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Flavio Pinheiro Martins, Anna Flavia Rodrigues Lima, Loan Diep, Luciana Oranges Cezarino, Lara Bartocci Liboni, Rita de Cassia Aleixo Tostes Passaglia, Priti Parikh

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**COVID-19, SDGs and public health systems: Linkages in Brazil**

Flavio Pinheiro Martins  
University of Sao Paulo - USP  
Ribeirão Preto Medical School  
[fpmartins@usp.br](mailto:fpmartins@usp.br)

Anna Flavia Rodrigues Lima  
University of Sao Paulo - USP  
Ribeirão Preto Medical School  
[annafrlima96@usp.br](mailto:annafrlima96@usp.br)

Loan Diep  
Postdoctoral Research Fellow  
The New School  
Urban Systems Lab  
[loan.diep@newschool.edu](mailto:loan.diep@newschool.edu)

Luciana Oranges Cezarino  
Assistant Professor  
Ca'Foscari University of Venice  
[luciana.cezarino@unive.it](mailto:luciana.cezarino@unive.it)

Lara Bartocci Liboni  
Research Fellow  
Western University  
Ivey Business School  
[laraliboni@usp.br](mailto:laraliboni@usp.br)

Rita de Cassia Aleixo Tostes Passaglia  
Associate Professor  
University of Sao Paulo - USP  
Ribeirão Preto Medical School  
[rtostes@usp.br](mailto:rtostes@usp.br)

Priti Parikh\*  
Professor  
University College London  
The Bartlett School of Sustainable Construction - Faculty of the Built Environment  
[priti.parikh@ucl.ac.uk](mailto:priti.parikh@ucl.ac.uk)

\*corresponding author

## Learning from the COVID-19 Pandemic in Brazil Through the Lens of the SDGs To Support Public Health Systems

### Abstract

**Background.** The global 2030 Agenda covers a range of interconnected issues which need interdisciplinary and holistic approaches to improve human well-being and protect the natural environment. The COVID-19 pandemic has brought to light critical inequities in society and policy gaps in health services. As highlighted through analyses of the interlinkages among the Sustainable Development Goals (SDGs), connections between human health and well-being and the environment, can help support new policy needs in addressing systemic health crises, including widespread pandemics. **Method.** We identify links between the COVID-19 crisis and multiple SDGs in the context of Brazil based on a review of the current literature in the health sector. **Findings.** We identify synergistic connections between 88 out of 169 SDG targets and COVID-19, notably around themes such as City Environment, Contextual Policies and the value created by improved Information and Technology. Using the context of the Brazilian National Health Service (SUS) highlights recurrent interconnections from the focal point of target 3.8. This includes topics such as challenges for universal healthcare coverage, budget allocation, and universalisation. **Conclusions.** The framework developed for supporting policy-making decisions and the design of toolkits for dealing with future health-related emergency scenarios offers a practical solution in the health sector. It is worth noting that progress and action on public health systems and policies must go hand in hand with addressing existing socio-economic vulnerabilities in society. This is vital for tackling future pandemics and simultaneously addressing the SDGs.

**Keywords:** Sustainable Development Goals, COVID-19, Brazil, health policy, health services, vulnerabilities.

### Highlights

- The paper reviewed published evidence to identify 88 links between COVID-19 and the 169 SDGs targets.
- The authors used the identified links to propose a systemic impact framework for health policy in Brazil.
- Existing socio-economic vulnerabilities undermined progress in tackling COVID-19 in Brazil.
- Future public health policies and interventions need to be interdisciplinary and consider, among others, the dimensions of city environment, contextual policies and information and technology.

## 1. Introduction

Over the past years, sustainable development has been at the centre stage of the debate to support governmental action (Dlouhá, J. & Pospíšilová, 2018), private businesses (Mio, Panfilo & Blundo, 2020) and individuals (Hermes & Rimanoczy, 2018). In the early 2000s, the Millennium Development Goals (MDGs) established guidelines for civilisational advance, paving the way for the forthcoming Sustainable Development Goals (SDGs). The goals invite and challenge policymakers and governments to use them as guidelines for strategic and localised integrated planning in various scenarios. In the following years, a higher degree of attention was drawn to the environmental dimension of sustainability (Sachs, 2012) whilst addressing socio-economic advances. The socio-economic goals and safeguarding of planetary life support systems are “twin priorities” of any upcoming sustainable development framework (Griggs et al., 2013).

The interlinkages between the SDGs have been demonstrated in many fields of knowledge, such as education (Andreoni & Ruiz Vargas, 2020; Cottafava, Cavaglià & Corazza, 2019; Franco et al., 2019), artificial intelligence (Vinuesa et al., 2020), the energy sector (McCollum et al., 2018; Santika et al., 2019; Castor et al., 2020; Nerini et al., 2018) and water and sanitation (Flörke et al., 2019; Alcamo, 2019; Parikh et al., 2020). Nevertheless, the main challenge to achieving the SDGs is to contextualise global goals in local, regional and national agendas. Studies such as Royo et al. (2022) explore links between the African Agenda and the SDGs to identify synergistic goals and targets. Political and institutional agreements also posit different setups in different countries as moderating aspects (Tosun & Leininger, 2017). With the aid of the SDGs' broader framework, scholars have established linkages at an international industry level and in particular national contexts. Fuso Nerini et al. (2018) found 143 positive relations and 65 trade-offs between energy and the 2030 agenda. Diep et al. (2020) disclosed evidence that 124 out of 169 targets held synergies with sanitation in Brazil that could act as leverage points. Identifying these interrelationships can significantly increase the quality of policy design, enhancing its impact and optimising budget allocation.

The use of the SDGs to aid health policymaking is related to scientific literature (Neupane et al., 2018; Taghvaei et al., 2021). The findings highlight guidelines and toolkit design on a wide array of topics, such as Neglected Tropical Diseases (Addisu et al., 2019; Engels, 2016), maternal health (Callister & Edwards, 2017), neonatal mortality (Hug et al., 2019), tuberculosis (Carter et al., 2018) and AIDS (Micah et al., 2020). However, given the complexity of the interlinks among the SDG targets, integrating them into the strategic plans of governments and organisations is challenging (Breuer, Janetschek & Malerba, 2019). The social and health goals in the SDGs represent global issues that need attention from researchers, governments, and users (Sweileh, 2020). There is a need for interdisciplinary and evidence-based interventions to deliver solutions in public healthcare. One example of a solution would be integrated health research and training practices to identify inequities in society and hence health services (Buss et al., 2020).

Following the reasoning of evidence-based health policy decision-making, there is room for using the guidelines of the 2030 Agenda to explore the COVID-19 burden in nations. With

almost 600 million cases and nearly 7 million deaths (Dong et al., 2022), the coronavirus pandemic is proving to be the main health challenge of this century. Studies have shown how COVID-19 impacted the SDGs directly and indirectly, hindering the achievement of the goals by 2030 (Clemente-Suárez et al., 2022) and public health (Haldane & Morgan, 2021). Historically, pandemics have triggered drastic social, economic and political changes beyond the health focal point. Impacts spill over to the work context, consumption patterns, global mobility and climate action (Shulla et al., 2021). As governments develop public health strategies to respond to the crisis, it is crucial that they also address existing weaknesses in their economic and social systems. These same weaknesses undermine efforts to promote sustainability, hindering equitable development (Ashford et al., 2020).

Although SARS-COV2 infects all human organisms, the higher incidence of disease and mortality among marginalised and vulnerable populations became evident within the first few months of the pandemic (Parikh et al., 2020). A country's socioeconomic and health indicators directly influence how it will manage a pandemic, a fact shown more clearly in the different mortality rates of COVID-19 but already observed in previous healthcare emergencies such as the H1N1 pandemic (Dong et al., 2022). OECD nations, such as France, Italy and the United Kingdom, managed to mitigate the economic and health consequences with an expansion of hospital capacity and a support policy for companies and the unemployed. In contrast, insular and low-income nations suffer from factors related to their economic resilience and intensification of existing social problems (Wang et al., 2021), especially inequality and poverty.

Latin American countries, like Brazil, were exposed to a challenge in greater proportions than they were able to handle due to inadequate resources for health, inequality and weak state capacity to deal with crises (Rocha et al., 2021). The first recorded COVID-19 case in the country occurred on February 25, 2020 (Rodríguez et al., 2020), later spreading to all Brazilian states. Currently, the country totals more than 34 million cases and 681 thousand deaths (Dong et al., 2022). COVID-19 greatly affected Brazil, hampering the agenda advance. A report from civil society indicated that 92 of its targets are reversing in progress, and 21 are threatened (Spotlight Report, 2021). The major problems linkages to the universalisation of basic education; gender equality and women's empowerment; improving maternal health; combating HIV/AIDS, malaria and other diseases; and improving environmental sustainability.

Multiple studies connect the 2030 agenda and COVID-19 (Osingada & Porta, 2020; Wang & Huang, 2021; Health, 2020; Heggen, Sandset & Engebretsen, 2020). In addition, studies have explored the connection between Brazilian National Health Service (SUS) and the SDGs (Vieira, 2020; Basu et al., 2022; Andrade et al., 2018); with one study exploring the resilience of health systems in Brazil in light of COVI-19 (Bigoni et al, 2022); nevertheless, a gap remains on studies covering links between the Covid-19 pandemic and SDGs in the context of the SUS. This study aimed to highlight existing and added connections in Brazil's health system and implications for SDGs, answering the following Research Question (RQ) "Using the SDGs as an analytical framework, what lessons can be drawn from Brazil's experience with the COVID-19 pandemic and its linkages with multiple aspects of sustainable development to support public health systems?" . The authors identify links between the SDGs' targets and Brazil's experience with COVID-19 through a review of current literature. This provided the authors with practical implications reflected in frameworks to help build capacity and resilience

against future systemic issues, such as possible climate crises, pandemic scenarios, and health emergencies.

In addition to the context overview presented above, the reader will find this study structured as follows: Section 2 describes the methodology used, and Section 3 describes the overview of the findings, focusing on the connections established with the SDGs. Furthermore, Section 4 discusses the findings in three axes: I) City environment, II) Contextual Policies and III) Information and Technology; the discussion is supported by the framework presented in Figure 3. To conclude, Section 5 summarises the highlights, proposes calls for action, and further research and limitations of the study.

## 2. Materials and methods

### 2.1. Methodological steps

Using published academic evidence, the authors reviewed data to identify links between COVID and the 169 SDG targets. This was supplemented by grey literature (i.e. policy documents and health manuals) to fill data gaps. The methodology builds on Diep et al. (2020) and Parikh et al. (2021). The theoretical implications rely on systematically structuring the 2030 Agenda data in a specific context, reinforcing the existing locus of academic literature on public health policy for COVID-19.

**Step 1.** Published evidence was collected using the databases Scopus and Pubmed. We used two search strings combined: I) with keywords: "COVID-19" and "Brazil" and II) with the keywords linked to each one of the 17 SDGs.

**Step 2.** Furthermore, we screened the published paper's abstracts and ran a preliminary categorisation of the 169 targets.

**Step 3.** Specialists validate the linkages from literature sourced and scoped into non-connecting targets to source evidence from different sources or with different search strings. The method is informed by similar research in the field (Parikh et al., 2020; Diep et al., 2020; Nerini et al., 2018).

**Step 4.** A summary of the linkages is presented in a table format, and the main connections are in a framework.

Figure 1 - Methodological Summary

### 2.2. The Brazilian National Health Service (SUS)

The Unified Health System (SUS) emerged in response to the Movement for Sanitary Reform, in the 1970s, as a form of resistance to the lack of structure in the peripheries, proposing a way of organising health care through government policies (Paim, 2008). The officialisation of the model instituted in 1988 went through several stages, from the Integrated Health Actions (AIS), in 1984, as an attempt to unify health organisations in the three federative spheres, to the Unified and Decentralized Health System (SUDS), which allowed the transition to the SUS that is currently known (Pugin, Nascimento & Cohn, 1996).

The SUS is composed of hierarchical healthcare networks, with complexities that vary between the primary, secondary and tertiary levels (Mendes, 2010), communicating directly, with Primary Health Care being the user's preferred gateway to the system. health, which may also be the emergency services (Foster et al., 2017). The SUS's organisational structure provides universal access to all Brazilians, regardless of their socioeconomic situation, guaranteeing comprehensive care, providing resources according to the needs of each user, organising them in governmental spheres and participating in the decision-making process. decision-making and problem-solving. In this way, it starts to be used beyond a purely curative objective for health promotion and disease prevention (Foster et al., 2017).

### **3. Findings**

#### **3.1. Overview**

Initially, we found 345 papers from Scopus and PubMed databases; after excluding the duplicates and the ones that did not address COVID-19, we narrowed the amount to 127 papers, which were analysed and categorised into the SDG targets. The research flow can be seen in Figure 2.

Figure 2 - Review Walkthrough

We found several connections between SDGs related to poverty alleviation (SDG 1), inequalities reduction (SDG 10), cities and communities (SDG 11) and sustainable economic growth (SDG 8) with COVID19. Among those studies, we highlight one tackling linkages on poverty alleviation (target 1.1), the study “The impact of socioeconomic vulnerability on COVID-19 outcomes and social distancing in Brazil.” (Lins-Filho et al., 2020), concerning how the social vulnerability indexes were predictors of deaths in Brazilian states. The increase of non-communicable diseases reporting (target 3.4) also is among the main focal points in the literature, specifically addressing diseases not directly related to COVID-19 but that also increased, such as mental health issues (Torres et al., 2021) and obesity (Gonçalves et al., 2021). Targets 3.8 and 3.d results were focused on Brazilian healthcare System resilience and innovations for monitoring and addressing the impacts of the crisis (Lotta & Nunes, 2022).

#### **3.2. Main dimensions identified**

Furthermore, in the specialist validation step, the target linkages were expanded to 88, as seen in Figure 3. The mapping procedure highlighted three main dimensions of action. The city environment (I) is one of the most recurrent on the evidence mapping, lack and flaws related to specific city-level policies; poor housing conditions and public transportation were the most challenging aspects of outbreak mitigation; on the positive side, the high amount of community health agents at city level reduced the impacts of COVID-19. Social security measures were taken to diminish the socio-economic impacts of the social distancing measures; financial aid programs and waivers for water and energy taxes were given to the poor and vulnerable.

Figure 3 - SDGs target linkages

With regards to contextual policies and social inclusion the review highlighted the need for contextual policies (II) for a widely diverse country: indigenous populations lacked special attention to their needs in preventing covid-19 infection while witnessing land ecosystems from amazon being hampered with an increased number of illegal logging, poaching and mining activities. Specific workers categories, such as informal workers and healthcare suffered the burden differently than the rest of the population. Women, black and vulnerable groups presented higher rates of mortality. In the wake of previous tens, we see technology, research and development (III) rising as tools for mitigating the impacts of the pandemics. Acting, for instance, in fostering remote medicine care and primarily represented the transnational partnerships for developing vaccines with partial technology transfer.

Figure 4 - Framework proposal of COVID-19 systemic impacts on Brazilian health policy

#### 4. Discussion

The following discussion dimensions are interwoven by direct and indirect aspects of the Brazilian healthcare structure. The healthcare policy in the Brazilian Territory is guided by the Brazilian Unified Health System (SUS), responsible for covering virtually 200 million people, making it the most effective government-run health system in the world. Despite the enormous challenges of providing healthcare in an emerging economy country of continental dimensions, since its implementation, in 1989, the SUS has offered free health assistance to all Brazilians and foreigners in Brazilian territory (Paes-Sousa et al., 2019).

The strengthening of early warning health services usually is through nationally coordinated efforts the SUS extends its grasp through all levels of the Brazilian federation, from national policy to local actions. We will address both surveillance (target 3.d.) and universal healthcare questions (target 3.8) through the lens of SUS, from a perspective of its historical success in some domains of public health (i.e. vaccination campaigns and family health systems) and its shortcomings that were undoubtedly aggravated by COVID-19.

##### 4.1. City Environment

The City Environment dimension is mainly connected to SDGs Targets 11.1, 11.2, 11.3 and 11.a, concerning the quality of housing, access to essential services and transport efficiency. The published evidence indicates that city-level policies were fundamental during the crisis. SUS structure shows its capacity at the municipality level: thousands of Family



Health Units and Community Health Agents are highly spread in the country's territory, allowing the national health strategy to reach many locations. COVID-19 also highlighted the relevance of integration between urban and peri-urban territories and subnormal and urbanised areas (target 11.a) and how impactful public transportation operating at capacity can hinder epidemic measures (target 11.2).

COVID-19 transmission follows the socio-spatial inequalities within the cities, thus reflecting different indexes that appear in neighbouring districts. In Sao Paulo, the district of "Brás" portrayed the highest number of (192.3 deaths), while the district of Jardim Paulista, 8 km away, reported the lowest (48.1) (Ribeiro et al., 2021). Figueiredo et al. (2020) study indicated that 59.8% of the COVID variation was linked to income inequality and housing conditions, which reflected in urban space occupation patterns and, therefore, in the COVID-19 propagation and number of cases (Cardoso et al., 2020; Alcântara et al., 2020). In more densely occupied regions, such as the metropolitan regions of Rio de Janeiro (Figueiredo et al., 2020), São Paulo (Ferreira, 2020) and Fortaleza (Braga et al., 2020), the worsening conditions are linked to factors such as the number of residents per household and sanitary conditions (Santos et al., 2020).

Education and information diffusion are essential when defining guidelines for social distancing and isolation and should consider regional political, socioeconomic and scientific dimensions (Thomé et al., 2020). One of the caveats of the communication policy adopted by some municipalities was that it was aimed at a specific income group (Schiray, 2021). In some vulnerable settlements, printed manuals and posters were distributed in addition to online and community radio campaigns (Rocha, 2021). In vulnerable urban areas such as favelas, the Covid-19 burden is more noticeable (Alves, Souza & Caló, 2021); therefore, a prevention policy and its communication must be differentiated, taking into account the socioeconomic characteristics of these areas, such as the lack or limited access to sanitation, the cost of personal hygiene products and the prevalence of the informal employment (Schiray, 2021).

## 4.2. Contextual Policies

In the Brazilian fight against the pandemic, existing poverty and day-to-day challenges in communities hindered the success of distancing policies. Social measures such as scholarships and financial aid could help; nevertheless, in Brazil, the crisis erupted in a scenario of systemic unemployment, economic crisis and reduction of primary health coverage due to austerity measures (Paes-Sousa et al., 2019).

The outcomes of the pandemic had uneven social and economic impacts on vulnerable populations in different countries (Shadmi et al., 2020), and Brazil is no different. Data from the Brazilian SUS (de Souza, Machado & do Carmo, 2020) indicate that the demographic aspects and healthcare structure are social determinants related to the incidence, mortality, and lethality (Hawryluk et al., 2020; Kerr et al., 2020; Braga et al., 2020; Martins-Filho et al., 2020). Studies indicate a higher infection rate in the black population (de Paula et al., 2021; Ribeiro et al., 2020) and in elders living in long-term care houses (Machado et al., 2020). In Brazilian, the odds of COVID-19-linked mortality were higher in groups such as non-white, healthcare workers or low-income residents (Li et al., 2021).

Marginalised workers in the informal sector jobs and healthcare workers also had an increased burden since they had no option but to isolate themselves, impacting standards for safe work (target 8.8) and healthcare force retention (target 3.c). Studies indicate that these workers had a higher mortality rate and experienced work-related illness (target 8.8), such as burnout and other mental distress (Barello, Palamenghi & Graffigna, 2020). Mental-related clinical disorders that are non-listed as comorbidities, such as depression and anxiety (target 3.4), are found to be associated with the condition of being an essential worker and also show linkages with COVID-19 (De Boni et al., 2020). In addition, health professionals, such as nurses and physiotherapists (Pegorari et al., 2020), are among the most vulnerable to financial problems (target 8.5) resulting from the disease (Minayo et al., 2020).

The collateral damage of COVID-19 connects with gender and violence issues, such as marital violence and children and elderly abuse (targets 5.2, 16.2, 11.7). In Brazilian households, all forms of violence increased during the COVID-19 pandemic (Silva et al., 2020; Marques et al., 2020; Telles et al., 2020; Valença et al., 2021). Women faced an increase in unpaid domestic labour (target 5.4) (Fares et al., 2021; Teixeira, 2021) in addition to barriers to career development (target 5.5) (Staniscuaski et al., 2021; Soares & Naegele, 2021).

COVID-19 is not just a health, sanitation, and economic crisis, but also a civilisational crisis. Civilisations develop due to an effective response to a historical crisis, promoting changes and adaptations of some elements of a universal nature (Huremović, 2019). First nations are a specific chapter of COVID-19 impacts in Brazil, with some studies addressing it as a civilisational risk for the decimation of some groups (Cupertino et al., 2020). Traditional communities such as indigenous, quilombolas, and river-dwellers are among the most vulnerable, whereas the pandemic exacerbates pre-existent issues, such as food insecurity (target 2.3) and sanitation shortage (target 6.2) (Floss et al., 2020; Korap, 2020).

The multidimensionality of the impacts of COVID-19 has reached Brazil and Latin America's most remote and vulnerable regions. The country's north suffered disastrous consequences, demonstrating its sensitivity to crucial issues for human survival. The country's northern regions, where most of the amazon forest is located, are also affected by an uneven offering of ICU beds and respirators compared to southern regions (Palamim et al., 2020). Some riverside people, for instance, are hardly accessible by public healthcare (target 3.8), especially concerning offering intensive care units (Jatobá et al., 2021; Floss et al., 2020). Several targets connect the first nation issues with biodiversity loss, deforestation, and COVID-19.

#### **4.3. Information and Technology**

Technology and research and development are linked to direct actions, such as the development of vaccines and outbreak monitoring, and mitigation of the spillover effects, such as caveats in emergency remote education and advances in telemedicine.

Brazilian public-funded research agencies took the lead on vaccine development; the Butantan Institute and the Fundação Oswaldo Cruz (Fiocruz) developed international partnerships towards making the Corovanac and the Oxford/AstraZeneca vaccines available to the Brazilian population. Immunisation campaigns faced an additional challenge concerning vaccine hesitation, a problem already present in Brazil linked to a low level of science literacy and misinformation about vaccines. For instance, measles vaccination coverage was a

problem already faced by the Brazilian health policy. When 2020 COVID-19 took the spotlight as a major health challenge, it also was impacted by issues related to misinformation (Matos, Barbieri & Couto, 2020).

The regional differences in the healthcare structure coverage have implications directly on mortality rates (De Andrade et al., 2020) and in flaws of proper COVID-19 monitoring and reporting (Macinko et al., 2020): many studies pointed out an under-reported (target 16.6) mortality rate (Bastos et al., 2021; Prado et al., 2020), the direct life-loss caused by the pandemics is still partially unknown. Thus, technology plays an important role in bridging the gaps. From monitoring borders to COVID-19 reporting, digital alternatives gain momentum to mitigate the shortcomings of epidemics in a continental country such as Brazil (targets 3.d and 9.1).

Epidemiological surveillance in Brazil was already facing challenges. In the country borders, the emergence of infectious diseases was linked to a lack of support for immigrants (target 8.8) coming to Brazil; the new arboviruses genotypes appeared in the national territory (target 3.3), such as Chikungunya (Souza et al., 2019) and the Zika Virus (Tramonte & Christofferson, 2019) thus highlighting the relevance of strengthening early warning mechanisms (target 3.d). Solutions appeared, from using telephone calls to monitor COVID-19 (Penna et al., 2020) to the development of a whole ecosystem for health surveillance (targets 3.b, 3.d, 9.1 and 9.a) specially designed and implemented by a consortium of health research facilities, public-funded universities, specialised research centres and the local public administration (Valentim et al., 2021).

Web platforms and apps also played their role in monitoring the pandemics, relying on collaborative efforts from the population to estimate the number of contaminations; 45 platforms were developed in 2020, the majority on “case monitoring” and “symptoms, prevention, and care” (Galindo Neto et al., 2020). The application in Brazil - called Together Against COVID, was used to estimate the cumulative incidence rates of COVID-19 cases in each Brazilian federative unit and compared them with the respective rates of reported cases. The COVID-19 case rates were 2.75 times higher than officially reported. The estimated per-reported case ratios were higher in areas with worse socioeconomic status (Hajar, 2021). These platforms were typically mobilised and resilience tested during the crisis (target 9.a and 11.b), and might exit pandemics validated and empowered, especially in a context of generalised attention to the risk for future outbreaks (target 3.d) of coronavirus disease, and other epidemics, in another place (Daon et al., 2020).

The COVID-19 burden is associated with the medical attention shortage caused by resource reallocation and social distancing protocols. Technology mitigates this gap since it enables medical interaction between physicians and patients (targets 9.c and 3.8). Lima et al. (2020) address the challenges and the importance of remote medical appointments for monitoring patients with chronic diseases, thus not leaving them unsupported. On the operational level of public health structures, there is also evidence of innovations, such as the case of the tertiary teaching hospital from the University of Sao Paulo, which had reconfigured its Epidemiologic Surveillance Centre to address the unprecedented increase in workload, as well as to provide decision-making information for the operational level (Marcilio et al., 2020).

Technologies developed and applied to COVID treatment can tackle the complex interaction between health and information in a systemic proportion. Products and processes

for cooperation and compatibility interfaces between institutional actors for decision-making and systems are critical. The population needs an engine for promoting equity, social justice, and democratisation of access to health services. This "post-pandemic legacy" has changed the way some regions treat public health care, as an illustration, for example, the Rio Grande do Norte in Brazil. In the application developed one can infer how to mobilise human, biological, financial or equipment resources to the specific purpose, articulating them in favour of a more efficient and successful approach, an example of an integrated way to manage health surveillance, organised by data and transparent information to the whole North-Brazilian society (Valentim et al., 2021).

## **5. Conclusions**

Our paper has shown the differences, potentialities, and limitations of health systems in the context of the SDGs, bringing important contributions to enable the achievement of the health-related SDGs and fulfil the global agenda. Considering the specificities and complexity of the Brazilian healthcare system, our framework which used COVID-19 as a basis can aid in improving Brazilian health coverage, quality and equity. It is worth noting that progress and action on public health systems and policies must go hand in hand with addressing existing socio-economic vulnerabilities in society. This is vital for tackling future pandemics and addressing the SDGs.

### **5.1. Limitations and further studies**

Research limitations lies in the specific aspect of the Brazilian National Health Service (SUS), which reflects on a contextual interpretation of the results, also the qualitative methodology applied can be improved with the addition of one more intercoder reliability method to the panel of experts (i.e. focus group validation with health policy agents). Further studies can explore more in-depth interrelations linking COVID-19 impacts with the sustainability agenda to improve the frameworks available, adding the upcoming scientific evidence from the resilience strategies developed during COVID-19. In addition, the Brazilian National Health Service (SUS) is a peculiar case study in terms of coverage; other countries with similar socioeconomic indexes (i.e. BRICS or Global South) yet different health system infrastructures could be studied with the same methodology. To conclude, reasoning on the study limitations, we suggest exploring the linkages from additional academic and grey literature sources, such as reports or policy documents.

### **5.1. Calls for action in a national context and global reflections**

In the Brazilian context, the preventive policies for upcoming pandemics, as well as for tropical infectious diseases such as Zika, chikungunya, and dengue, are directly linked to poverty, poor health conditions, water and sanitation management, and specifically impactful in settings such as favelas and slums. Placing health in the sustainable development context can facilitate prevention alongside treatment, considering social, environmental, economic, and institutional aspects which underlie the 2030 Agenda. The way forward is to strengthen

evidence-based decision-making, strengthening and sharing reliable data, information, and health systems and policies.

Considering the outcomes of this work, we argue that there are calls for action in three thematic dimensions.

**I) City environment.** Public management would benefit from incorporating the resilience from the emergent crisis management policy into blueprints for similar situations, with detailed protocols that merge the WHO guidelines for pandemics within regional evidence-based programs.

**II) Contextual Policies.** Beyond the recurrent challenges of Brazil's socio-economic condition, our work highlighted how COVID-19 unveiled the relevance of pre-conceived emergent assistance programs for health epidemic events. The sooner the basic needs of communities are addressed, the more effective public health interventions will be in tackling pandemics.

**III) Information and Technology.** The democratisation of access and the production of new technology and information makes a significant set of open data areas available. Such data improves transparency for society and serve as a basis for the scientific community as a valuable source of research (Valentim et al., 2021). Emerging economies and the global-south society of scientists would benefit from open data and editable applications to global health care. A systemic endeavour of developed countries' governments is needed to stimulate this technology democratisation that can benefit the world's poorest people.

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Fig. 1.

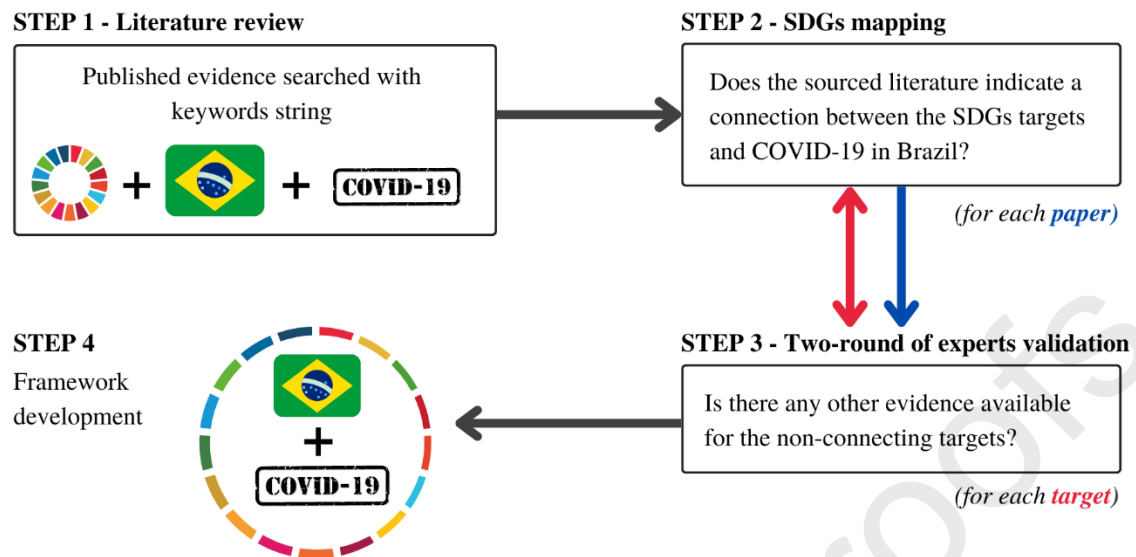
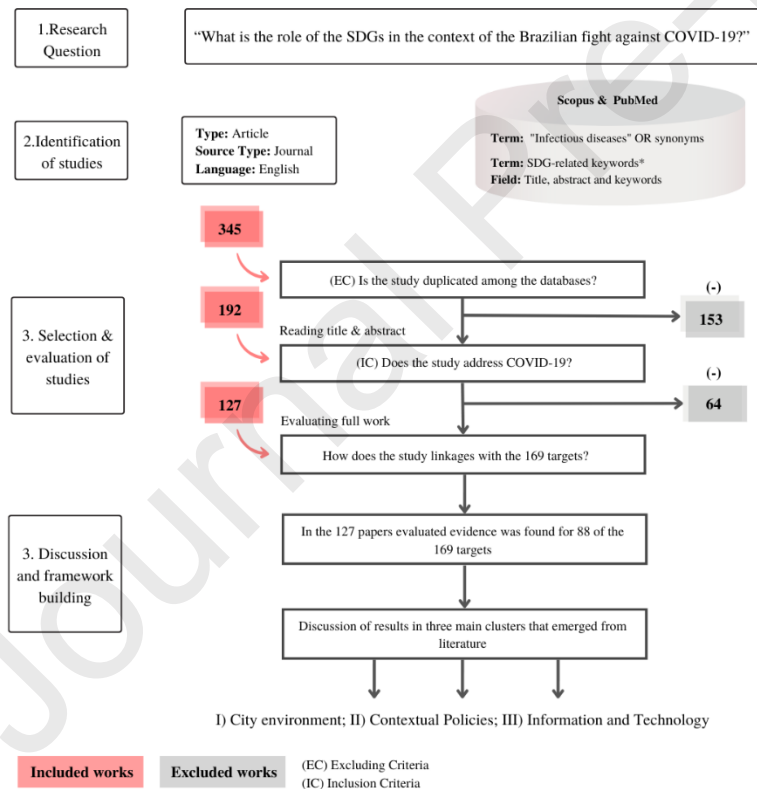


Fig. 2.



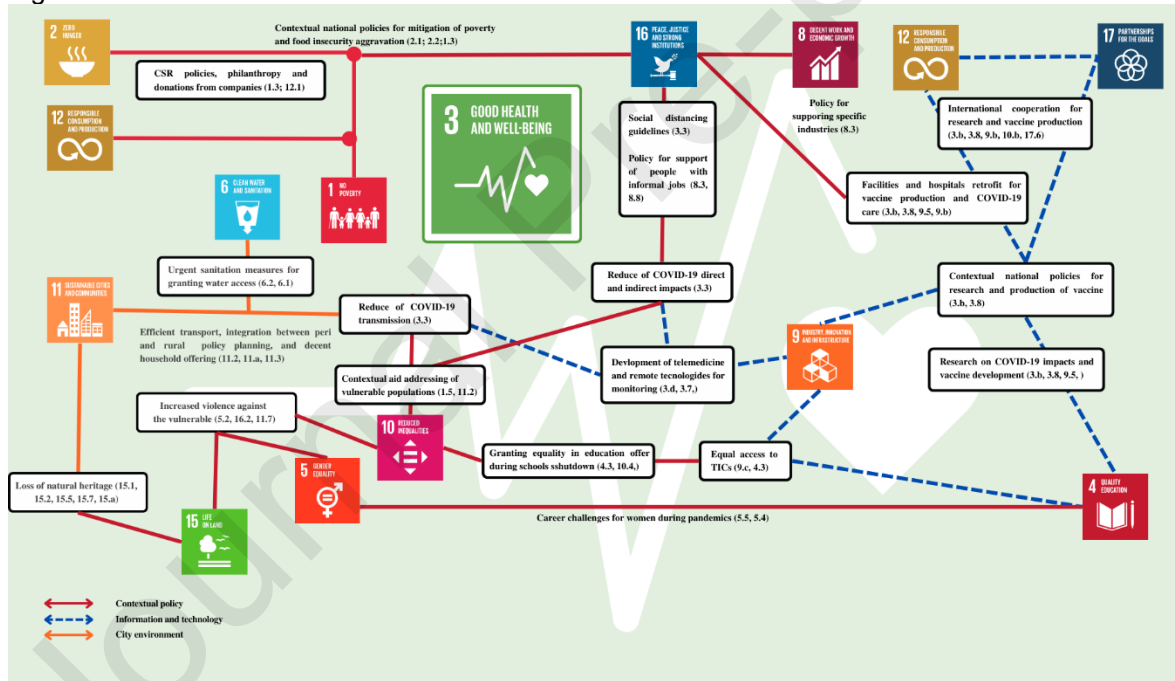
\* For instance, considering SDG 2 the keywords used were: "SDG 2" OR "hunger" OR "food security" OR "improved nutrition" OR "sustainable agriculture" OR "bad nutrition" OR "malnutrition" OR "overweight"

Fig. 3.

SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17
1,1	2,1	3,1	4,1	5,1	6,1	7,1	8,1	9,1	10,1	11,1	12,1	13,1	14,1	15,1	16,1	17,1
1,2	2,2	3,2	4,2	5,2	6,2	7,2	8,2	9,2	10,2	11,2	12,2	13,2	14,2	15,2	16,2	17,2
1,3	2,3	3,3	4,3	5,3	6,3	7,3	8,3	9,3	10,3	11,3	12,3	13,3	14,3	15,3	16,3	17,3
1,4	2,4	3,4	4,4	5,4	6,4	7,a	8,4	9,4	10,4	11,4	12,4	13,a	14,4	15,4	16,4	17,4
1,5	2,5	3,5	4,5	5,5	6,5	7,b	8,5	9,5	10,5	11,5	12,5	13,b	14,5	15,5	16,5	17,5
1.a	2.a	3,6	4,6	5,6	6,6		8,6	9,a	10,6	11,6	12,6		14,6	15,6	16,6	17,6
1.b	2,b	3,7	4,7	5,a	6,a		8,7	9,b	10,7	11,7	12,7		14,7	15,7	16,7	17,7
	2,c	3,8	4,a	5,b	6,b		8,8	9,c	10,a	11,a	12,8		14,a	15,8	16,8	17,8
		3,9	4,b	5,c			8,9		10,b	11,b	12,a		14,b	15,9	16,9	17,9
		3,a	4,c				8,1		10,c	11,c	12,b		14,c	15,a	16,1	17,1
		3,b					8,a				12,c		14,c	15,b	16,a	17,11
		3,c					8,b						14,c	15,c	16,b	17,12
		3,d														17,13
																17,14
																17,15
																17,16
																17,17
																17,18
																17,19

Published evidence was found for 88 of the 169 SDGs targets

Fig. 4.





## **COVID-19, SDGs and public health systems: Linkages in Brazil**

### **Highlights**

- The paper reviewed published evidence to identify 88 links between COVID-19 and the 169 SDGs targets.
- The authors used the identified links to propose a systemic impact framework for health policy in Brazil.
- Existing socio-economic vulnerabilities undermined progress in tackling COVID-19 in Brazil.
- Future public health policies and interventions need to be interdisciplinary and consider, among others, the dimensions of city environment, contextual policies and information and technology.

**Author Contributions form - COVID-19 systemic interactions: the 2030 Agenda linkages in Brazil**

**Author Contributions.**

Flavio Pinheiro Martins contributed to study conception, manuscript writing, data collection, analysis and graphisms. Anna Flavia Rodrigues Lima contributed to data collection and data analysis. Loan Diep contributed to the methodological design, manuscript writing and final reviews. Luciana Oranges Cezarino contributed to the final reviews. Lara Bartocci Libone contributed to the final reviews. Rita de Cassia Aleixo Tostes Passaglia contributed to data collection and analysis. Priti Parikh contributed to the study conception, methodological design, manuscript writing and final reviews.

**Conflict of interest Form - COVID-19 systemic interactions: the 2030 Agenda linkages  
in Brazil**

*Flavio Pinheiro Martins*  
*University of Sao Paulo - USP*  
*Ribeirão Preto Medical School*  
*[fpmartins@usp.br](mailto:fpmartins@usp.br)*

*Anna Flavia Rodrigues Lima*  
*University of Sao Paulo - USP*  
*Ribeirão Preto Medical School*  
*[annafrlima96@usp.br](mailto:annafrlima96@usp.br)*

*Loan Diep*  
*Postdoctoral Research Fellow*  
*The New School*  
*Urban Systems Lab*  
*[loan.diep@newschool.edu](mailto:loan.diep@newschool.edu)*

*Luciana Oranges Cezarino*  
*Assistant Professor*  
*Ca'Foscari University of Venice*  
*[luciana.cezarino@unive.it](mailto:luciana.cezarino@unive.it)*

*Lara Bartocci Liboni*  
*Research Fellow*  
*Western University*  
*Ivey Business School*  
*[laraliboni@usp.br](mailto:laraliboni@usp.br)*

*Rita de Cassia Aleixo Tostes Passaglia*  
*Associate Professor*  
*University of Sao Paulo - USP*  
*Ribeirão Preto Medical School*  
*[rtostes@usp.br](mailto:rtostes@usp.br)*

*Dr Priti Parikh\**  
*Associate Professor*  
*University College London*  
*The Bartlett School of Sustainable Construction - Faculty of the Built Environment*  
*[priti.parikh@ucl.ac.uk](mailto:priti.parikh@ucl.ac.uk)*

*\*corresponding author*

The aforementioned authors declare no conflict of interest