

## **Estimate of underreporting of COVID-19 in Brazil by Acute Respiratory Syndrome hospitalization reports**

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### **Abstract**

The number of COVID-19 infected people in each country is a crucial factor to determine public policies. It guides the governments to strengthen movement restrictions of people or to relieve it. The number of infected people is very important to forecast the needs of the health systems, which are collapsing in many countries. Thus, underreporting of infected people is a huge problem, since authorities do not know the real problem and act in darkness. In the present work, we discuss this subject for the Brazilian case. We take the time series of acute respiratory syndromes reported in the health public system in the last ten years and estimated the number for March/20 when the COVID-19 appeared in Brazil. Our results show a 7.7:1 rate of underreporting, meaning that the real cases in Brazil should be, at least, seven times the publicized number.

### **Introduction**

As pointed out by the World Health Organization, by several epidemiologists and massively disseminated by the media whether in Brazil or globally, it is extremely important to know the real number of COVID-19 cases. This number informs the stage of evolution of a

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pandemic in each location and allows us to project its further evolution, giving to the government conditions to decide to harder containment measures or even know if it is time to relieve such measures.

However, several countries have been facing great difficulties in estimating the real amount of infected people mainly due to reduced capacity for COVID-19 diagnostic tests. Among these difficulties are: absence of adequate laboratory infrastructure and qualified people, which are often not available in the appropriate quantity; difficulty in buying tests due to high international demand and low availability of suppliers; logistical difficulty in the national distribution of tests in a country of continental dimensions such as Brazil.

Among the countries with population greater than 1 million people, Brazil is in the 13th position in the rank of infected reported people, but it is in the 29th position in the ranking of application of diagnostic tests. Up to 04/12/2020, 296 tests per million inhabitants have been applied (Figure 1). While the USA has applied about 8,000 tests per million inhabitants and countries like Germany and Italy have applied about 16,000 tests per million inhabitants.

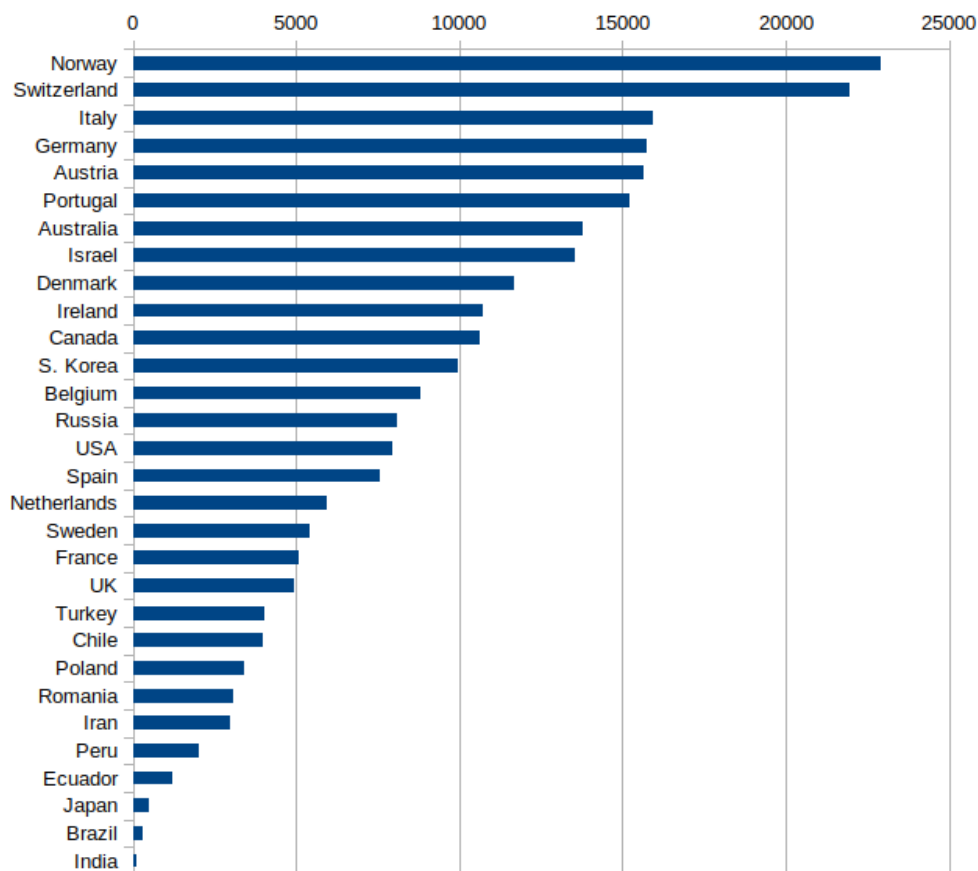
This statistic makes clear the low effectiveness in confirming cases of infected people by COVID-19 in Brazil. We presume that there is a large gap between the number of suspected and confirmed cases in Brazil. Therefore, there is great uncertainty about the actual number of cases of COVID-19 infection and, consequently, the current stage of the evolution of the pandemic in Brazil and which containment measures are necessary.

Thus, it can be suspected that there is an underreporting of cases in Brazil. This was pointed out in a study by the London School of Hygiene and Tropical Medicine (LSHTM)<sup>3</sup> that estimated that only 11%

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3 [https://cmmid.github.io/topics/covid19/severity/global\\_cfr\\_estimates.html](https://cmmid.github.io/topics/covid19/severity/global_cfr_estimates.html)

of the actual cases of deaths were being reported, which generates a 9:1 ratio between the actual cases and those reported.



**Figure 1** - COVID-19 diagnostic test ranking. 30 countries with higher number of infected people. Only countries with population greater than 1 M inhabitants have been computed. (Source: Worldometers<sup>4</sup>; Author's elaboration)

The present paper has been also developed seeking to estimate the proportion between real and confirmed cases. Different from previous studies, we do not consider only the cases of deaths, but all the cases of hospitalization in Brazil having as cause some type of acute respiratory syndrome (ARS).

### Data and Methodology

Statistics on the number of hospitalizations in Brazil by ARS are

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4. <https://www.worldometers.info/coronavirus/covid-19-testing/> accessed on 04/12/2020

collected by Fundação Oswaldo Cruz - Fiocruz<sup>5</sup> and are available on the website <http://info.gripe.fiocruz.br/>. The total number of new cases of hospitalization by ARS for the months from January, February, and March, from 2012 up to 2020 are shown in Table 1.

**TABLE 1** - Hospitalizations due to ARS

	Jan	Fev	Mar
2020	1264	1726	12508
2019	1034	1646	3305
2018	729	772	1704
2017	718	1097	1770
2016	428	787	3821
2015	669	537	1001
2014	712	572	812
2013	581	434	638
2012	302	247	468

Source: <http://info.gripe.fiocruz.br/> accessed on 04/12/2020, those data can be updated by Fiocruz.

Plots of temporal evolution for January, February and March were constructed in the period considered and shown in Figures 2 respectively.

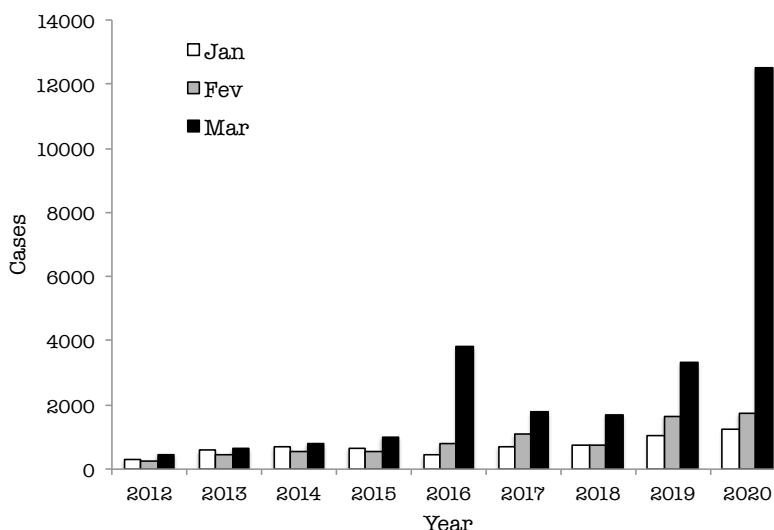
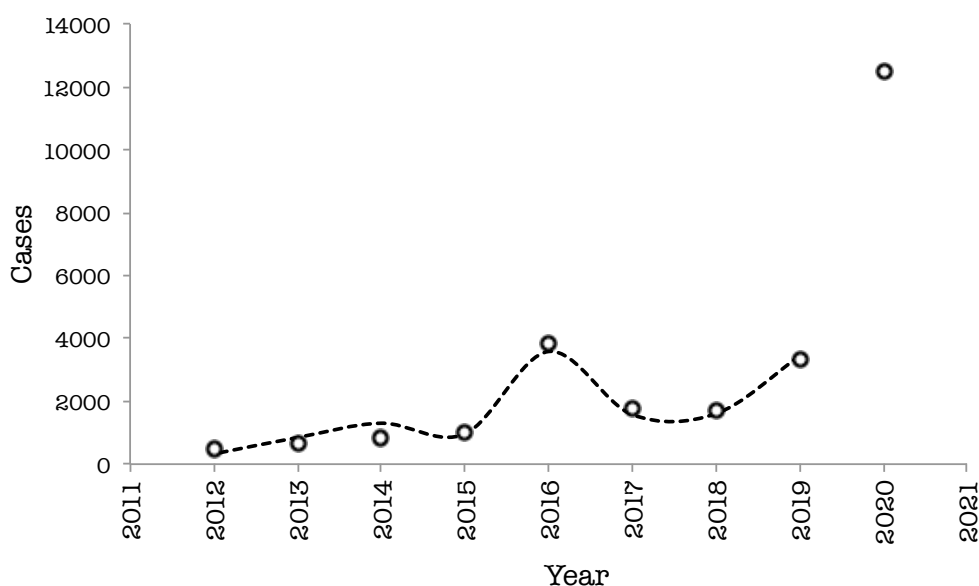


Figure 2: Total number of ARS hospitalizations as given by Fiocruz. The high number of cases in 2016 are attributed to H1N1 (Source: <http://info.gripe.fiocruz.br/>, those data can be updated by Fiocruz; Author's elaboration)

<sup>5</sup> Fundação Oswaldo Cruz is a public institution of science and technology in health, belonging to the Ministry of Health.

Based on these data, a mathematical analysis of the temporal evolution of hospitalizations for each month of the period between 2012 and 2019 has been performed, and therefore, excluding the period in which the occurrence of cases of COVID-19 infection in Brazil began. This analysis identified, using the regression technique, a mathematical function that replicates, with a high degree of reliability (given by a correlation coefficient near 0.9), the typical behavior of cases of hospitalization due to ARS. Note that this function does not intend to explain the relation of causality between the two variables, but only to be used to extrapolate data. The dotted line in Figure 3 shows the behavior of the curve obtained with the mathematical analysis and makes clear the similarity between the modeled curve and the actual behavior of the data. The mathematical curves obtained for each month are shown in Annex I.



**Figure 3:** Hospitalizations due to ARS in Brazil in March. Circles represent real data and dotted line represents a mathematical function that matches them. (Source: <http://info.gripe.fiocruz.br/> accessed on 04/12/2020, those data can be updated by Fiocruz; Author's elaboration)

Those functions allow us to use the concepts of impact analysis using time series<sup>6</sup>. The typical behavior of the system obtained between 2012 and 2019 was then extrapolated to the year 2020 (by using the mathematical functions described above). This extrapolation, therefore, represents the number of cases that would be expected if the system followed its natural dynamics, that is, there was no outbreak of infection that would lead to an atypical increase in hospitalizations for ARS. It is known that, in the present moment in Brazil, there is no atypical outbreak by other viruses such as Influenza, H1N1, MERS-Cov, etc. So we assume that an atypical increase in the cases of ARS hospitalization must then be attributed to COVID-19 infection.

## Results

Following this procedure, we compute the difference between the simulated data extrapolated to 2020 and the actual number of cases of hospitalization due to ARS as informed by Fiocruz:

- Cases of hospitalization due to ARS above the simulated trend for February: 404
- Cases of hospitalization due to ARS above the simulated trend for March: 9174

As we have mentioned above, this atypical behavior would be given by hospitalizations due to COVID-19. However, the number of cases of hospitalizations for COVID-19 confirmed by the Ministry of Health are<sup>7</sup>:

- Cases of hospitalization due to ARS and confirmed as infection by COVID-19 in February: 1
- Cases of hospitalization due to ARS and confirmed as infection by COVID-19 in March: 1195

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6. Montgomery, D.C.; Jennings, C.L. & Kulahci, M. (eds). Introduction to Time Series Analysis and Forecasting, 2nd Ed. Hoboken, NJ: John Wiley and Sons. 2015.

7 . <https://portalarquivos.saude.gov.br/images/pdf/2020/April/03/BE6-Boletim-Especial-do-COE.pdf>

Therefore, we can compute the relation between atypical cases of hospitalizations and those confirmed cases of COVID-19 for March and reported by the Ministry of Health. This relation is of 9174:1195, that is, approximately 7.7:1. This means that the confirmed number of cases must be multiplied by a factor of 7.7 to obtain the actual number of infected patients in hospital conditions.

This underreporting index was obtained from the number of hospitalization cases, which are severe cases. So, it is to be expected that in the general scenario, also considering the cases that do not generate hospitalization, this rate of underreporting should be even higher.

Considering an optimistic scenario in which this lower notification rate is applied to all cases, Brazil would have on 04/12/2020 approximately 160 thousand cases of infection by COVID-19 and not only the 21 thousand confirmed cases.

As a comparison, the proportion between confirmed cases of COVID-19 infection in the USA and cases of hospitalization due to ARS has been calculated using the information provided by the Centers for Disease Control and Prevention<sup>8</sup>. The proportion obtained, using 03/28/2020 data, was approximately 8:1, that is, each 8 confirmed cases of COVID-19 cause hospitalization in the USA. Applying this proportion to the total number of hospitalizations for COVID-19 obtained in this study, we estimate that there are approximately 136 thousand cases, which is close to the most accurate estimate above.

In conclusion, our study shows that the numbers reported by Brazilian government should be far from the real situations. In this context, manifestations of some politicians in favor of a less restrictions of people movement should be seen with enormous worrying.

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<sup>8</sup> [https://gis.cdc.gov/grasp/COVIDNet/COVID19\\_3.html](https://gis.cdc.gov/grasp/COVIDNet/COVID19_3.html), accessed on 04/08/2020.

**Annex I**

The mathematical curves obtained for each month through the regression performed:

- January

$$\text{Cases} = 67.154 * \text{Year} - 134703.797 - 155.567 * \cos(\text{Year} + 0.104) + 47.412 * \cos(2 * \text{Year} + 0.104) + 65.483 * \cos(3 * \text{Year} + 0.104)$$

- February

$$\text{Cases} = 158.428 * \text{Year} - 318551.285 - 44.433 * \cos(\text{Year} + 0.931) + 150.624 * \cos(2 * \text{Year} + 0.931) + 403.2453933 * \cos(3 * \text{Year} + 0.931)$$

- March

$$\text{Cases} = 367.654 * \text{Year} - 739318.297 + 473.568 * \cos(\text{Year} + 1.667) + 995.201 * \cos(2 * \text{Year} + 1.667) + 755.105 * \cos(3 * \text{Year} + 1.667)$$