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Could poor waste management be an additional factor for the spread of COVID-19? Case of preliminary reports in a Brazilian state

A má gestão de resíduos pode ser um fator adicional para a disseminação do COVID-19? Estudo dos casos preliminares em um estado brasileiro

¿La mala gestión de los residuos podría ser un factor adicional para la propagación de la COVID-19? Caso de informes preliminares en un estado brasileño

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Abstract
COVID-19 is a new coronavirus respiratory disease caused by SARS-CoV-2, first described in China in December 2019 and since March 2020 has been affecting the whole world. The principal mode of transmission is through exposure to respiratory droplets carrying infectious virus. Contact with contaminated surfaces or objects (fomites) is also possible, although the risk is generally considered low. However, the widespread community viral transmission makes it difficult to experimentally demonstrate human contagion via fomites. As human coronaviruses can be found on inanimate surfaces for hours up to days (depending on the inoculum shed), in materials as metal, glass or plastic, waste management can pose a problem in the context of the spread of the disease. Thus, the main objective of this work was to discuss the influence of poor waste management for the spread of SARS-CoV-2 in the state of Minas Gerais, Brazil, based on the first reported cases in 853 cities. Therefore, different variables related to socioeconomic data, waste management services, and number of COVID-19 confirmed cases were correlated and discussed. Overall, the associations found in this study in relation to reported cases and poor waste management raise the need for attention to this issue, which is still little explored despite being potentially aggravating for numerous diseases.
Keywords: COVID-19; Infection; Epidemic; Environment; Waste management; Urban solid waste.

Resumo
A COVID-19 é uma nova doença respiratória causada pelo SARS-CoV-2, descrita pela primeira vez na China em dezembro de 2019 e desde março de 2020 vem afetando o mundo inteiro. O principal modo de transmissão é através da exposição a gotículas respiratórias portadoras de vírus infecciosos. A transmissão através do contato com superfícies ou objetos contaminados (fômites) também é possível, embora o risco seja geralmente considerado baixo.

No entanto, a ampla transmissão viral comunitária dificulta a demonstração experimental do contágio humano por meio de fômites. Como os coronavírus humanos podem ser encontrados em superfícies inanimadas por horas a dias (dependendo do depósito de inóculo), em materiais como metal, vidro ou plástico, o gerenciamento de resíduos pode representar um problema no contexto da disseminação da doença. Assim, o objetivo principal deste trabalho foi discutir a influência da má gestão de resíduos para a disseminação do SARS-CoV-2 no estado de Minas Gerais, Brasil, com base nos primeiros casos notificados em 853 cidades. Portanto, diferentes variáveis relacionadas a dados socioeconômicos, serviços de gerenciamento de resíduos e número de casos confirmados de COVID-19 foram correlacionadas e discutidas. De modo geral, as associações encontradas neste estudo em relação aos casos notificados e a má gestão de resíduos levantam a necessidade de atenção para essa questão, que ainda é pouco explorada apesar de ser potencialmente agravante para inúmeras doenças.
Palavras-chave: COVID-19; Infecção; Epidemia; Ambiente; Gestão de resíduos; Resíduos sólidos urbanos.

Resumen
El COVID-19 es una nueva enfermedad respiratoria por coronavirus causada por el SARS-CoV-2, descrita por primera vez en China en diciembre de 2019 y desde marzo de 2020 afecta a todo el mundo. El principal modo de transmisión es a través de la exposición a gotitas respiratorias portadoras de virus infecciosos. También es posible el contacto con superficies u objetos contaminados (fómites), aunque el riesgo generalmente se considera bajo. Sin embargo, la transmisión viral comunitaria generalizada dificulta demostrar experimentalmente el contagio humano a través de fómites. Dado que los coronavirus humanos se pueden encontrar en superficies inanimadas durante horas o días (según el cobertizo del inóculo), en materiales como metal, vidrio o plástico, la gestión de residuos puede plantear un problema en el contexto de la propagación de la enfermedad. Así, el objetivo principal de este trabajo fue discutir la influencia de la mala gestión de residuos para la propagación del SARS-CoV-2 en el estado de Minas Gerais, Brasil, a partir de los primeros casos notificados en 853 ciudades. Por lo tanto, se correlacionaron y discutieron diferentes variables relacionadas con los datos socioeconómicos, los servicios de gestión de residuos y el número de casos confirmados de COVID-19. En general, las asociaciones encontradas en este estudio en relación con los casos notificados y la mala gestión de los residuos plantean la necesidad de atención a este tema, que aún es poco explorado a pesar de ser potencialmente agravante de numerosas enfermedades.
Palabras clave: COVID-19; Infección; Epidemia; Ambiente; Gestión de residuos; Residuos sólidos urbanos.

1. Introduction

The coronavirus infectious disease 2019 (COVID-19), a new coronavirus respiratory infection caused by SARS-CoV-2, first reported in Wuhan, Hubei Province, China in December 2019, has been characterized as pandemic since March 11, 2020 (Covid-19 2020a; Holshue et al. 2020). Well-described modes of transmission for SARS-CoV-2 are respiratory and direct or indirect contact, although the latter has been considered to be of low risk. These pathways are closely related. When infected people cough or sneeze, their expelled respiratory droplets are potentially infectious to others close to them. Thus, people can be infected by breathing or direct contact with those droplets or indirectly, by contact with surfaces contaminated, which can be brought to the mouth, nose or eyes by hands (Covid-19 2020b; Kampf et al. 2020). Data from studies regarding indirect transmission of respiratory viruses are limited, but some evidences via stochastic transmission models and literature review have suggested a possible fomite mode of transmission for influenza viruses (Brankston et al. 2007; Bridges et al. 2003).

The persistence of novel coronavirus on materials of inanimate surfaces was studied by van Doremalen et al (2020). The results indicated as plausible the SARS-CoV-2 transmission via aerosol and fomite, since the virus can remain viable and infectious for several hours or even days depending on the surface and conditions where it is found. However, little is yet known about the minimum infective viral load, so laboratory experiments may not accurately simulate the natural conditions of fomite transmission.

Possible risk of virus spreading through wastes was discussed during infected patient recovering, either at home or at healthcare facility (Mol and Caldas 2020). The safe process of waste management, in particular the healthcare wastes (HCW), could be critical during the COVID-19 emergency. The amount of household waste generated increased due to the pandemic around the world, associated to changing in life style during the lockdown (Sharma et al 2020). Calma (2020), in the USA, also reported an increase in household waste generation, in particular highlighting infectious wastes as personal protective

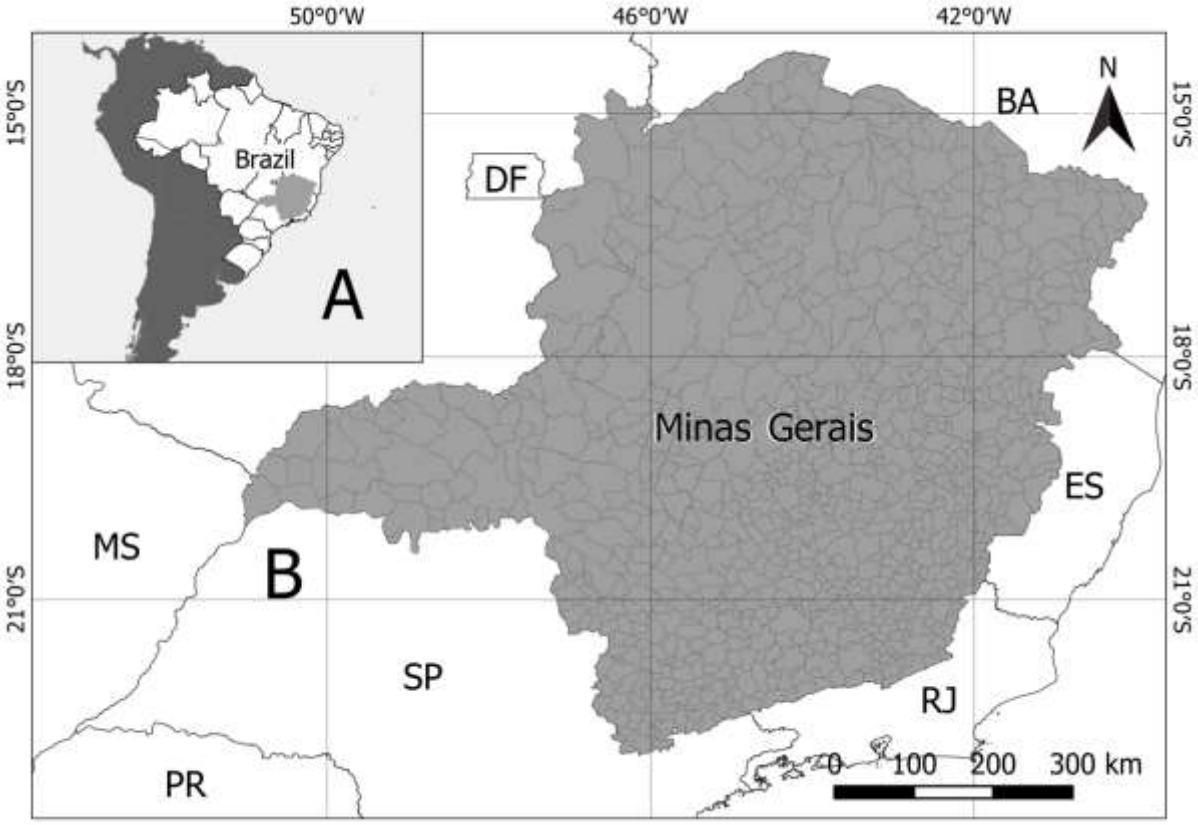
equipment, including masks and gloves. Changing in waste generation also affected hospitals in Wuhan, that increased to 240 metric tons per day during the pandemic, five times higher than previous period (Zambrano-Monserrate et al 2020).

The waste management is a topic to be addressed in this pandemic, especially when discussing the potential risks associated with the spread of disease. Therefore, the aim of our study was to analyse socio and sanitation variables according to the influence for SARS-CoV-2 spread in Minas Gerais state, Brazil, from first reported cases.

2. Methodology

In this study, 853 cities in the Brazilian State of Minas Gerais (Figure 1) were considered, including their socioeconomic data, additional information about waste management services and rates of COVID-19. The disease incidence was analysed considering the variables below: waste score by environmental agency; amount of wastes collected; waste collection coverage; city population; Human Development Index (HDI); percentage of financial incomes per family and GINI coefficient (a measure of economic inequality in a population).

Figure 1 - Location of Brazil (A) and Minas Gerais state (B).



Source: IBGE (2019); Sistema de Coordenadas Geográficas, Datum SIRGAS (2000).

In particular, waste score by environmental agency was published by Mol et al. (2020) and represent a validation about solid waste quality disposal system, correlated with waste management parameter as collection, coverage of services and public cleaning service.

Data was analyzed by stepwise multiple regression statistical model, adopting exclusion of each variable less

significant (level of 5%), one at a time. Regression measure and multicollinearity were calculated to ensure the representative results.

Statistical analysis was performed using software R, version 3.5.3.

3. Results and Discussion

SARS-CoV-2 infection is typically, although not exclusively, characterized by respiratory symptoms, pointing to the inhalation of droplets transmitted from person to person or by deposition of those droplets on surfaces and subsequent contagion by contact with the facial mucosa. However, several studies have demonstrated gastrointestinal symptoms and/or detection of viral RNA in stool samples from some patients with COVID-19, suggesting the occurrence of faecal-oral transmission and its possible involvement in the spread of the disease (Gao et al. 2020; Heller et al. 2020; Xiao et al. 2020; Xu et al. 2020; Zhang et al. 2020). This condition could be also associated with waste management, once household wastes usually present toilet wastes. In addition, viral shedding from the digestive system might remain even longer than that of the respiratory tract (Xiao et al. 2020; Xu et al. 2020). It is known that SARS-CoV-2 uses the cell entry receptor - angiotensin converting enzyme II (ACE2) for cell invasion mediated by its spike glycoproteins (Wrapp et al. 2020; Xiao et al. 2020; Zhou et al. 2020). In line with the digestive manifestations of COVID-19, ACE2 is abundant not only in the lung tissue, but also in the intestinal epithelium (Gao et al. 2020; Lu et al. 2020).

COVID-19 positive results until end of March 2020 in Minas Gerais Brazilian state reported 258 infected patients, in 31 different cities (SES 2020). Table 1 show some associations between the variables described above, which may be related to the SARS-CoV-2 dispersion.

As shown in Table 1, the final multiple regression model focused on municipalities with at least one case reported suggesting a positive association between cases of COVID-19 with GINI, as well as with city population and with average household income. So, the higher reported cases, higher these variables were presented. Overall, the spread of COVID-19 has been reported primarily in large cities, possibly related to the presence of airports with international flights and the population with a typically higher family income. In Minas Gerais, the only international airport is located in the metropolitan region of the capital Belo Horizonte, which has presented the largest number of reported cases when compared to other cities in the state. Also in Belo Horizonte city was found the 13th bigger GINI index of the state, suggesting a large gap between the rich and poor population.

On the other hand, negative associations shown in Table 1 were found to waste management variables, such as waste management quality score and amount of waste collected. In these cases, the higher the confirmed cases of COVID-19, the lower the amount of waste collected and the quality of waste management score reported by environmental agency. As shown, high COVID-19 cases were associated with a larger size of the municipal population; however, the association with amount of waste collected showed an opposite direction. Furthermore, the lower waste score represents poor management conditions, and the higher incidence of COVID-19 in these cities raises a possible contribution of infected waste as an additional factor for viral spread.

As presented by Kampf et al. (2020), in an analysis of 22 studies, human coronaviruses such as Severe Acute Respiratory Syndrome coronavirus, Middle East Respiratory Syndrome coronavirus or endemic human coronaviruses can persist on inanimate surfaces up to 9 days, in materials as metal, glass or plastic. Another paper by van Doremalen et al. (2020) found SARS-CoV-2 more stable on plastic (72 hours) and stainless steel (48 hours), although the virus titer was greatly reduced, and on copper and cardboard, no viable SARS-CoV-2 was measured after 4 and 24 hours respectively.

Table 1 - Multiple regression model of COVID-19 (until 31th March 2020) and socio/sanitation variables of cities from Minas Gerais state (Brazil) reporting at least one confirmed case.

Variables	COVID-19					
	Initial model			Final model		
	Coef	S.E.*	P	Coef	S.E.*	P
(Intercept)	8.476	35.840	0.816	-37.388	12.369	0.006
HDI	-131.130	52.340	0.021	-	-	-
GINI	70.817	29.533	0.027	71.095	24.946	0.009
Population	6.082E-05	4.011E-06	4.561E-12	6.307E-05	4.833E-06	7.793E-12
Household average income	0.105	0.028	0.001	0.031	0.017	0.079
Waste management quality	-0.930	0.437	0.047	-1.481	0.405	0.001
Precarious sanitation	0.136	0.090	0.144	-	-	-
Waste coverage collection	0.057	0.225	0.802	-	-	-
Amount of waste collected	-11.666	5.245	0.038	-11.546	5.258	0.039
Vif maximum		10.26			1.39	
R^2		92.29%			91.94%	

HDI: human development index; GINI: measure of economic inequality in a population; Coef.: coefficient; S.E.: standard error; P: p value of statistic text; Vif: variance inflation factor; R^2: coefficient of determination; *: Heteroskedasticity-Consistent. Source: Authors.

In particular, waste management can pose a problem in the context of the spread of COVID-19 when considering patients being treated at home, or asymptomatic silent infection, due to infected waste generated. Managing these infected wastes poses risks to workers if inadequate waste management is adopted. Unfavourable waste management conditions have often been presented in developing countries. As presented, the association between higher cases of COVID-19 and the poor waste management suggested in Minas Gerais state may represent an increased risk for virus dissemination.

These results also pointed to a tendency for cases to occur in cities where a lower HDI has been established and suggest a condition to be analysed more closely in order to protect and articulate health solutions for these cities. When analysing the waste coverage collection, the results showed the spread of the virus in cities where this waste management stage is poor and, because of this, may represent a worse scenario considering the virus resistance in discarded materials (Chin et al. 2020; van Doremalen et al. 2020; Kampf et al. 2020).

When exposed to sunlight, Ratnesar-Shumate et al (2020) demonstrated the effects of natural sunlight rapidly inactivating SARS-CoV-2 on surfaces, specifically when the virus was dried on stainless steel coupons. The inactivation of simulated sample of saliva dried on a surface achieve 90% of infectious virus in 6.8 minutes on the summer solstice at 40°N latitude, while 14.3 minutes during the winter.

It is not possible to confirm a cause-effect association by analysing these results, however, as suggested by Yeo et al. (2020) and Chen et al. (2020), the presence of viral RNA in stool samples raises the possibility of the potential route of faecal transmission. This route of transmission has not yet been proven by scientific study, however if considered, the context of Minas Gerais state results indicates that sanitation conditions can be related as increasing factor to the spread of COVID-19. Another study by Casanova et al. (2009) showed that SARS-CoV-2 can be found for days or weeks in water and sewage, suggesting a potential vehicle for human exposure. As discussed by Qu et al. (2020), the possible ability of SARS-CoV-2 to survive for long periods outside the host organism suggests that measures to minimize the chances of infection should consider the development of practical large-scale disinfection methods in different environmental contexts.

Zambrano-Monserrate et al (2020) and Silva et al (2020) highlighted a significant association between the contingency measures and the environmental negative effects on reduction in recycling and increasing in waste generation.

Klemes et al (2020) and Sharma et al (2020) pointed out the changes in waste recycling during the pandemic, in particular due to the infectious risks in waste management, reducing the amount of wastes sent to recycle process. Nzediegwu and Chang (2020) suggested proactive measures as restrict access to landfill, related in Nigeria to preserve of waste pickers. Authors also reported a special waste collection adopted using buckets to collect disposable PPEs near the buildings and in public places, collected at least daily by trained workers.

Finally, as discussed by Silva et al (2020), same potential pathways could increase the risk of waste management, especially when improper management action were adopted during discard of used personal protective equipment. As discussed, improving the waste management is mandatory due to protect the health of waste workers and all population during collection, transport and final disposal processes.

4. Conclusion

Although direct droplet transmission appears to be the most important route for SARS-CoV-2 spread, faecal excretion, environmental contamination and fomites should be better investigated. In particular, correlations found in this study about those reported cases and poor waste management conditions highlight the prudent recommendation that more attention should be given to basic hygiene issues, including all stages of waste management.

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