%		n	%
North	**11,089**	**3,655**	**46%**	**16,912**	**7,124**	**70%**
RO	815	140	18%	1,210	277	28%
AC	466	128	31%	662	126	22%
AM	3,038	1,496	95%	5,030	2,926	138%
RR	282	80	35%	401	149	53%
PA	5,507	1,654	42%	8,205	3,339	68%
AP	326	95	28%	578	239	55%
TO	654	62	9%	825	67	8%
Northest	**42,826**	**8,974**	**26%**	**50,973**	**13,885**	**36%**
MA	5,118	1,724	50%	7,673	3,272	74%
PI	1,882	64	3%	2,344	68	3%
CE	9,153	3,264	55%	10,686	4,478	72%
RN	2,225	117	5%	2,524	296	12%
PB	2,887	141	5%	3,394	559	19%
PE	8,876	2,334	36%	9,925	3,398	52%
SE	1,366	129	10%	1,499	167	11%
AL	2,478	668	34%	2,882	958	48%
BA	8,842	534	6%	10,045	688	7%
Southest	**72,490**	**10,702**	**17%**	**80,345**	**15,181**	**23%**
MG	14,099	661	5%	15,565	673	4%
ES	2,723	441	19%	3,285	684	26%
RJ	21,050	5,054	32%	23,586	8,358	55%
SP	34,617	4,546	15%	37,910	5,467	17%
South	**19,142**	**808**	**4%**	**21,600**	**1,087**	**5%**
PR	7,038	377	5%	8,287	650	8%
SC	3,802	133	3%	4,420	188	4%
RS	8,302	298	4%	8,893	249	3%
Midwest	**7,652**	**273**	**3%**	**9,968**	**800**	**8%**
MS	1,401	68	4%	1,991	211	11%
MT	1,351	54	3%	2,009	179	8%
GO	3,394	48	1%	4,200	199	5%
DF	1,506	103	7%	1,768	212	13%

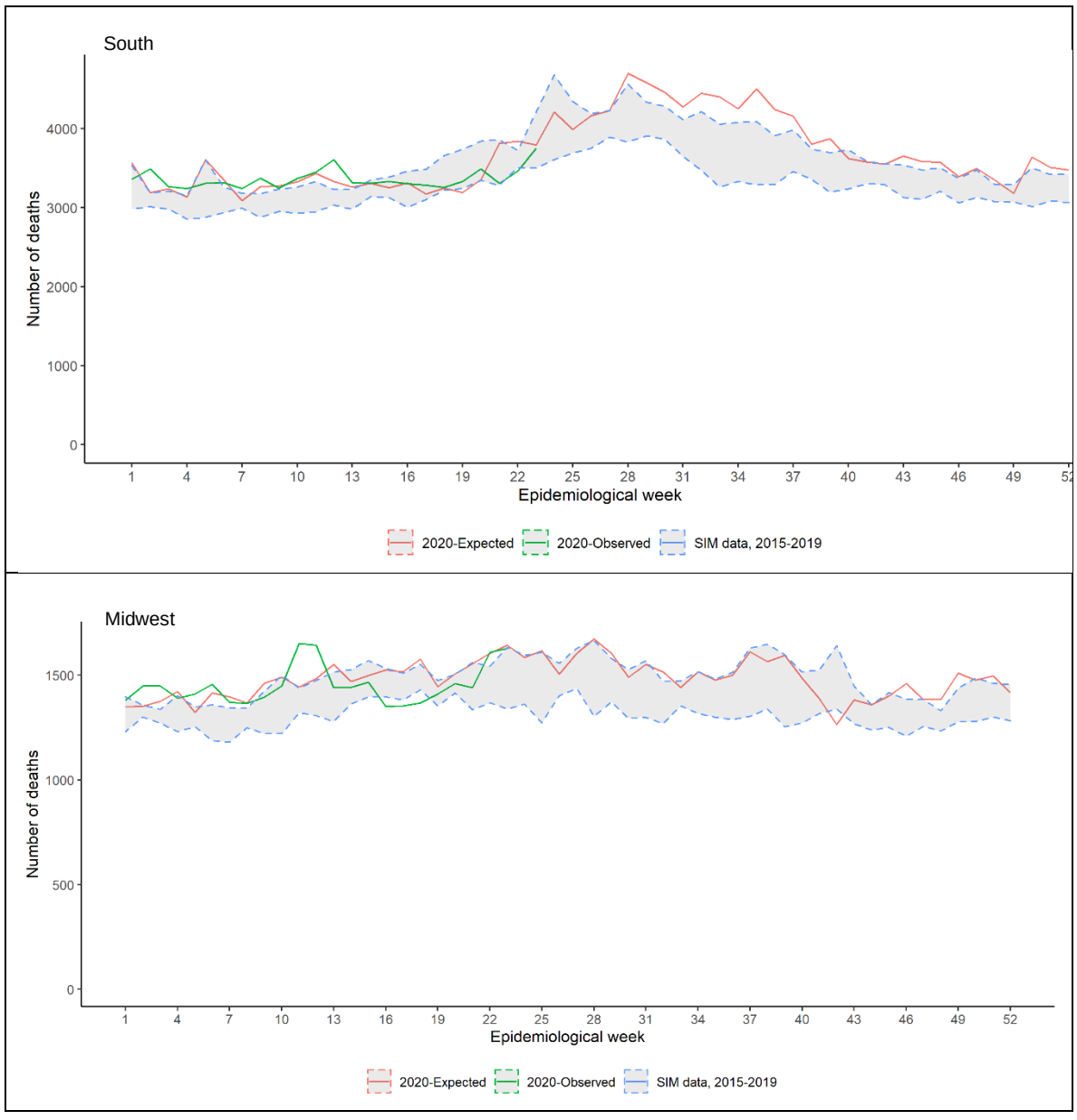
Table 4. Excess death by age group. Country regions and states, 2020 EW 12 to 23.

States	0 to 59 years old			60 years or older		
	Observed	Excess		Observed	Excess	
		n	%		n	%
North	**8,186**	**2,376**	**38%**	**19,815**	**8,403**	**70%**
RO	660	201	41%	1,366	216	17%
AC	404	83	23%	724	171	27%
AM	2,304	933	67%	5,765	3,490	152%
RR	297	115	55%	386	114	38%
PA	3,827	895	30%	9,885	4,098	70%
AP	317	100	31%	587	235	52%
TO	377	50	12%	1,103	79	7%
Northest	**24,897**	**5,863**	**30%**	**68,903**	**16,997**	**32%**
MA	3,694	1,163	46%	9,098	3,833	72%
PI	1,244	76	6%	2,982	56	2%
CE	4,273	1,376	47%	15,566	6,366	69%
RN	1,252	150	12%	3,497	263	7%
PB	1,644	274	19%	4,637	426	10%
PE	5,162	1,755	51%	13,639	3,977	41%
SE	848	111	13%	2,017	186	9%
AL	1,515	449	40%	3,845	1,176	42%
BA	5,265	507	11%	13,622	715	5%
Southest	**36,838**	**8,099**	**28%**	**115,997**	**17,784**	**18%**
MG	7,294	545	8%	22,370	789	3%
ES	1,663	419	33%	4,345	706	19%
RJ	11,237	4,117	58%	33,399	9,295	39%
SP	16,644	3,018	22%	55,883	6,994	14%
South	**9,367**	**1,011**	**12%**	**31,375**	**884**	**3%**
PR	3,816	519	16%	11,508	507	4%
SC	2,057	144	7%	6,166	177	3%
RS	3,494	348	11%	13,701	199	1%
Midwest	**5,257**	**595**	**12%**	**12,363**	**479**	**4%**
MS	1,026	182	20%	2,366	97	4%
MT	1,110	118	10%	2,250	115	4%
GO	2,045	143	7%	5,549	103	2%
DF	1,076	151	16%	2,198	164	8%

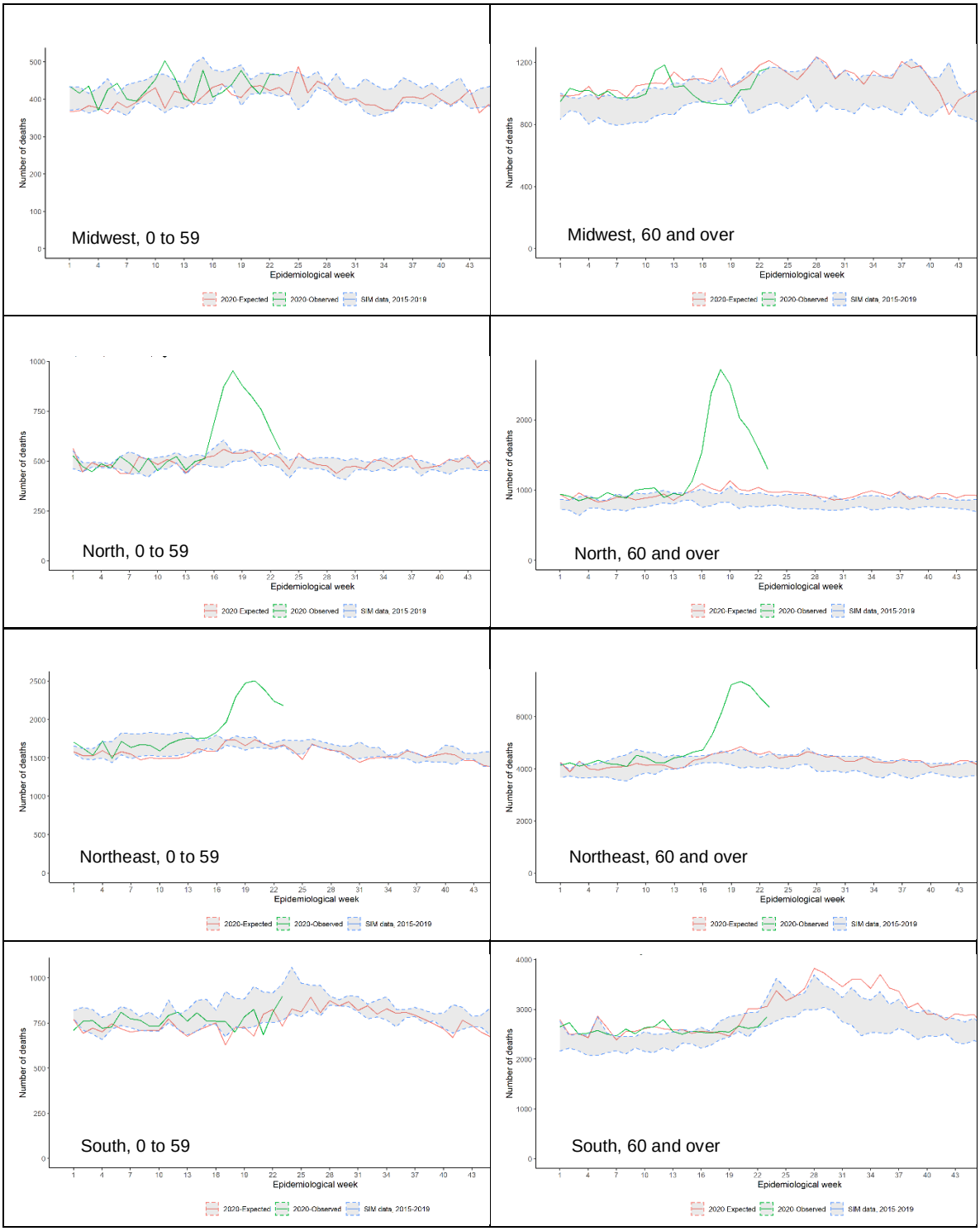
Table 5. Excess death by age group. State`s capital cities, 2020 EW 12 to 23.

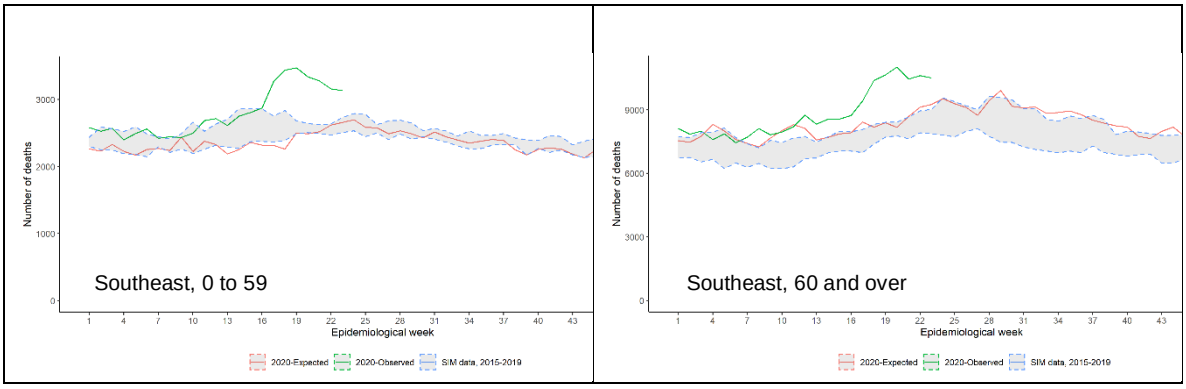
Capital cities	Observed	Excess	
		n	%
North			
Porto Velho	1,030	486	77%
Rio Branco	874	297	46%
Manaus	5,874	3,461	142%
Boa Vista	589	221	52%
Belém	6,021	3,242	111%
Macapá	637	216	36%
Palmas	349	70	17%
Northest			
São Luís	4,388	2,308	107%
Teresina	1,440	117	7%
Ceará	8,972	4,751	112%
Natal	1,711	229	12%
João Pessoa	1,786	337	20%
Recife	8,323	3,346	66%
Aracajú	1,356	216	16%
Maceió	3,034	1,144	57%
Salvador	6,260	2,263	56%
Southest			
Belo Horizonte	6,766	1,751	35%
Vitória	1,025	256	30%
Rio de Janeiro	21,976	7,952	56%
São Paulo	23,361	6,208	36%
South			
Curitiba	2,735	287	11%
Florianópolis	785	139	18%
Porto Alegre	3,204	243	7%
Midwest			
Campo Grande	1,313	83	5%
Cuiabá	1,139	214	19%
Goiania	2,705	181	6%
Brasília	3,274	315	10%

Graph 8. Total number of deaths per epidemiological week. South and Middle West regions, 2020 EW 1 to 23.



Graph 9. Total number of deaths by age group. Country's regions, 2020 EW 1 to 23.




Number of deaths
Epidemiological week
Southeast, 0 to 59
2020-Expected
2020-Observed
SIM data, 2015-2019
Number of deaths
Epidemiological week
Southeast, 60 and over
2020-Expected
2020-Observed
SIM data, 2015-2019

Graph 10. Total number of deaths per epidemiological week. State`s capital cities with the highest numbers, 2020 EW 1 to 23.