

Severe acute respiratory infection surveillance in Brazil: the role of public, private and philanthropic healthcare units

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Abstract

Epidemiological surveillance and notification of respiratory infections are important for management and control of epidemics and pandemics. Fact-based decisions, like social distancing policies and preparation of hospital beds, are taken based on several factors, including case numbers; hence, health authorities need quick access to reliable and well-analysed data. We aimed to analyse the role of the Brazilian public health system in the notification and hospitalization of patients with severe acute respiratory infection (SARI). Data of SARI cases in Brazil (2013–20) were obtained from SIVEP-Gripe platform, and legal status of each healthcare unit (HCU) responsible for case notification and hospitalization was obtained from the National Registry of Health Facilities (CNES) database. HCUs that are part of the hospital network were classified as 'Public Administration', 'Business Entities', 'Philanthropic Entities' or 'Individuals'. SARI notification data from Brazilian macro-regions (North, Northeast, Midwest, Southeast and South) were analysed and compared between administrative spheres. This study reveals that hospitalizations due to SARI increased significantly in Brazil during the coronavirus disease 2019 (COVID-19) pandemic, especially in HCUs of Public Administration. In the Southeast and South, where incidence of SARI is high, philanthropic HCUs also contribute to hospitalization of SARI cases and attend up to 74% of the cases notified by the Public Administration. The number of cases is usually lower in other regions, but in 2020 the Northeast showed more hospitalizations than the South. In the South, SARI season occurs later; however, in 2020, an early peak was observed because of COVID-19. Notably, the contribution of each administrative sphere that manages hospital networks in Brazil in the control and management of SARI varies between regions. Our approach will allow managers to assess the use of public resources, given that there are different profiles of healthcare in each region of Brazil and that the public health system has a major role in notifying and attending SARI cases.

Keywords: Acute respiratory infection, surveillance, infectious diseases, health information system, public health, hospitals

Key messages

- The majority of cases of severe acute respiratory infection (SARI) in Brazil are notified by and hospitalized in healthcare units of Public Administration, especially during the coronavirus disease 2019 (COVID-19) pandemic.
- Hospitals administered by Philanthropic Entities and Private Entities also contribute to notifying and attending patients with SARI in Brazil.
- Data of SARI surveillance provide information about the seasonality of viral infections in different regions of the country, enabling health authorities to better prepare for preventing and controlling outbreaks.
- The Brazilian Unified Health System has a paramount role in the surveillance of respiratory infection, as well as in attending and treating patients.

Introduction

Epidemiological surveillance of respiratory viruses is key to disease control and outbreak response. In addition, timely notification of cases of respiratory infection can prevent epidemics and pandemics. Despite many initiatives and programmes of the World Health Organization (WHO) for the global surveillance of influenza and other respiratory viruses (Hay and McCauley, 2018; Legand *et al.*, 2013; WHO, 2019), the year 2020 started with an unprecedented pandemic caused by the coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In a few months, the coronavirus disease 2019 (COVID-19) that started in Wuhan, China, at the end of 2019 reached all geographical regions and, as of November 2021, ~260 million people had been infected and 5.2 million had died of COVID-19. The highest number of cases is seen now in the USA, in India and in Brazil (Dong *et al.*, 2020). Although the former has a higher number of

cases and deaths, the latter faces additional problems such as one of the worst economic crises in its history, huge poverty belts and uncontrolled diseases including dengue, malaria and tuberculosis, among others.

In Brazil, surveillance of respiratory infections is divided into influenza-like illness (ILI) and severe acute respiratory infection (SARI), the latter being of universal notification since 2009 (Brasil, 2010). In the case of ILI, the country adopts a sentinel surveillance network for influenza and other respiratory viruses, which started with a single sentinel unit in 2000 and gradually expanded to reach 60 units in 2010, with at least 1 unit in 26 of the 27 Federal Units (comprising 26 states and the Federal District). The network of sentinel units includes outpatient clinics, emergency units and general hospitals that report weekly the aggregate total number of visits and total visits for ILI through an online system called SIVEP-Gripe. ILI is defined as any individual presenting fever, accompanied by a cough or sore throat without further diagnosis (Martins *et al.*, 2011). Brazil has been in line with the WHO guidelines for SARI surveillance for many years (WHO, 2013); thus, the country was prepared to capture notification cases during the COVID-19 pandemic without having to create a surveillance system from the very beginning. Even so, there is a need to improve this surveillance system in order to increase the level of confidence and timeliness of the data generated.

At the end of 2009, all cases of SARI started to be included on SINAN (Information System on Diseases of Compulsory Declaration), a digital platform used by the Brazilian Health Ministry for reporting notifiable conditions (SINAN—Sistema de Informação de Agravos de Notificação, 2020). In 2018, SARI notification migrated to the SIVEP-Gripe database (SIVEP-Gripe—Sistema de Informação da Vigilância Epidemiológica da Gripe, 2020). Health institutions throughout the country notify SARI cases according to a specific notification sheet (Brasil, 2020) and insert them directly in the system in case they have access to it or, more commonly, send those sheets to health authorities such as the Municipal and State Health Secretariats for insertion into SIVEP-Gripe (Martins *et al.*, 2011).

As proposed by WHO and adopted by several countries, notification of SARI cases is used as syndromic surveillance aimed at quantifying hospitalizations and deaths related to respiratory viral infections (WHO, 2013), which can be caused by influenza A virus, influenza B virus (IBV), respiratory syncytial virus (RSV), human adenovirus (HAdV), human parainfluenza virus (hPIV) 1, 2, 3, and 4 and rhinovirus, among others (Martins *et al.*, 2011). In Brazil, surveillance at healthcare units (HCUs) is coupled with public laboratories that test for these viruses in order to assess viral circulation and seasonality, as well as the emergence of novel respiratory viruses of clinical relevance (Martins *et al.*, 2011; Brasil, 2019).

According to the official protocol, every patient notified as a SARI case must have a suitable biological sample collected for laboratory testing, provided by the Brazilian Unified Health System (SUS) without any additional charge to the patient. In response to the SARS-CoV-2 pandemic, the Brazilian SARI surveillance guideline was updated to monitor COVID-19 hospitalizations as well (Brasil, 2021a). Due to its syndromic nature, SARI surveillance provided a general overview of the impact of COVID-19 hospitalizations

in Brazil, even before the guideline update (Niquini *et al.*, 2020).

Brazil is a country of continental size divided into 26 states and a Federal District, categorized into five regions: North, Northeast, Midwest, Southeast and South. Notably, the incidence of respiratory viral infection varies among different regions, with higher incidences in the South and Southeast; in addition, respiratory viruses may show different circulation patterns and seasonality (Almeida *et al.*, 2018; Martins *et al.*, 2011; Gregianini *et al.*, 2019; Veiga *et al.*, 2020). Therefore, the existence of a uniformly defined national surveillance system with a centralized database is fundamental for situation assessment at the national level and the development of coordinated mitigation efforts.

The hospital network in Brazil is administered primarily by four administrative spheres (CNES, 2021):

- Public Administration: comprises public bodies, autarchies and public foundations of the Union, the States, the Federal District and the Municipalities, among others. It is worth mentioning that a subgroup in this category attends only patients linked to the Brazilian Armed Forces;
- Business Entities: made up of public companies, mixed capital companies, open and closed corporations and limited companies, among others;
- Philanthropic Entities: composed of private foundations, autonomous social service, private association, social organization, non-profit entities and religious organizations;
- Individuals: this is an administrative sphere with little representation in the data collected and consists basically of independent professionals, such as physicians.

The hospital network managed by the public administration has exclusively public beds, free of charge, whereas hospitals managed by the other entities can have both free public beds and private, paid beds. Since the national surveillance system is administered by the Ministry of Health as part of the freely accessible SUS, and because SARI notification is not mandatory in Brazil despite being universal, there is no guarantee that HCUs outside public administration actually report SARI cases, especially regarding patients under private beds. Therefore, the difference observed in the number of reported cases in March 2020 [incidence of 10.4 cases per 100 000 inhabitants between epidemiological weeks (EWs) 10 and 13] with respect to not only January and February (2.1 per 100 000 inhabitants between EW 1 and 9) but also previous years (median of 1.1 with 95% confidence interval [1.4–3.0] between EW 10 and 13 from 2013 to 2019) (Fiocruz, 2020) triggered warranted concerns whether this difference was simply due to sudden adherence of business and philanthropic entities to the notification protocols.

Therefore, to better understand the role of the public health system and investigate the hypothesis of a significant increase in 2020 data solely by a greater contribution from non-publicly administered HCUs, the present study assessed cases of SARI in Brazil between 2013 and 2020, providing the historical level of notifications by each administrative sphere at the national level, as well as in each region. Our results provide a detailed analysis of the potential impact of SARI cases in each administrative sphere measured by notifications and of potential territorial differences of network coverage. Moreover, this study highlights the importance of the Brazilian public health system in the control and surveillance of respiratory viral infections.

Materials and methods

The data used in this study were obtained from the SIVEP-Gripe database (SIVEP-Gripe—Sistema de Informação da Vigilância Epidemiológica da Gripe, 2020) and from the CNES system (National Registry of Health Facilities) (CNES, 2021). The SIVEP-Gripe platform provides information about cases of SARI notified by health institutions in the country and includes data such as symptoms, date of first symptoms, date of hospital admission, notification unit code, inpatient unit code and establishment's CNES code. Of note, the case definition for SARI was any individual presenting dyspnoea (oxygen saturation below 95%), with fever (above 37.5°C), myalgia, lethargy, cough and sore throat (Martins *et al.*, 2011; Brasil, 2019; Gregianini *et al.*, 2019; Fiocruz, 2020; Veiga *et al.*, 2020). To guarantee comparability over the years and across HCUs, we only kept those cases that were notified with explicit mention of the following signs and symptoms: (fever) and (cough or sore throat) and (dyspnoea or oxygen saturation below 95% or difficulty breathing) and (hospitalized or deceased).

The CNES system was accessed to obtain information about each health unit indicated in the SIVEP-Gripe platform, including company name, type of unit, legal nature, location, etc. (CNES, 2021). With regard to the legal nature, each health unit was classified based on four administrative spheres: 'Public Administration', 'Business Entities', 'Philanthropic Entities' and 'Individuals'.

The population data were collected through the projection of the population of the federation units by sex and age groups, found in Tabnet DATASUS (Brasil. Ministério da Saúde, 2021b). Due to the different population structures in each region of Brazil, the number of hospitalizations and their incidence were standardized according to the direct standardization method (Pan American Health Organization, 2002). The Brazilian population in the year 2020, extracted by age and sex, was considered as the standard population. The calculation of uncertainties associated with observations of cases of hospitalization and notification related to SARI in each administrative sphere for each region and year was performed using a multinomial model, based on the method proposed by Sison and Glaz (1995), Glaz and Sison (1999) and May and Johnson (2000). To facilitate data visualization, some graphs do not show data from the 'Individuals' administrative sphere because of its low volume of notifications (0.04% of all reported cases).

Information on beds was obtained from the Applied Health Data Science Platform, from the Institute of Communication and Scientific Information and Technology in Health from the authors' institute and complemented with data obtained from DATASUS (Brasil. Ministério da Saúde, 2021b). It is important to note that the number of beds reported by each HCU in the available databases does not reflect the actual number of set up and staffed beds but rather licensed ones. Due to the ineffectiveness of data on available hospital beds in Brazil, it is not possible to carry out a direct analysis considering the volume of hospitalizations and available hospital beds. We included a table (Supplementary Table) as a proxy for the number of hospital beds available in each region, based on the yearly average number of complementary (those reserved for intensive and semi-intensive care) and clinical beds reported monthly by each health unit. Beds reserved for surgeries were left out.

At its inception in 2009, the Brazilian SARI surveillance focused on pandemic influenza strains. In August 2012 (wintertime in the Southern Hemisphere), the notification sheet was updated to include additional respiratory viruses such as IBV, RSV, hPIV-1, 2 and 3 and HAdV (Brasil, 2012). Due to that change, our analysis included cases of SARI notified from EW 1 of 2013 to EW 53 of 2020, with a total of 615 709 cases. Of these, 2928 records had invalid notification HCU codes and were excluded, totalling 612 781 cases that were included in further analyses. Of note, 106 315 invalid inpatient unit codes were also found, meaning that the patient was admitted in a health unit; however, it is not possible to know in which establishment this admission was made; usually hospitalization occurs in the reporting unit, but this is not always the case, as we show further in this article. Regardless of that, records with such inconsistency were not discarded. As of EW 53 of 2020, 429 448 SARI cases had been notified on SIVEP-Gripe attending the criteria defined here.

For the preparation and generation of data for analysis, the Knime tool was used (Berthold *et al.*, 2009). Graphics were generated with the R tool (R Core Team, 2020), the ggplot2, dplyr and stringr packages (Wickham *et al.*, 2019), and R package DescTools' function MultinomCI (Signorelli *et al.*, 2021). The environment for executing R codes was Google Colaboratory (Bisong, 2019). The study was approved by the Ethics Committee of the authors' institute (CAAE 75118217.9.3001.5347). All analysis relied on individually based but anonymous SARI notification data, such as those openly provided by the Brazilian Ministry of Health at <https://opendatasus.saude.gov.br/dataset/srag-2020>. Data regarding the administrative sphere of each HCU, as well as the number of licensed beds are publicly available through the National Registry of Healthcare Units (CNES).

Results

Hospitalizations by Brazilian region

The analysis of the total number of hospital admissions that occurred yearly in each Brazilian health institution showed that there was a great increase in hospitalizations in 2020 compared to previous years (Figure 1a). Notably, in hospitals of Public Administration, a >10-fold increase was observed, revealing the contribution of this administrative sphere in attending patients during the COVID-19 pandemic.

When evaluating the proportion of notifications of admissions by administrative sphere in each region, our analysis reveals that Philanthropic Entities have historically played a relevant role in the South region, whereas for other regions, the administrative sphere Public Administration has a greater volume of hospitalization in relation to other spheres (Figure 1b). Results also show that the highest volume of hospitalizations related to SARI in Brazil is usually in the South, except for the year 2020, when the standardized number of hospitalizations in this region was smaller compared to other regions. In contrast, the North and Northeast regions had much higher hospitalization volumes in 2020 than in previous years (Figure 2).

Considering the typical seasonality of SARI in the different Brazilian regions, the analysis shows that the peak of respiratory infections in the South usually occurs later than in the northern regions (Figure 3).

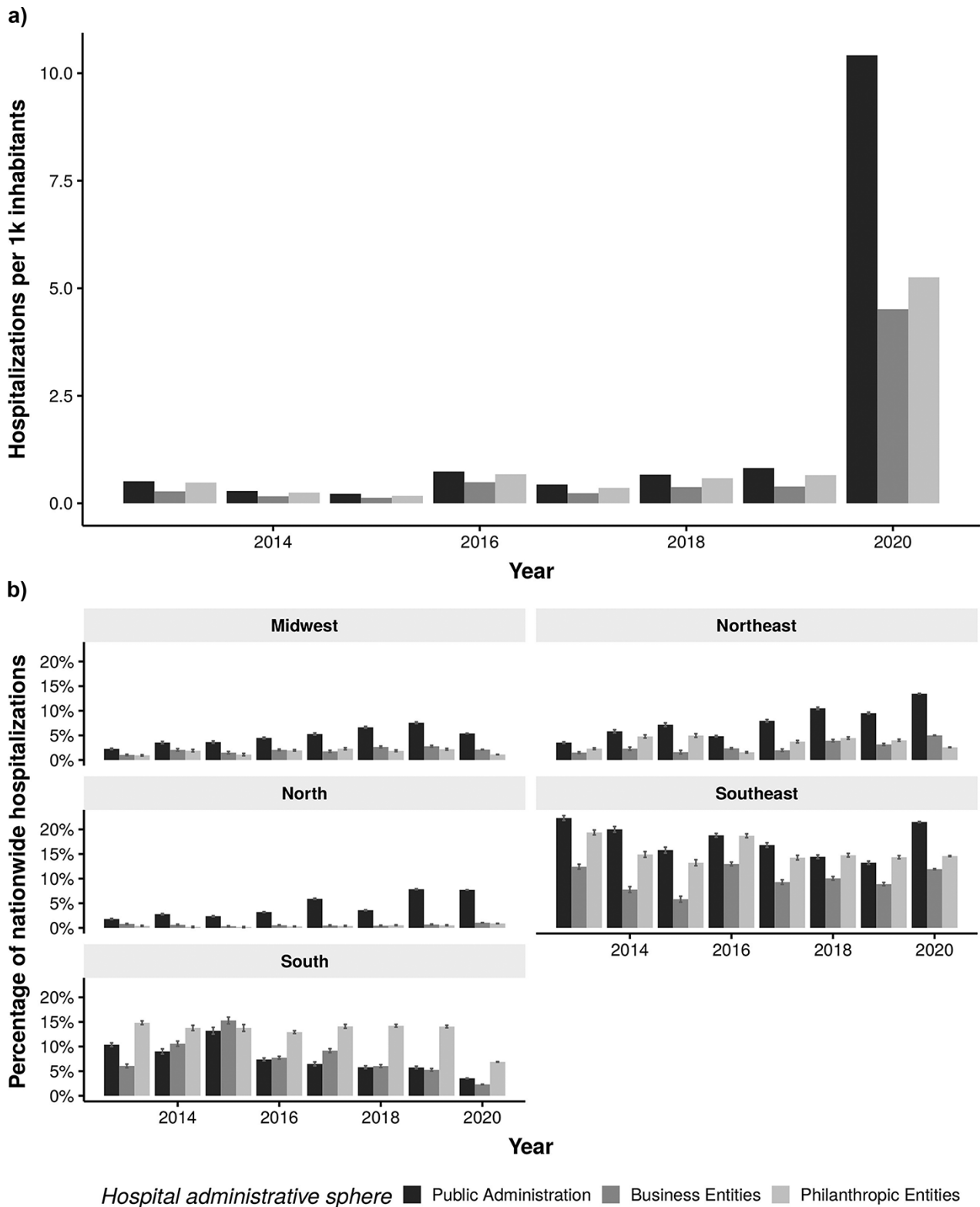


Figure 1. (a) Number of hospitalizations due to SARI in Brazil, 2013–20. The graph represents the total number of hospital admissions per 1000 inhabitants for each year, stratified by administrative sphere, according to the order in the graph: Public Administration, Business Entities and Philanthropic Entities. The individual administrative sphere is not considered due to a small number of hospitalization cases. (b) Proportion of hospitalizations due to SARI in each Brazilian region, by administrative sphere. The five Brazilian regions are shown according to the order in the graph: Midwest, Northeast, North, Southeast and South

Hospitalization by administrative sphere

Further analyses of hospitalizations due to SARI in health units of different administrative spheres in each Brazilian region confirmed that most hospitalizations in the Midwest,

Northeast and North regions are reported from institutions of Public Administration, whereas in the South, most hospitalizations are reported in Philanthropic Entities, with the exception of the year 2015 (Figure 4a). In the graph, the

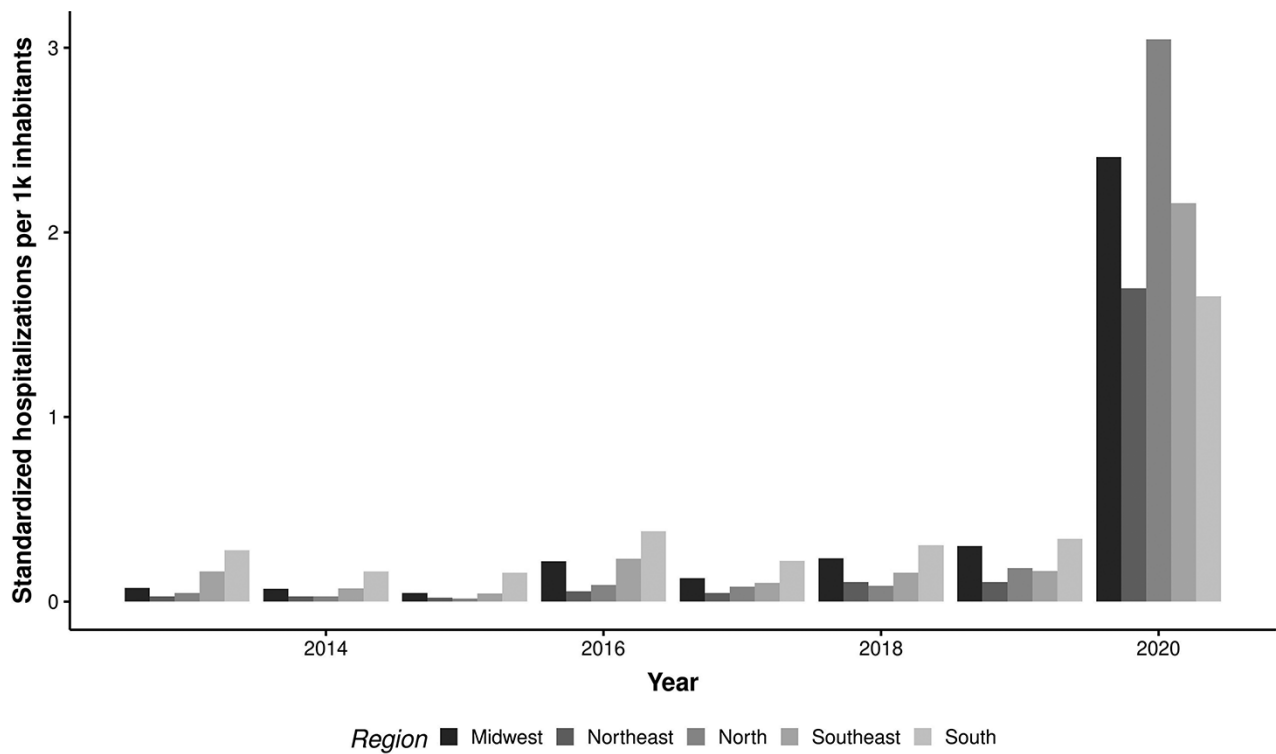


Figure 2. Standardized number of hospitalized cases per 1000 inhabitants, by region in each year

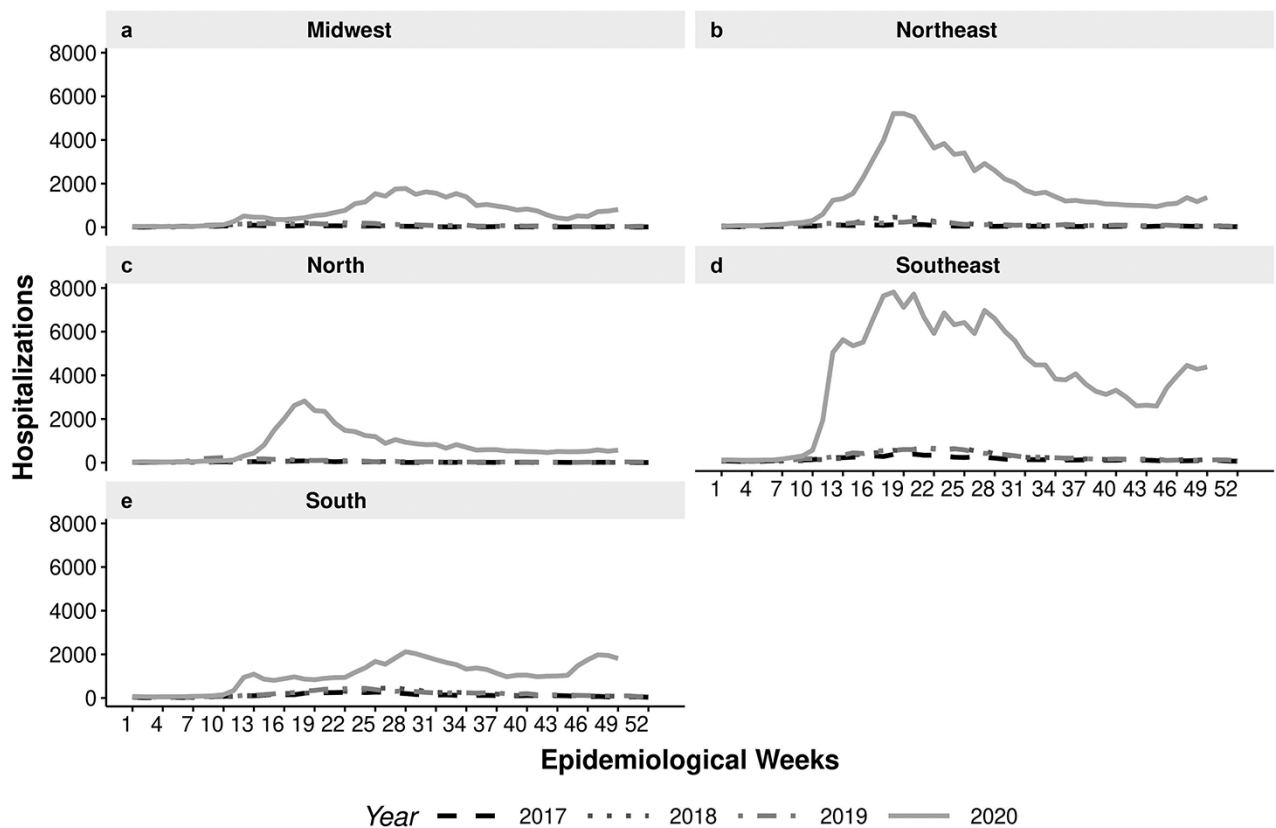


Figure 3. Seasonality of SARI in Brazil. The total number of patients hospitalized with SARI in each EW (2017–20) is shown for each Brazilian region; data for 2020 is shown until EW 49

year 2020 is shown separately to facilitate data visualization, given the much larger volume of notifications for that year.

The contribution of each administrative sphere in the hospitalization of SARI cases in each Brazilian region is maintained along the period, including 2020 during the COVID-19

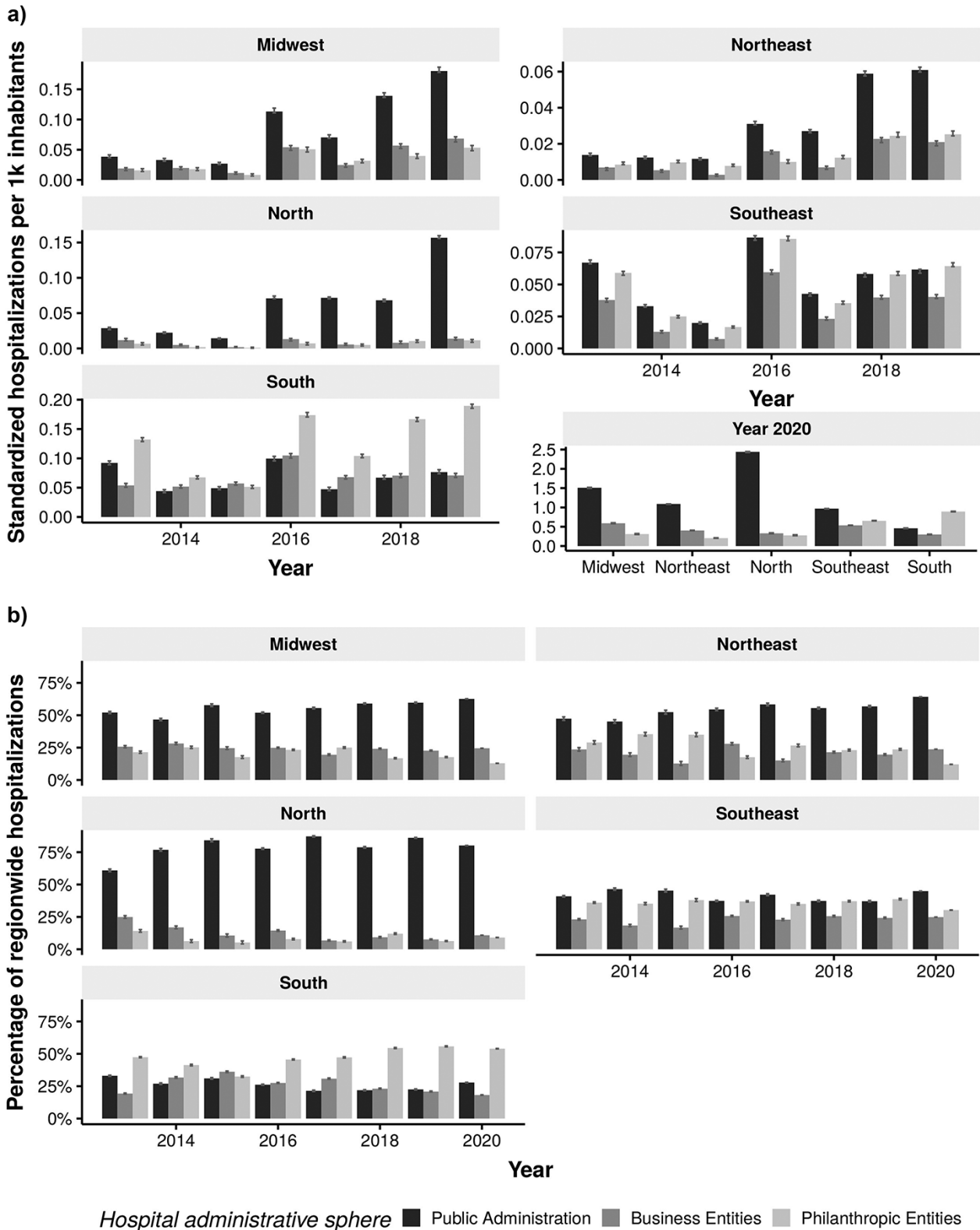


Figure 4. (a) Total cases of admissions per region per 1000 inhabitants in each administrative sphere, with a standardized population. To improve the visualization of the graph, data from the administrative sphere ‘individuals’ are not presented, as the number of cases is not significant (only 0.04% of the total cases). The year 2020 is shown separately from the other years because, due to the COVID-19 pandemic, the scale was very different from other years and this would make it difficult to visualize the data in the graphs. (b) Percentage of standardized cases of hospitalization due to SARI, as reported by administrative sphere and in each region, in relation to the standardized total number of hospitalized cases due to SARI in each region

pandemic (Figure 4b). Of note, the ‘Individuals’ administrative sphere has little representation in hospital admission notifications; therefore, this group is not shown in the graphs.

In some cases, notification of SARI is performed by a certain administrative sphere, but hospitalizations of some patients occur in HCUs of a different administrative sphere

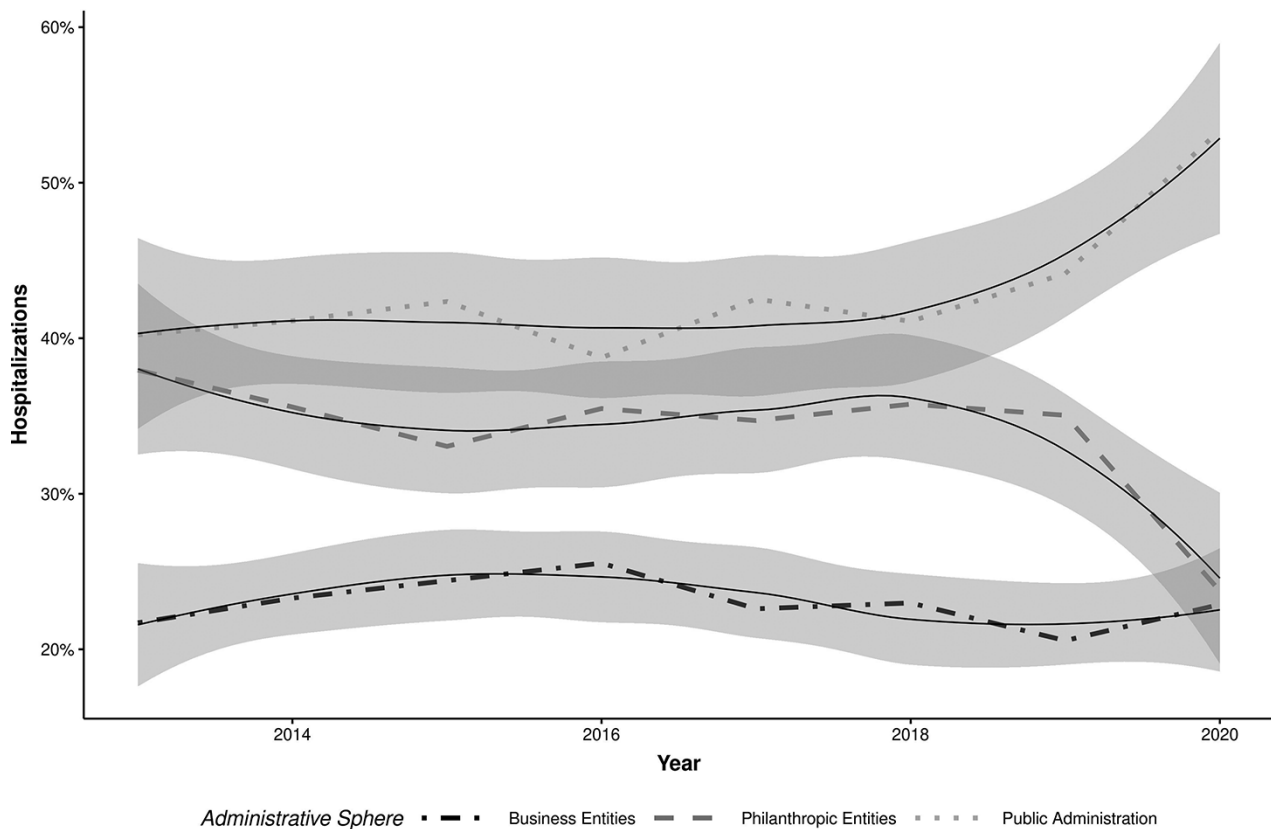


Figure 5. Proportion of hospitalizations notified by each administrative sphere. Percentages were normalized by the total number of hospitalizations notified in each year. The figure shows the percentage of each group along the period 2013–20 (Public Administration, dotted line; Philanthropic Entities, dashed line; Business Entities, dashed-dotted line), adjusted values and 95% confidence interval (solid lines and shaded area)

(Supplementary Figure). This is evident in the administrative sphere ‘Public Administration’, for which 7.4% of the SARI cases notified in 2013 were hospitalized in hospitals of the administrative sphere ‘Philanthropic Entities’. For other administrative spheres, admission to another administrative sphere is less common, except for the ‘Individuals’ administrative sphere, which makes sense considering that this administrative sphere has little contribution to SARI notification and comprehends mainly physicians in small clinics. Of note, for the years 2018 and 2019, the data reported in the SIVEP-Gripe platform presented inconsistencies for the inpatient unit code; therefore, these years were not included in order to avoid misinterpretation.

Distribution by administrative sphere

The distribution of hospitalizations along the period (2013–20) among administrative spheres for the whole country is shown in Figure 5; the administrative sphere ‘Individuals’ was omitted because the volume of notifications was very low for this group. As can be observed, hospitalizations in institutions of Public Administration increased significantly in 2020, whereas a significant decrease in hospitalizations was observed for the ‘Philanthropic Entities’ group. For the administrative sphere ‘Business Administration’, no significant differences were observed over the years.

Discussion

This study analysed the notification of SARI cases in Brazil over 8 years. Of note, this is the first study about the SARI notification system in Brazil that takes into account differences among institutions according to which administrative sphere they belong to. In a large country such as Brazil, this type of analysis gives a view of each administrative sphere’s performance in the different country’s regions. Consequently, it allows a better assessment of public health policy implementation for treating and mitigating diseases, especially those related to epidemics and pandemics such as respiratory infections.

Our analyses show that in the North, Northeast and Midwest regions of Brazil, health institutions of the public sector are the main ones responsible for hospitalization and notification of SARI cases. In contrast, in the South region, hospitals administered by Philanthropic Entities are the institutions where patients with SARI are hospitalized the most and in which confirmed cases are notified to health authorities. As for the Southeast, the most populous region in Brazil, a certain balance can be observed between the notifications made by the Public Administration sphere and Philanthropic Entities. These findings can be a consequence of different levels of participation of philanthropic and private HCUs in SUS, as well as of the socioeconomic inequalities within the country. For instance, a national survey from 2013 showed that families residing in the North and Northeast regions of Brazil were the ones with the lowest percentages of private health plan

coverage, with estimates of 13.3% and 15.5%, respectively. On the other hand, the remaining regions had >30% of the families with private health coverage. The country's overall percentage of families with a private health plan was 27.9% (IBGE—Instituto Brasileiro de Geografia e Estatística, 2015). These disparities among different regions have substantial consequences in terms of the role of the public sector in covering healthcare, be it in the direct administration of HCUs or in offering beds through partnerships with philanthropic and other not-for-profit institutions.

Although the vast majority of SARI cases notified by an HCU from a given administration group refer to hospitalizations in an institution of the same group, this is not always true. For example, in 2013, ~7.4% of the SARI cases notified by HCUs administered by the public sector were admitted to hospitals of Philanthropic Entities administration. Those situations are a clear example of the latter's contribution to SUS, since they usually refer to patients who sought medical attention at an HCU administered by the public sector and were triaged for hospitalization at a philanthropic one that had beds available.

The fact that most cases are notified and hospitalized within the same administrative sphere allows the use of the notification unit as a proxy for the hospitalization unit in the years 2018 and 2019, for which the latter was unavailable. As shown in Figure 5, it is clear that the dramatic increase in the number of notified SARI cases was not a consequence of greater adherence of the private sector to the national notification system. Although this study could not evaluate the level of compliance each year, the fact that the relative contribution from the Private Sector to the total number of notified cases decreased in 2020 is sufficient to discard that hypothesis. It is indeed possible that the COVID-19 pandemic increased professionals' and HCUs' adherence, making a direct comparison with previous years not necessarily accurate. Nonetheless, it is clear that this change in compliance, if true, was not driven by privately ran units. Moreover, as shown in this study, each administrative sphere's proportional contribution to SARI cases' hospitalizations during the COVID-19 pandemic in 2020 was very similar to that of the pre-pandemic years. Considering that in 2020 Brazil had ~7.7 million confirmed COVID-19 cases (Brasil. Ministério da Saúde, 2021c), these findings reinforce the role of public health institutions in controlling and managing the pandemic.

One of the main limitations of the present study is the fact that the SARI notification database (SIVEP-Gripe) does not allow for case stratification between public and private healthcare access directly. The use of the judicial/legal administrative sphere employed by cross-referencing with the HCU database (CNES) provides a proxy for that which can have important biases. For instance, units administered by Business Entities or Philanthropic Entities can have beds reserved for public access through SUS. Still, there is no clear way of separating the percentage of beds reserved for each type of access, let alone for each kind of health motivation. Nonetheless, it is known that philanthropic institutions usually share a larger portion of their facilities with SUS in comparison to units administered by Business Entities. Finally, this limitation does not affect the conclusions regarding the hypothesis of whether the dramatic increase in the case counts during 2020 could be solely or largely explained by a disproportionately increased adherence to reporting by private units. In fact, this limitation

only reinforces the role of public healthcare access, since there are cases from this particular network being notified by and hospitalized at Business and Philanthropic Entities.

Another limitation is the lack of reliable information about the number of hospital beds in the country. For instance, the number of beds reported by each HCU in the available databases does not reflect the actual number of set-up and staffed beds but rather licensed ones. Therefore, using such data as a relevant denominator would be subject to phantom beds that could vary between HCUs and administrative spheres (Phillip *et al.*, 1984). Hence, an analysis considering the number of beds and the volume of admissions is unreliable.

The policies for notification of health conditions and diseases vary among countries. For example, in New Zealand, the healthcare system is predominantly public and SARI is monitored by the public hospital network (Huang *et al.*, 2014). In Portugal, hospital administration is either Official (Public Entities) or Private, and the number of private and official hospitals is quite similar; basically, there are no philanthropic hospitals because in 1970, with the emergence of the Portugal SNS (National Health Service), philanthropic health institutions, known as *Misericórdias*, started to be administered by the State (Fernandes and Nunes, 2016). Of note, acute respiratory infections, including ILI, are not diseases of mandatory notification in Portugal (Portugal, 2017). Previous experiences with outbreaks of highly infectious diseases usually impact health policies, making some countries more prepared to face new epidemics and pandemics. In addition, as seen in many Asian countries, people become more aware of the risk of pathogen transmission and are more prone to adhere to measures such as mask-wearing and isolation when such events take place. For example, in Vietnam, not only SARS-CoV in 2003 but also dengue epidemics and avian influenza contributed to strengthening the health surveillance system as well as animal monitoring and vaccination. Hence, despite having a weak healthcare infrastructure, Vietnam rapidly responded to the COVID-19 pandemic by closing borders, isolating suspected and confirmed cases and tracing contacts. Strong citizen compliance to the governmental public health measures also contributed to control the pandemic in Vietnam (Willoughby, 2021).

Our study allows a comparative analysis between Brazil and these other countries. The universal coverage of the Brazilian SARI surveillance network was established in 2009 as a response to the influenza A H1N1pdm09 pandemic (Brasil, 2010). This policy complies with the current Global Influenza Strategy proposed by WHO (WHO, 2019) and has a pivotal role in preparing the country to deal with seasonal SARI epidemics and pandemics. Notifications are made by outpatient clinics, emergency care departments or general hospitals, from both public and private networks (Martins *et al.*, 2011). This diversification has proven to be efficient in Brazil, as it represents all social strata of the population, including both sexes and different age groups. Of note, the lowest income group makes use of the public and philanthropic network, while the highest income group uses primarily the private health network.

As shown by our results, systemic surveillance helps in identifying regions of higher incidence of SARI, whereas assessment of healthcare institutions involved in case notification and hospitalization is important to better prepare

resources and respond to epidemics. Therefore, it is important that governments provide support to regions with lower conditions to face events of health emergencies like the COVID-19 pandemic. This is even more necessary in countries with disparities in health capacity and financial conditions of both public and private hospitals, such as Brazil. Another example in South America is Colombia, which, unlike Brazil, does not have a strong epidemiological surveillance system and policy for pandemic preparedness. Nonetheless, Colombia was able to mitigate COVID-19 during the first months of the pandemic. Some of the actions taken by the Colombian government included renovation and adaptation of hospitals to receive patients, training for health workers, decentralization of testing and making surveillance data available in a timely manner to better guide health authorities in decision-making (Acosta *et al.*, 2021).

The universal coverage of the Brazilian SARI surveillance network has shown to be capable of identifying epidemiological characteristics of cases from novel viruses in contrast with known ones, early detection of invasion (Niquini *et al.*, 2020), as well as genomic characterization (Souza *et al.*, 2020; Varela *et al.*, 2021). Moreover, as shown in the present study, data of SARI surveillance provide information about the seasonality of viral infections in different regions of the country, enabling health authorities to better prepare for preventing and controlling outbreaks. Nonetheless, SARI surveillance in Brazil still faces important challenges, especially in terms of timeliness of data insertion, which are paramount for its usage as a data source for analytical methods for up-to-date situation assessment to support decision-making for mitigation strategies (Lana *et al.*, 2020). Another challenge is political polarization and denialism, which threatens national response even when adequate surveillance systems are in place, as has been the case of Brazil during the COVID-19 pandemic (Fonseca *et al.*, 2021).

This study shows the importance of SARI notification data in defining the profile of the different administrative spheres responsible for HCUs in Brazil and also of the surveillance network. Much of the SARI notification data originates from HCUs belonging to the public sphere; nonetheless entities that constitute complementary healthcare, mostly Philanthropic Entities and Business Entities, also provide a significant portion of SARI notification data. In Brazil, SARI notifications made by HCUs that make up complementary healthcare are made by adherence, and there is no routine evaluation to check whether HCUs are effectively and correctly reporting cases. It is important to ensure that the occurrences of SARI cases are fully being notified; therefore, it is necessary that the Ministry of Health increase the articulation with the HCUs, especially those that are part of the complementary healthcare network, so that SARI cases are notified correctly and in a timely manner in the system.

Although the present study focuses on the Brazilian SARI surveillance and its notification profile by each HCU administrative sphere, it offers insights into other countries that also have their hospital care infrastructure provided by both public and private entities. In such a scenario, adequate guidelines and means of systematic evaluation of HCU adherence to the surveillance protocol are fundamental for proper risk assessment, resource allocation and disease outbreak mitigation.

Conclusion

Data from the SARI surveillance system in Brazil allow us to draw a profile of the performance of HCUs of different administrative spheres responsible for the hospital care network in the five Brazilian macro-regions. This analysis provides important information for health managers about regional situations and needs. By knowing when and where SARI epidemics occur, authorities can better allocate resources and make decisions, such as hiring more beds in HCUs managed by the private sphere or the philanthropic one, depending on the region and year's seasons. Also, knowledge of SARI notification profiles in Brazil can allow the definition of strategies to ensure that HCUs adhere to notification guidelines. Since each sphere can cover different socioeconomic strata, it is fundamental that the surveillance network adequately represents them all. Otherwise, risk assessment and profiling can be biased, hindering the adequate implementation of public policies such as vaccination strategies and resource allocation that can mitigate or prevent the occurrence of SARI cases.

Due to the continental dimensions of Brazil, each region has different needs for government action, and knowledge of these differences is essential for the adoption of strategies for the hospital network to function properly. Despite regional differences, the public health system is present in all country regions. In addition, the strong performance of Philanthropic Entities also contributes to the free access to the hospital structure for people with low income, thus avoiding a more significant burden on the service network provided by the Public Administration. The Brazilian surveillance system still needs improvements that make it more efficient in collecting data on notification of SARI cases, thus allowing faster and more accurate information to reach health managers in their decision-making.

Supplementary data

Supplementary data is available at *Health Policy and Planning* online.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Author contributions

Conception or design of the work: A.B.G.d.V. and M.F.d.C.G.; data collection: A.D.d.S. and M.F.d.C.G.; data analysis and interpretation: A.D.d.S., A.B.G.d.V., O.G.C., L.S.B. and M.F.d.C.G.; drafting the article: A.D.d.S. and A.B.G.d.V.; critical revision of the article: A.B.G.d.V., O.G.C., L.S.B. and M.F.d.C.G.; final approval of the version to be submitted: A.D.d.S., A.B.G.d.V., O.G.C., L.S.B. and M.F.d.C.G.

Reflexivity statement

The authors include one female and four males and span multiple levels of seniority, including one Master's student, besides four professors. One of the authors is specialized in Business Administration with emphasis on Systems Analysis and Software Engineering; one author is a molecular biologist specialized in epidemiological and genomic surveillance of respiratory virus infection; one author is specialized in Epidemiology and Public Health, with experience in epidemiological surveillance, data mining and analytical methods; one author is a researcher in Public Health specialized in the development of statistical methods for epidemiological analysis of infectious diseases; and one author is a physicist specialized in public health with experience in mathematical and computational modelling in epidemiology, metapopulation models and dynamic systems. All authors have extensive experience conducting research in Epidemiology and Public Health in Brazil.

Ethical approval. The study was approved by the Ethics Committee of UFCSPA (CAAE 75118217.9.3001.5347).

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