**Exploring excess mortality in Latin America in the context of covid pandemic: the cases of Brazil and Ecuador**

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**BACKGROUND**

The covid-19 pandemic has considerably affected the mortality numbers of many countries in the world, and Latin America is now the epicenter of the diseases. There is a great demand on analyzing the impact of this new disease in the amount of deaths, but available information of deaths by cause is still lacking in most of the countries in the region.

**OBJECTIVE**

We aimed to measure the effects of the disease on mortality, using excess mortality, in two Latin America countries that were most affected by the covid-19 pandemic in the region: Brazil and Ecuador.

**METHODS**

We measured the effects of the pandemic by looking at the excess mortality, and comparing estimates of differences in the average number of deaths, variation coefficients and percentages of deaths between the months of March to May for 2019 and 2020.

**RESULTS**

Our findings indicated an excess of deaths initially in major cities, but then is spreading towards the least urbanized areas. In the next phase, pandemic will probably affect countries' cities in worse socioeconomic and sanitary conditions. In Ecuador, we saw that the most affected locations were the less socioeconomic areas of the country.

**CONCLUSION**

Despite the lack of information on causes of death, the excess of deaths is a good indicator for measuring the effects of the coronavirus pandemic, especially in the context Latin America countries. We find strong evidence of the pandemic's impact and interiorization, especially in Brazilian cases.

**CONTRIBUTION**

This study provides an initial discussion of the effects of pandemic in small and less urbanized areas of Brazil and Ecuador.

## 1. Introduction

In early 2020, several cases of the Covid-19 pandemic emerged in Latin America, following what was observed in Europe and the United States (Rodriguez-Morales et al 2020; Burki 2020; Muñoz 2020). Some empirical evidence indicates that the mortality data for Covid-19 pandemic in Brazil and Ecuador, as well as in other countries of Latin America, are underreported (Torres and Sacoto 2020; Croda et al 2020). One of the main problems concerning the pandemic is the small amount of tests (Burki 2020; Peto 2020). Overall, Latin America has the lowest test rates in the world, around 63 per 100,000 inhabitants, and expanding tests is one of the most important ways to control the spread of the pandemic. There are also delays between the Covid-19 tests and the time that their results are released, in some cases taking more than two weeks to reveal the outputs (Werneck and Marilia Sá 2020; Bastos et al 2020).

In the case of Brazil, contradicting recommendations from the World Health Organization, Brazilian president has also encouraged people to go out, commonly advocating for relaxing social-distancing measures. Brazil's President primarily regards the virus as "just a little dose of flu". Evaluating the effects of asymmetric information on social distancing, Ajzenman, Cavalcanti and Da Mata (2020) showed that Bolsonaro's words and actions have had a stronger effect on relaxing social distancing in the municipalities of the country, which in turn might increase the spread of infection. Ecuador was one of the first Latin American countries to be affected by coronavirus with the majority of deaths being reported at Guayaquil and Guayas provinces. There is evidence that the pandemic is spreading towards the least urbanized Ecuador's areas (Laberthe 2020; UN 2020).

The fight against the pandemic in Latin America is more complicated due to data limitations, especially on causes of deaths, and the low number of Covid-19 tests available. In the current crisis, proper information on causes of deaths are crucial to understand the effects of the pandemic. However, one cannot expect that information on causes of deaths will be released very fast, since they need to follow a specific number of procedures that are particular to each country. Even in more developed economies, with mature vital registration programs, there will be a lag in the access of causes of deaths data.

Notwithstanding, in the context of a world pandemic, the knowledge of how Covid-19 is affecting mortality and the health status of a population really becomes an important issue for mortality and health studies. However, reliable methods to estimate and project the pandemic impact on the number of deaths (and life expectancy) are still limited or inaccurate. In fact, a clear death toll of the pandemic might take some time to be understood, since proper mortality registration systems do not report real-time data for most of the countries by causes of death (Appleby, 2020; Labib, Arrori, 2020). Also, there are some complicated matters in the definition of mortality by Covid in several places of the world related to underreporting of the cause (Lau et al 2020).

One way to estimate the dynamics of the pandemic and to measure its impact is by looking at the existing mortality data. One alternative is to investigate the excess mortality, both overall or age-specific, in the year 2020 relative to the number of deaths from previous years, in the same period for both years. There are several reports showing estimates of excess

mortality for the country level[1], but very few for the subnational level. There are well-suited methods for dealing with this, making it possible to get an idea of how mortality has increased at a given point in time and which ages were the most affected by death numbers (Felix-Cardoso et al 2020; Kontopantelis et al 2020; Krieger et al 2020).

It is important to emphasize that not all excess deaths are due to COVID, but if we observe the excess of deaths, in comparison with previous years, that can work as a good tool to understand trends in lethality of this disease (Nogueira 2020; Adjiwanou et al 2020; Krieger, Chen and Waterman, 2020; Felix-Cardoso, et.al, 2020; Kontopantelis, et.al, 2020). As indicated by Noymer (2020)[2] and Hellenriger (2020)[3], we consider the effect of the epidemic on four types of mortality that are reflected in excess mortality (Adjiwanou et al 2020). First, we have the direct mortality effects, which are the current deaths recorded as Covid-19. Second, the direct-indirect effects that are measured as early deaths in the occurrence of COVID, and that have been mistakenly recorded as influenza or other respiratory illness. The second effect is the subsequent deaths from COVID that are not registered as such. The third effect is Indirect mortality. These are deaths from a health problem, which was not treated due to the overload of the health system and intensive care destined to Covid treatment. Finally, we have competitive mortality risks, which represents a person who died due to COVID today, but he/she would have died by other diseases in the near future, caused by another morbidity, that is, Covid-19 is now a competing risk of mortality (Santos & Howard 2018; Santos et al 2018).

During the course of the pandemic we will not be able to measure these four effects of this disease, but we can access the excess number of deaths. Excess mortality is generally understood as the number of deaths (from any cause of death) that we are seeing in a given time period, subtract or divided by the number of deaths that could occur in the absence of SARS-CoV-2 pandemic (Nogueira, et.al., 2020; Leon, et.al., 2020, Santos-Lozada and Howard, 2018). A central question is how to measure this counterfactual, that is, "what is the number of deaths that could occur in the absence of Covid19"? In most cases, it is calculated either the average number of deaths over a given period in recent years, that is, when SARS-CoV-2 did not occur as a cause of death (Adjiwanou et al 2020).

Daily counts of deaths usually come from hospital reports, where they focus on COVID fatalities, and this daily information is passed to Ministries of Health around the globe. Data on overall mortality (that allows to estimate excess mortality) are provided by civil registrations systems. This is the administrative system that continuously records all deaths. It also includes deaths at home and outside the hospitals, and in many causes they do not report a specific cause of death. To know how many COVID deaths have been counted, we need to wait for the vital statistics publication with cause of death data and we need to conduct much more refined modeling exercises - what might take several months.

Brazil and Ecuador are the countries most affected by the SARS-CoV-2 in the Latin America region. Both countries are also characterized by large socioeconomic and regional inequality.

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[1] https://www.bbc.com/news/world-53073046; https://ig.ft.com/coronavirus-chart/; https://www.economist.com/graphic-detail/2020/04/16/tracking-covid-19-excess-deaths-across-countries

[2] https://twitter.com/andrewnoymer/status/1241620295095468035

[3] https://twitter.com/helleringer143/status/1252580218432348162?lang=en

In addition to that, there is strong evidence of variation in the data quality for both countries (Peralta, et.al, 2019b; Queiroz, et.al, 2017). Thus, one needs to be careful with all the analysis performed here. They have been collecting monthly mortality data. In the case of Brazil, we have municipality information gathered via notary offices (administrative records) and Ecuador the collection is by civil register across provinces, making it possible for us to analyze the excess of mortality at less populated areas of both countries. In this paper, instead of looking at the national level, we focus on smaller areas and look at province capitals and cities around the capitals for both countries. There are very few studies, to our knowledge, looking at the sub-national level (Blangiardo et al 2020; Krieger, Chen and Waterman, 2020). If in the first moments of the epidemic in Brazil and Ecuador, the large volume of deaths was concentrated in places where the first infections were registered, throughout the process of spreading and internalizing the pandemic it is important to consider the impacts of the pandemic in other areas of the countries.

## 2. Data and Methods

For Brazil, we use data from administrative death records, through death certificates. These data are provided by the Brazilian Civil Registry Offices on the 'Transparency Portal - Civil Registry', These data are disaggregated by municipalities in all Brazilian states. The data can be obtained through the link https://transparencia.registrocivil.org.br/registral-covid. From this webpage, the data can be collected only manually, which is a time consuming job in the case of gathering information for all cities with at least fifty cases of Covid-19 in the country. But, we applied data scraping tools to assemble this data in a more efficient way (Mehta, et.al, 2019; Chandrika, et.al, 2020).

We selected 27 Brazilian Metropolitan Areas (MAs) for comparisons. As pointed out by the civil registry system in Brazil, data on the most recent death dates may undergo some changes due to the entry of new records. The procedure for bringing the data into the system may take a few days, and there are corrections made to those events already registered (Fujiwara, 2020). That means, the analysis must be updated and adjusted regularly. However, it is important to assess recent trends to observe what has been happening with the dynamics of mortality. For Ecuador, we use register monthly death civil registers for the year 2020, available at https://www.registrocivil.gob.ec/cifras/.

For these analyses, we compare the number of the monthly deaths in 2020 relative to the deaths recorded in similar months in 2019. We choose March as the baseline month for both countries, due to the fact that the first case of coronavirus detected in Brazil and Ecuador were on 26 and 29 February 2020, respectively (Ministry of Health 2020; Comercio 2020). We compare the average number of deaths, percentage deaths variation and the mortality coefficient of variation in small areas of both countries.

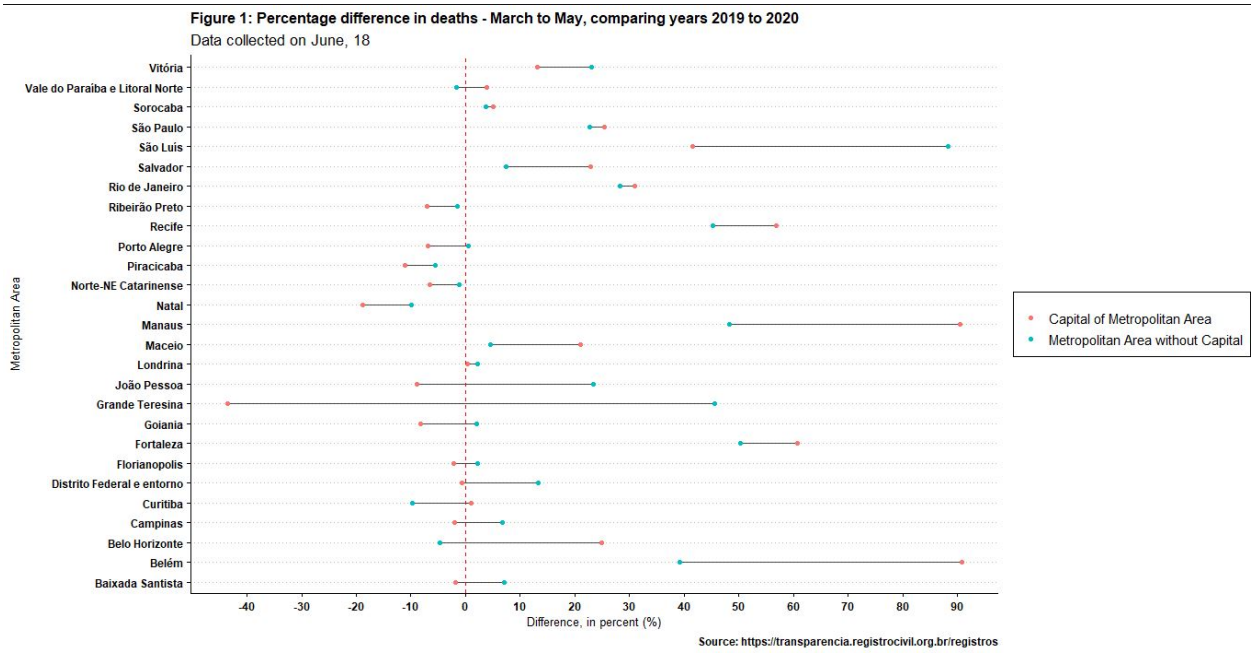
Ideally, information should be broken down into external causes of death, as these may fluctuate from one year to the next (fluctuations in the number of homicides, traffic deaths, etc.). However, these estimates are based on provisional data, which are incomplete. It is important to stress that these data might have several limitations: delay in reporting of events, under-reporting of events and problems in data quality. Thus, the estimates reported here are representing the lower bound of the impacts of the pandemic.

## 3. Results

For Brazil, in Figure 1, it shows the percentage difference in mortality (death counts) considering all causes of deaths, between 2019 and 2020, for the cumulative months of March and May for each year. We show the results for the major cities and each area without the capital city in these areas. Showing the results this way, allows us to understand whether the pandemic is concentrated in a larger city or it is already spreading for its surrounding minor municipalities.

The findings indicate impressive increases in mortality in many regions of the country. Considering all the 27 regions, only four areas have not shown any increase in the percentage of deaths between the two years (2019 and 2020). In the case of metropolitan capitals, 12 cities stand out, compared to the MAs without its major city. The most expressive differences are found in cities located in the north and northeast of the country. Here, we give special attention to the municipalities of Recife, Fortaleza Manaus and Belém, where mortality has increased more than 50% in 2020. Yet looking at Figure 1, we also see in 10 cases that the excess of mortality in the surrounding municipalities is more noticeable than its capital between 2019 and 2020, which may probably indicate the effects of the pandemic are spreading throughout the country's inland. Once more, in the municipalities in the poorest regions of north Amazon and seaside northeast of the country, we see this development to a large extent.

**Figure 1: Difference, in percent, between the number of deaths registered in 2020 compared to 2019 in the months March to May. Metropolitan Areas and Metropolitan Areas without Capital**.

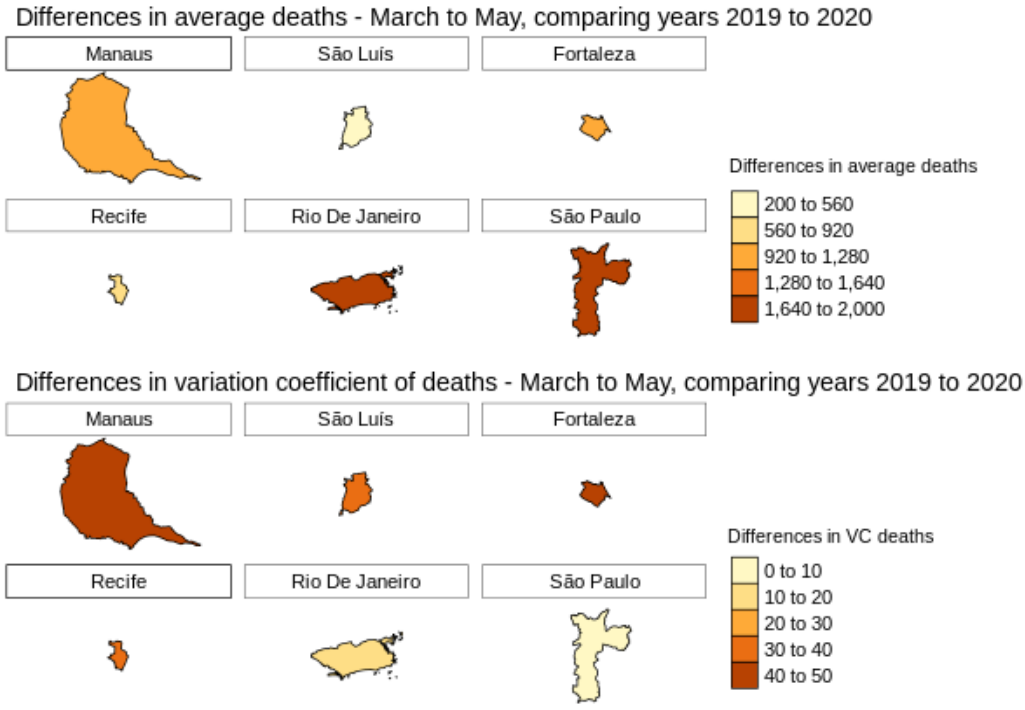



Source: Civil Registers Brazil, 2019 - 2020.

Figure 2 shows maps for particular areas of each country. The results show the evolution of deaths in terms of average number and variation coefficient for a selected number of locations, between the two years in study. These selected municipalities give a good geographic overview of the pandemic spread across the country, since it integrates areas from distinguished regions of the country. These cities are also the ones most affected by the beginning of the SARS-CoV-2 pandemic.

When we look at the average differences in mortality, in the two major country cities of São Paulo and Rio de Janeiro, the excess of mortality stands out. In these cities, the differences indicate an average number of more than sixteen hundred deaths occurring solely in the month of March of 2020 in comparison with the previous year. Important to mention that, both municipalities are located in the most developed region of Southeast of the country, also in terms of health access and facilities. This result is expected, because tourism traffic and business travels, especially from Europe, provided these two cities with the first contacts with the virus. In addition, these are the most populated cities of the country, so it is expected that more people are exposed to death risks.

**Figure 2: Differences and average deaths and variation coefficients in selected cities of Brazil. Overall mortality between 2019 and 2020, months March to May.**

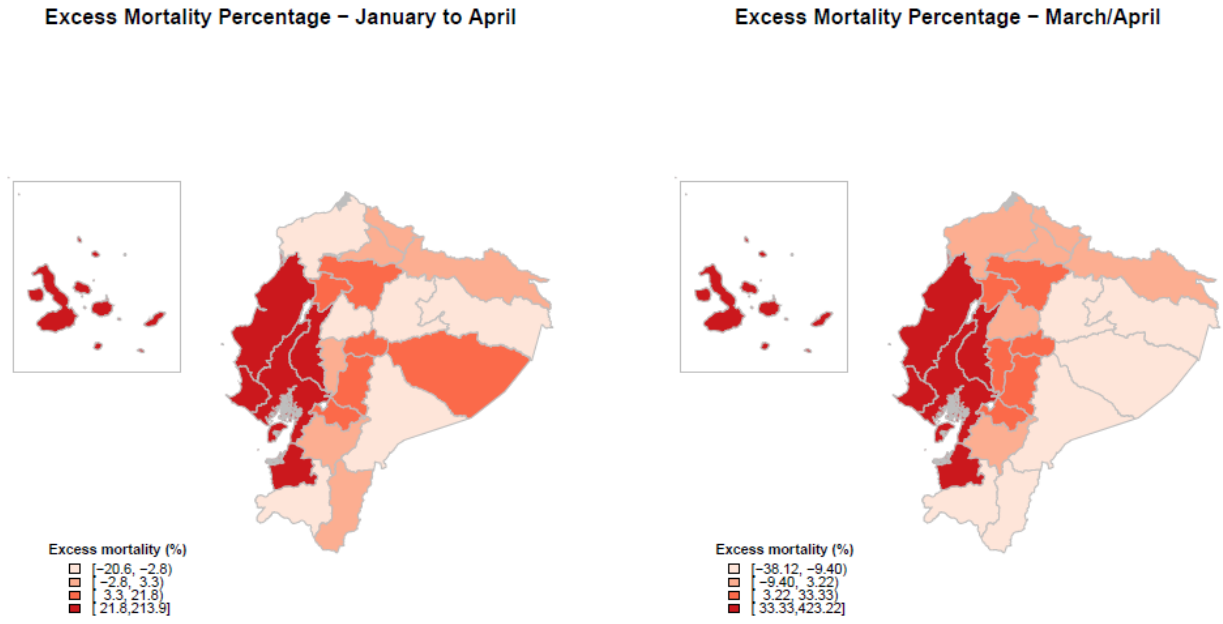



Source: Civil registers Brazil, 2019 - 2020.

On the other hand, when we pay attention to the variability of deaths, cities from North and Northeast are the ones with distinctive numbers, especially in Manaus (North Amazon) and Fortaleza. Manaus is a good example of a place that, despite being isolated from many other major cities, the pandemic has hard hit the city, and since mid April the number of deaths has increased strongly (Fundação de Vigilância em Saúde 2020). We also believe that this increased heterogeneity in those cities may be related to the Covid-19 pandemic.

In the case of Ecuador, we also see the effects of excess of deaths, especially in the region of Guayaquil. This city is composed by millions of inhabitants, characterized by enormous inequalities; a city where the climate at this time of year is especially harsh due to the high temperatures and other discomforts typical of the time. The city also lacks adequate drinking water sources, and 60% of people do not have access to internet, which in turn makes it difficult to impose lockdown because many people cannot work or study remotely (Acosta 2020). Highest levels of excess mortality are observed in the western part of the country. Peralta et.al (2019a) shows that with the most deprived cantons located in the Amazon, central Andean, and northern and central coastal regions.

**Figure 3: Differences in percentages of deaths in Ecuador. Overall mortality in 2020 in relation to 2019, months January to April.**




Source: Ecuador, https://www.registrocivil.gob.ec/cifras/, 2020.

## 4. Discussion

In the end, the excess mortality from all causes is a great indicator of the magnitude of the health crisis in which we are inserted, much better than the hospital count of cases and deaths due to COVID. That has been shown in the results comparing the developments of total mortality in small areas of Brazil and Ecuador, during the months of March-May (March-April 2020 in the case of Ecuador) from the years 2019 and 2020.

The mortality trend analysis, allows us to indicate that we are not thinking for a normal moment, and it is not a simple flu outbreak. Therefore, during the pandemic, with everything else equal, we should not expect more deaths from other causes throughout the year, because now people may be dying from Covid. In other words, Covid has now become a competitive risk. But in addition, we will have the effects of direct-indirect mortality (the poorly classified ones) and indirect mortality. In addition, we see that mortality is starting to increase inland, in the case of Brazil, and is also affecting the lesser developed regions of Ecuador.

In these early moments of social isolation, we can expect that death rates from external causes (accidents and violence) may decrease due to reduced car traffic and fewer homicides. But, the current database does not yet allow us to observe this, since the Civil Registry does not disclose the causes with this level of detail so quickly. On the other hand, the rate at which people die from other causes may increase also due to greater difficulty in accessing health services, less health care, increased stress due to isolation and other things.

It is essential, however, that this analysis is constantly updated. The data evaluated and analyzed carefully. The main caveat of the analysis is the quality of information, but all the estimates indicate very high levels of excess mortality despite data limitations. It is also important that the agencies release the data in as much detail as possible: sex, age, causes of death, allowing health managers to monitor the potential effect of the epidemic on the general health of the population.

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