Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company’s public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Incidences of COVID-19 in major mining municipalities in the Brazilian Amazon: Economic impacts, risks and lessons

Fernando Ferreira de Castro a,*, Geraldo Sandoval Góes b, Jose Antonio Sena do Nascimento c, Monica Monnerat Tardin d

a Researcher at Center of Mineral Technology (CETEM), Brazil
b Institute for Applied Economic Research (IPEA), Brazil
c Researcher at Center of Mineral Technology (CETEM), Brazil
d Analyst at Center of Mineral Technology (CETEM), Brazil

ARTICLE INFO

Keywords:
Brazilian Amazon
Covid-19
Royalties
Gold mining

ABSTRACT

This paper provides an assessment of COVID-19 occurrences in the Brazilian Amazon, with special emphasis on municipalities where mining activity is prevalent. It does so with a view to exploring how mining may be influencing the spread of coronavirus, not only within municipalities where the sector is widespread but also other areas of the Amazon. The analysis draws on findings from qualitative research and case studies of selected mining municipalities in Brazil. The results were analyzed by population range, and cases reported from the onset of the pandemic were mapped and evaluated. It is revealed that: (1) within the 772 municipalities in the Amazon, incidence of COVID-19 is relatively higher in the 33 largest mining localities; (2) there have been a higher proportion of COVID-19 cases in the selected municipalities than in other municipalities which have a similar population range; and (3) between 2020 and the first quarter of 2021, among the Amazon’s mining municipalities, those containing gold experienced the most significant growth as well as highest rates of infection. Overall, the results suggest that in the Brazilian Amazon, COVID-19 has spread fastest in major mining municipalities. These results and continuation of this research will provide support for decision-makers and local governments.

1. Introduction

This paper examines the impacts of the COVID-19 pandemic in mining municipalities in the Brazilian Amazon, drawing heavily on data collected by the country’s Ministry of Health. Mining activity is viewed by the Brazilian Government as an essential activity, which is why it has been permitted to continue during the pandemic. There are, however, concerns about its operations fueling spread of the disease, in particular in the Amazon. Specifically, has continued mining activity during the pandemic increased the exposure of vulnerable groups in the Amazon to the disease? This study aims to address this issue, in turn, informing policy decisions central to the Brazilian Amazon. It does so through an assessment of official health data retrieved from the territory’s mining municipalities.

While there is an abundance of important mineral reserves in the Brazilian Amazon, much of its mining activity tends to be most heavily concentrated in its remote, ecologically-sensitive and underdeveloped areas. These include protected areas and indigenous territories. As such, this activity may disturb traditional populations’ way of life, health, habitat and social practices (ACUNA, 2015). If managed effectively, however, mining can create jobs and generate local revenue in the Amazon via royalties, stimulate innovation, and diversify local economies through attracting investment for infrastructure. But if poorly managed, mining can cause environmental degradation, displace populations, fuel social inequality, intensify conflicts, lead to increased incidences of local violence, as well as fuel overdependence, economically, on its activities (UNDP – United Nations Development Program; Columbia University 2017).

https://doi.org/10.1016/j.exis.2021.101033
Received 22 July 2021; Received in revised form 3 December 2021; Accepted 3 December 2021
Available online 7 December 2021
2214-790X/© 2021 Elsevier Ltd. All rights reserved.
Initially, the pandemic affected the Brazilian economy as a whole, pushing it into recession and causing most of its economic sectors to stagnate (World Bank, 2020). The effects were felt throughout the country’s production chains, especially in their most vulnerable places, such as small municipalities and indigenous communities in the Amazon (Angelo, 2020). The pandemic has also caused considerable uncertainty in the country’s extractive industries (Lein, 2020). Despite gloomy forecasts for the Latin American economy (UNCTAD – United Nations Conference on Trade and Development 2020), the region’s mining activity grew in 2020, generating, for its governments, 35% more in royalties than 2019 (ANM – Agência Nacional de Mineração 2020). For Brazil, this was brought about by rises in global commodity prices, especially for iron ore (IMF, 2020; IBRAM - Instituto Brasileiro de Mineração 2020); China’s increased demand for its minerals (SISCO-MEX, 2020); and the devaluation of country’s currency against the US dollar, which fueled increases in exports (Göes et al., 2020).

The Amazon region has poor sanitation, impoverished land and river transportation infrastructure, and overwhelmed health services. Here, public services and housing developments have not kept pace with the rate of urbanization. On average, only 13% of municipal residents in the Amazon have access to a sewage system, compared to the national average of 77.1%, and only a limited part of the collected waste is treated (MDR – Ministério de Desenvolvimento Regional 2019). At the time of writing, Brazil ranked third globally in the number of incidences of COVID-19, with over 17 million cumulative cases and 500,000 deaths officially registered (MS – Ministério da Saúde 2021). The country’s public health system is considered to have the best coverage in Latin America. But given the challenges posed by vast territorial extension and the rapid spread of the disease, the pressure on health institutions has been disconcerting (Groda et al. 2020). These realities are particularly magnified in the Brazilian Amazon, where again, public health infrastructure is not as developed as in other regions of the country (IFDM – FIRJAM Municipal Development Index 2018). The sizable distances between urban centers with health infrastructure, absence of reliable transportation systems and low demographic density of the general population have contributed to the rapid spread of COVID-19 here.

A study carried out by the Socioenvironmental Institute (Instituto Socioambiental, ISA), in partnership with the Federal University of Minas Gerais (UFMG) shows that populations inhabiting Indigenous Lands (ILs) in the Amazon region are the most susceptible to COVID-19. Two of the most vulnerable ILs in the region with the highest indigenous populations in Brazil, Yanomami in the state of Roraima and Vale do Javari in the state of Amazonas, recorded an incidence rate five times above the national average. The study also presents evidence which reveals a strong correlation between the advance of illegal mining in ILs and incidences of infection of indigenous populations (OLIVEIRA et al., 2020). Like most countries, Brazil established restrictive policies to cope with the pandemic but implemented these in an uncoordinated manner, which has caused its share of problems. In particular, exceptions to social distancing policies implemented to prevent the spread of the virus were made for some economic activities considered essential (Brasil, 2020a; 2020b; 2020c; 2020d). The list included mining, the rationale being that it plays an important role in the economy of the Brazilian Amazon.

The objective of this study is to examine COVID-19 incidence in mining municipalities in the Amazon. It focuses specifically on those dependent on this sector, namely those where mining royalties generated yearly exceed one million Brazilian Reais (singular Real, BRL), or the equivalent to US$200,000. Drawing on findings from surveys, as well as socioeconomic and health data, the study seeks to: (i) provide an overview of COVID-19 incidence in selected mining municipalities in the Brazilian Amazon; (ii) conduct a spatial analysis of COVID-19 cases in selected mining municipalities, broken by type of ore production, and (iii) compare those findings to those of broader Amazon region and Brazil as a whole. Since mining is considered by the Government of Brazil to be an essential economic activity that must be sustained during the pandemic, this COVID-19 data assessment is crucial in minimizing the spread of the disease in the Amazon.

The paper begins by reviewing the data sources used and research methods adopted in the study. Section 3 examines COVID-19 incidence in selected mining municipalities in the Brazilian Amazon. Section 4 summarizes the main results and prescribes policy recommendations for mitigating this problem.

2. Data sources and methodology

A qualitative research methodology was adopted to evaluate the spread of COVID-19, over the period March 2020-March 2021, in the largest mining municipalities in the Brazilian Amazon and to compare these findings with those of other municipalities in the region with similar population sizes. The research used data collected by the Brazilian Ministry of Health (MS – Ministério da Saúde 2021) to measure the incidence of cases of infection of, and deaths linked to, COVID-19 for all municipalities in the Brazilian Amazon.

The qualitative research methodology adopted featured the following four phases: (I) selection of mining municipalities in the Brazilian Amazon; (II) a survey of official municipal data on COVID-19 and selection of study variables; (III) a survey of socioeconomic data for selected municipalities, selected on the basis of contribution of mining industry to (municipal’s) gross domestic product, monthly variation of jobs in the sector, and performance according to human development indicators; and (IV) data analysis and comparison of findings retrieved from mining and non-mining municipalities. In this study, major mining municipalities were determined to be those receiving more than one million Brazilian Reais (BRL) (approximately US$200,000) per year. These were selected here purposefully for states in the Brazilian Amazon, namely Rondônia (RO), Acre (AC), Amazonas (AM), Pará (PA), Roraima (RR), Amapá (AP), Tocantins (TO), Mato Grosso (MT) and the western

---

### Table A1

Research variables used in this study.

| Theme                      | Database                                      | Data collection(variables)                     | Period             | Territorial dimension |
|----------------------------|-----------------------------------------------|------------------------------------------------|--------------------|-----------------------|
| Mining royalties           | CFEM collection system (ANM, 2021)            | Operation, Royalties (Current values)          | 2019-2020 (annual) | Selected Mining Municipalities |
| Covid-19                   | Coronavirus Panel (Ministry of Health) (MS, 2021) | Accumulated cases (No. of cases)               | Until March 31st 2021 | 772 municipalities in the Brazilian Amazon |
| Job supply                 | CAGED (Ministry of Economy) (PDET, 2020)      | Monthly variation (admissions and layoffs)     | 2020 and 2021 (Jan.–Mar.) | Selected mining municipalities |
| Economic activities        | Municipal Gross Domestic Product (IBGE, 2018) | 1st and 2nd largest economic sector            | 2017 (latest available) | Selected mining municipalities |
| Municipal Development Indicators | FIRJAM Municipal Development Index (IFDM, 2018) | Municipal Index (2018, latest available)       | 2018 (latest available) | Selected mining municipalities |

Source: Prepared by the authors.
portion of Maranhão (MA). All of the variables considered in this work are presented in Table A1 (Appendix). The analysis and discussion of preliminary results for the selected municipalities were compared with findings retrieved from other municipalities in these states.

In Brazil, mine royalties (Financial Compensation for Exploitation of Mineral Resources or “CFEM”) are collected following the sale of mineral products (BRASIL 2017). They are distributed as follows: (i) 60% for the producing municipality; (ii) 15% for the corresponding state government; (iii) 15% for neighboring (non-mining) municipalities affected by the activity; and (iv) 10% for the federal government and regulatory and research entities linked to the sector. Using the criterion of BRL 1 million reais (BRL) in annual royalties collected, 33 mining municipalities were selected. Combined, they account for close to 90% of total mine royalties collected in the Brazilian Amazon.

COVID-19 incidence data were examined for all municipalities in the Brazilian Amazon. These data were retrieved from the Ministry of Health database on COVID-19 (Coronavirus Panel), an online platform of health information were gathered. Analysis of these sources revealed the information contained in the IFDM Index (FIRJAM Municipal Development Index). The IFDM is updated annually, providing a picture of the development Index (HDI). The IFDM is updated annually, providing a picture of the development of 216,403 COVID-19 cases until March 31, 2021. An explanation for this high incidence could be the maintenance of economic activities, which continued even when the government called for strict quarantines. The IFDM is an updated compilation of indicators of local development (maximum): the closer to the latter, the higher the level of development. The IFDM has four categories of development, namely low (from 0 to 0.4), regular (0.4 to 0.6) moderate (from 0.6 to 0.8) and high (0.8 to 1).

The next section of the paper shares details of the evaluation of COVID-19 incidence in selected municipalities in the Brazilian Amazon.

3. Impacts of COVID-19 in selected mining municipalities in the Brazilian Amazon

Rates of COVID-19 in mining municipalities were compared with those of other municipalities in the Brazilian Amazon according to the criteria presented in Table A1(Appendix). After selecting the mining municipalities focused on in this study, COVID-19 data and other crucial health information were gathered. Analysis of these sources revealed the following:

(i) The number of COVID-19 cases in the Brazilian Amazon was 1860,217, with an average incidence of 6.69%, which is higher than the national average for Brazil (6.13%). However, in major mining municipalities in the Amazon, the average incidence was 9.62%, which exceeds both of these figures.

(ii) Gold is the most widely extracted mineral in the Brazilian Amazon. At the time of writing, there were 744 active mines engaged in the extraction of gold here. Between 2019 and 2020, gold experienced the highest rise in production of all minerals mined in the Brazilian Amazon. Unsurprisingly, some of the main gold-producing municipalities in the Amazon have the highest incidences of COVID-19.

Table 1 presents details of the ten municipalities which, of the 33 mining municipalities selected, registered the highest incidence of COVID-19. The table also includes their ranking among the 772 municipalities in the Brazilian Amazon. All have incidence above 10%.

A point that needs highlighting from these results is that selected mining municipalities in the Brazilian Amazon have a higher average incidence of COVID-19. The set of 33 selected municipalities, as mentioned, has an average rate of 9.62%, with a total of 4322 deaths out of 216,403 COVID-19 cases until March 31, 2021. An explanation for this high incidence could be the maintenance of economic activities, specifically mining as well as other related economic activities deemed “essential” by the Brazilian Government during the pandemic, and therefore permitted to maintain levels of labor activities and social interactions. This is a subject which warrants further investigation.

Taking into account the contribution of economic activities to municipal gross added value, in the 10 municipalities presented in Table 1:

*patterns up to 31 March 2021.*

---

Table 1

| Ranking | Selected mining municipalities | Population | No. of cases | No. of deaths | Incidence rate | Mining sector growth |
|---------|--------------------------------|------------|--------------|---------------|----------------|---------------------|
| 1       | Vistoria do Jari (AP)          | 15,931     | 3639         | 18            | 22.84%         | 15.59%              |
| 6       | Pedra Branca do Amapari (AP)   | 16,502     | 3164         | 8             | 19.17%         | 4.44%               |
| 8       | Canais do Carajás (PA)         | 37,085     | 6888         | 64            | 18.57%         | 69.76%              |
| 11      | Paraopebas (PA)                | 208,273    | 36,932       | 260           | 17.73%         | 32.76%              |
| 23      | Presidente Figueiredo (AM)     | 36,279     | 5688         | 325           | 15.46%         | –4.92%              |
| 28      | Arquipel (RO)                  | 107,863    | 15,973       | 325           | 14.81%         | 40.04%              |
| 34      | Xambio (TO)                    | 11,540     | 1613         | 19            | 13.98%         | 14.86%              |
| 58      | Porto Velho (RO)               | 529,544    | 66,601       | 1833          | 12.58%         | 110.53%             |
| 97      | Tucumã (PA)                    | 39,602     | 4334         | 43            | 10.94%         | 260.26%             |
| 115     | Curionopolis (PA)              | 17,929     | 1859         | 22            | 10.37%         | –85.15%             |

Source: MS (2021); IBGE (2020); ANM (2021).

2 The Coronavirus Panel (CP) can be accessed at https://covid.saude.gov.br/.

3 Patterns up to 31 March 2021.
Table 2: COVID-19 incidence ratio among selected mining municipalities and other municipalities in the Brazilian Amazon by population range.

| Population range | Selected mining Municipalities | Other Municipalities | Ratio (A/B) |
|------------------|--------------------------------|---------------------|-------------|
|                  | No. of Municipalities          | No. of municipalities | Covid-19 incidence | Covid-19 incidence |             |
|                  | (A)                           | (B)                  | (A)           | (B)            | (A/B)       |
| More than 500 K  | 1                             | 6                    | 12.58%        | 6.32%          | 1.99        |
| 200 to 500 K     | 2                             | 8                    | 10.41%        | 8.95%          | 1.16        |
| 100 to 200 K     | 4                             | 21                   | 7.51%         | 6.17%          | 1.22        |
| 50 to 100 K      | 4                             | 59                   | 6.40%         | 6.38%          | 1.00        |
| 20 to 50 K       | 10                            | 189                  | 9.84%         | 5.80%          | 1.70        |
| 10 to 20 K       | 10                            | 205                  | 10.62%        | 5.95%          | 1.78        |
| Less than 10 K   | 2                             | 251                  | 6.41%         | 6.78%          | 0.94        |
| TOTAL            | 33                            | 739                  | 9.62%         | 6.43%          | 1.50        |

K = 1000.

Source: Prepared by the authors, from MS (2021) and IBGE (2020).

Table A2: Largest mining municipalities in the Brazilian Amazon, based on quantity of royalties received in 1999.

| Selected Municipalities | State | Mineral Operation | Royalties (US $) | Main substances | Covid-19 Incident |
|------------------------|-------|-------------------|------------------|----------------|-------------------|
| Pedro Branca do Amapari | AP    | 245,841,107.90    | 404,722.31       | Gold           | 7.53%             |
| Ipixuna do Pará         | PA    | 141,749,877.62    | 308,556.81       | Gold           | 10.94%            |
| Presidente Figueiredo   | AM    | 104,285,138.40    | 2271,651.88      | Cassiterite    | 15.46%            |
| Nova Senhora do Livramento | MT   | 61,731,013.96    | 966,502.27       | Cassiterite    | 6.39%             |
| Nova Xavantina          | MT    | 48,559,674.93    | 914,725.51       | Cassiterite    | 9.79%             |
| Vitória do Jari         | AP    | 43,095,873.57    | 910,930.52       | Kaolin         | 23.84%            |
| Sáo Félix do Xingu      | PA    | 43,544,737.18    | 875,058.20       | Cassiterite    | 2.16%             |
| Pontes e Lacerda        | MT    | 57,414,910.42    | 872,716.65       | Nickel         | 9.20%             |
| Porto Velho             | RO    | 46,466,203.48    | 770,189.20       | Cassiterite    | 6.39%             |
| Matupá                 | MT    | 50,798,490.34    | 759,103.97       | Nickel         | 9.20%             |
| Nova Progresso          | PA    | 29,889,604.85    | 449,286.28       | Dolomite       | 5.88%             |
| Cocalinho              | TO    | 16,784,784.86    | 412,317.29       | Dolomite       | 7.26%             |
| Bandeirantes do Tocantins | TO | 16,237,601.51    | 405,502.37       | Dolomite       | 7.26%             |
| Xambioá                | TO    | 17,572,214.68    | 340,655.40       | Dolomite       | 13.98%            |
| Santa Maria da Barrares | PA   | 22,464,690.04    | 338,882.47       | Dolomite       | 3.25%             |
| Barra do Bugres         | MT    | 7879,887.31     | 310,731.64       | Dolomite       | 5.57%             |
| Tucumá                 | PA    | 20,445,877.62    | 308,556.81       | Gold           | 10.94%            |

Source: ANM (2020), MS (2021).

Table 1: The mineral extractive and mineral transformation industries provide the largest shares in Pedra Branca do Amapari (AP), Canaí dos Carajás (PA), Paraúna Pebas (PA), Presidente Figueiredo (AM), Xambioá (PA) and Curionópolis (PA). These findings underscore the economic importance of the mining sector in these municipalities, which have been among the most affected by COVID-19 in the Amazon. Table 2 evaluates the ratio between the sum of the accumulated COVID-19 cases from the selected municipalities and other municipalities in the same population range. This ratio allows for comparison of accumulated cases and their incidence rates between both groups: a ratio greater than 1 indicates there is a higher incidence of COVID-19 in the selected municipalities (A) compared to others in the same population range (B).

The results presented in Table 1 and Table 2 reveal a higher incidence of COVID-19 in the selected mining municipalities. The epidemiological dynamics of the disease and local social and economic conditions, such as poor health and sanitation infrastructure, may explain certain related facts, such as variations between population groups. However, based on the results presented in Table 2, there is a correlation between mining as an essential activity during the pandemic and higher incidence or accumulated cases of COVID-19 in these selected municipalities compared to similar Brazilian Amazon municipalities. Table A2 (Appendix) presents a comparative overview of COVID-19 incidence among states in the Brazilian Amazon.

As noted in these tables, the higher incidence rates in these municipalities reflect the greater impacts of the disease in these locations, where economic activities considered “essential”, such as mining, have continued to function. Fig. 1 shows the locations of selected mining areas.
municipalities, the areas where selected minerals are mostly produced, and corresponding COVID-19 incidence rates (represented on the map by the circle’s diameter around the municipalities). The colors of the circles indicate the most-produced mineral substances by value.

The map shows two spatial concentrations of municipalities with high COVID-19 incidence rates: southern Pará (PA), in the Tapajós and Carajás mining regions (largest mining provinces of Pará); and southern Mato Grosso (MT), near the Pantanal biome. With respect to mining activities in the Brazilian Amazon, it is noteworthy that gold ore is the most exploited mineral substance. The majority of the mining municipalities selected in this study, therefore, are mainly gold producers. Even though iron ore accounts for the biggest share of mineral production in the Brazilian Amazon, the official number of active gold mines here is 744 (official active operations), while for iron ore, there are only three active projects.

During 2020, a huge upsurge in illegal small gold mining was reported in the Brazilian Amazon, fueling conflict in Indigenous Lands and other protected areas due to overlapping territories and outside encroachment. These interactions have also been responsible for a spike in COVID-19 infections in Indigenous communities (Siqueira-Gay and Sánchez, 2021; Scarr, 2020). An increase in infection was also observed in small-scale mining operations located within Indigenous lands already experiencing an increase in COVID-19 cases within resident populations. A total of 18 conflicts were registered between indigenous people on the one hand, and miners and mining companies on the other hand, over COVID-19. Open letters and petitions addressed to national and international bodies, reporting on the danger posed by mining in the spread of infection are available in support of this (Wanderley et al., 2021). A spatial correlation was also found between mining activity and the concentration of urban areas with high incidence of COVID-19 in the Brazilian Amazon, specifically, areas where there is an overlap of Indigenous Lands and Conservation Units (Figure A1, Appendix).

In the case of COVID-19-related deaths, the mortality rate (number of deaths over population) for Brazil as a whole was 0.152% while in the selected municipalities it was 0.192% (up until 31 March 2021). Although a study conducted by FIOCRUZ indicated that there is possibility of an underreporting of COVID-19 deaths in Brazil (Orellana et al., 2021), the official data on accumulated cases used in this study still point to the situation being severe in the region. Of the selected municipalities, the highest mortality rates were reported in Porto Velho (RO), with 0.346%; Pontes e Lacerda (MT), with 0.337%; and Porto Esperidião (MT), with 0.316%. Brazil’s lethality rate (number of deaths over the number of registered cases) was above the general rate of the selected municipalities. However, the lethality rates of nine of these municipalities were above the national average. The lethality rates in Juruti (PA) at 15.56%, Porto Esperidião (MT) at 4.66%, and Pontes e Lacerda (MT) at 3.60%.

### Table A3
COVID-19 incidence in selected mining municipalities, Amazon’s states and Brazil.

| Territorial coverage                        | No. of cases | Average Incidence |
|---------------------------------------------|--------------|-------------------|
| Brazil                                      | 12,991,148   | 6.13%             |
| North Region                                | 1594,016     | 8.65%             |
| Amazon                                      | 1860,217     | 6.69%             |
| Pará (PA)                                   | 417,523      | 4.85%             |
| Mato Grosso (MT)                            | 308,546      | 8.85%             |
| Amapá (AP)                                  | 97,542       | 11.53%            |
| Rondônia (RO)                               | 187,270      | 10.54%            |
| Tocantins (TO)                              | 140,975      | 8.96%             |
| Amazonas (AM)                               | 349,123      | 8.42%             |
| Maranhão (MA)                               | 242,401      | 3.43%             |
| Acre (AC)                                   | 69,657       | 7.90%             |
| Roraima (RR)                                | 89,525       | 14.78%            |
| Amazon without Selected Municipalities      | 1644,174     | 6.43%             |
| **Selected Mining Municipalities**           | **216,043**  | **9.62%**         |

Source: MS (2021).

Fig. 1. COVID-19 incidence map of selected mining municipalities in the Brazilian Amazon. Source: Prepared by the authors, adapted using information from MS, 2021; ANM, 2020; and IBGE, 2020.
A brief assessment of living conditions in selected mining municipalities in the Brazilian Amazon, according to information contained within the IFDM Index (IFDM – FIRJAM Municipal Development Index 2018), reveals that: (i) most municipalities have a ‘moderate’ score (from 0.6 to 0.8) in the IFDM general (22 municipalities), while the others obtained a ‘regular’ score (from 0.4 to 0.6 – 11 municipalities); (ii) among the municipalities with the highest incidence of COVID-19, the remote rural municipalities of Vitória do Jari (AP) and Pedra Branca do Amapari (AP) stood out, receiving ‘regular’ scores (respectively, 0.5562 and 0.5230); and (iii) Tucumã (PA) also stood out with its ‘regular’ score on the IFDM General and a ‘low’ score on IFDM Health, along with a high incidence rate (10.94%). Another observation made in the assessment of mining performance in the 2019–2020 period was that Brazilian mineral production grew 35%, when measured on the basis of royalties and that growth in the Brazilian Amazon was 69%, nearly twice the national average. Extending this analysis to the level of the selected municipalities, taking into account only those whose main product is gold (14 out of 33), the average increase over the same period was 123.94%. The strongest growth experienced was in Novo Progresso (PA) with 304.2% (PA). When considering the 10 municipalities with highest COVID-19 incidence rates (Table 1), Tucumã (PA) and Porto Velho (RO), whose main product is gold ore, registered respective growth of 110.53% and 260.26% between 2019 and 2020.

Finally, from the standpoint of jobs, variation in mineral extraction and mineral processing, the Brazilian Amazon’s performance was higher than the rest of the country. In the Amazon’s mineral extraction industries, employment increased by 9.0% in 2020 and 5.93% in the first quarter of 2021, while jobs in the mineral transformation industry grew 7.2% in 2020 and 9.7% in the first quarter of 2021. This variation was far above the Brazilian average in the mineral extractive industries, which were 2.1% in 2020 and 2.37% in the first quarter of 2021, and also above the average of the mineral transformation industry, which was 3.64% in 2020 and 4.39% in the first quarter of 2021 (PDET – Programa de Divulgação das Estatísticas de Trabalho 2020).

4. Final considerations

This paper has shed light on the relative tradeoff between the maintenance of mining activities in mineral-producing municipalities in the Brazilian Amazon. The Government of Brazil declared mining as an “essential activity” to be maintained to face the challenge of reducing the spread of COVID-19 in the country. The analysis of findings reported here can be summarized as follows:

(i) Of the 772 municipalities in Brazilian Amazon, the selected mining municipalities had a higher incidence of COVID-19 infection.

(ii) In general, there was a higher proportion of COVID-19 cases in the selected mining municipalities than others in the Brazilian Amazon with similar population dynamics.

(iii) From the standpoint of mine production, the selected municipalities grew almost twofold the average of the entire mining sector in Brazil; gold-producing municipalities experienced the highest growth rates (on average, 3.5 times higher than that of the national average) in comparison with the previous year.

(iv) Among the mining municipalities that mainly produce gold, in general, they recorded high incidence of COVID-19 during the study period examined.

In line with the measures and procedures aimed at preventing and treating COVID-19 laid out by the World Health Organization (WHO) (UN – United Nations 2020), this study underscores the importance of adopting a series of stringent policies and practices for individuals working in, and who interact with, mining in Brazil. There is especially a need for improved guidance for those in operational roles in the Brazilian Amazon, where COVID-19 incidence has proved to be among the highest in the country. Due to the seriousness of the pandemic in mining regions of the Amazon, several companies engaged in the extraction of minerals here have been heavily criticized and have even been targeted in lawsuits (Wanderley et al., 2021).

For “essential activities” such as mining, some of the more significant measures that are necessary to mitigate the problem include periodic testing, monitoring of cases, and priority vaccination of all people who work in this sector. In addition, the number of people infected and suspected cases in the sector must be periodically disclosed because, as this paper has shown, of the higher risk of incidence and comparatively rapid spread of the disease in locations where minerals are produced. Priority attention must be paid to Indigenous Lands that overlap Mining Areas (OLIVEIRA et al., 2020).

Although the analyzed data demonstrate that the largest mining municipalities in the Brazilian Amazon have on average incidence of COVID-19 higher than other municipalities in the region and Brazil as a whole, it cannot be stated conclusively from these data alone that mining has been the main factor behind its increased incidence in this case. However, the presented information reveals the region’s vulnerability to the pandemic and the need to expand data collection and analysis on functioning economic activities with a view to shedding light on health infrastructure issues in the Brazilian Amazon that can be contributing to COVID-19’s spread.

These territories have often suffered disputes due to the ever-expanding activities of artisanal miners (garimpeiros); it has been verified that artisanal and small-scale mining activities tend to increase local people’s vulnerability (Hilson et al., 2021), especially in the Brazilian Amazon (Scarr, 2020; Calvimontes et al., 2020). Another point worth noting was raised by Wanderley et al. (2021), who found in ILs a correlation between the advance of COVID-19 and the expansion of illegal artisanal mining operations. Following Zvarivadzwa and Nhlekoa (2018), artisanal mining in the Amazon has fueled the spread of the disease spread, given the high mobility of those engaged in the sector; has endured a high fatality rate, in many cases due to the absence or failure to use personal protective equipment (PPE); and its sites have been the locations of major human rights abuses and endured a lack of security. Environmentally, these activities have caused water pollution, including mercury and cyanide poisoning, and land degradation, and economically, they have suffered from low adoption of efficient technology, shortsighted planning and the problems that are typically associated with mineral rushes. The pandemic has illuminated these problems and added another layer to an industry that is in desperate need of greater regulation. All of these issues need to be further evaluated.

Among the aspects described in this paper, we suggest there is a link between the risk of infection and the maintenance of economic activities, which in the case of mining, can be better observed through monitoring the situation in mineral-producing municipalities and comparing findings from those retrieved via comparative analysis of the situations facing other localities in the same region. Maintaining services that are fundamental to the economy while at the same time combating the pandemic must go hand in hand with guaranteeing the support of the most vulnerable populations (LOAYZA and PENNINGS, 2020). Especially in the context of the Amazon, the development of indicator sets and monitoring are not only vital for decision-makers but also contribute to the Sustainable Development Goals in the long run (UN – United Nations, 2016; UN – United Nations 2020). To broaden this analysis, it is important to extend the scope of research to include additional dimensions such as health infrastructure (including indigenous communities), transportation systems, and economic dependence on mining and related activities.

These results reported in this paper sound a warning that mining activity, while essential to the livelihoods of many people and the functioning of the economies of regions such as Brazilian Amazon, requires periodic critical assessment. This monitoring must be carried out with integrity and an appreciation of the quality of life of workers and
the population in mining areas overall. The results reported here and the expansion of the research undertaken is a key to devising tangible recommendations for decision-makers and local governments in mineral-rich localities.

Appendix

Dummy citations Table A1, Table A2, Table A3 and Fig. A1.

References

ACUNA, R.M. 2015. The politics of extractive governance: indigenous peoples and socio-environmental conflicts. Extr. Ind. Soc. 2 (1), 85-92.

ANGEL, Maurício. (2020). Mais vulneráveis à Covid-19, terras indígenas com povos isolados também são alvo de mineradoras e garimpeiros. Observatório da Mineração, 31 jul. 2020. Available at: <https://observatoriodamineracao.com.br/mais-vulneraveis-a-covid-19-terras-indigenas-com-povos-isolados-tambem-sao-alvo-de-mineradoras-e-garimpeiros/>. Accessed on: Apr. 19th, 2021.

ANM – Agência Nacional de Mineração (2020). CFEM Collection System. (Online). Available at: <https://sistemas.anm.gov.br/arrecadacao/extra/Relatorios/cfem/maiores_arrecadadores.aspx>. Accessed on: Jul. 10th, 2020.

BRASIL, 2020a. Law No. 13.979, from Feb. 6th 2020, Provides Coping Measures For the Coronavirus Pandemic. Presidência da República, Brasília.

BRASIL, 2020b. Decree No. 10.282, from March 20th 2020, Provides For Public Services and Essential Activities. Presidência da República, Brasília.

BRASIL, 2020c. Decree No. 10.329, From Abril 28th 2020, Amends Decree No. 10,282 and Regulates Law No. 13,979. Presidência da República, Brasília.

BRASIL, 2020d. Ordinance No. 135 /GM, from March 28th 2020, Provides For the Attribution of the Mineral Activity As Essential. Ministério de Minas e Energia - MMA, Brasília, MML.

BRASIL, 2017. Law No. 13.540, from Dec. 27th2017, Provides For the Financial Compensation For the Exploitation of Mineral Resources (CFEM). Senado Federal, Brasília, 2017.

CALVIMONTES, J., MASSARO, L., ARAUJO, C.H.X., MORAES, R.R., MELLO, J., FERREIRA, L.C, 2020. Small-scale gold mining and the Covid-19 pandemic: conflict and cooperation in the Brazilian Amazon. Extr. Ind. Soc. 7 (2020), 1347-1350.

CRODA, J., OLIVEIRA, W.K., FRUTUOZO, R.L., et al. 2020. COVID-19 in Brazil: advantages of a socialized unified health system and preparation to contain cases. Rev. Soc. Bras. Med. Trop. 53 (c20200167).

GOES, Geraldo S., CARDOSO, Daniel M., SENA, José A., REYMAO, Ana E.N., BEGOT, Ligia H., RODRIGUES, Cintiha P. (2020). Macroeconomy ambiental and pandemic: impactos da Covid-19 no setor mineral. Carta de Conjuntura/IFEA, n. 5 (4th quarter).

HILSON, G., VAN BOCKSTAELE, S., SAUERWEIN, T., HILSON, A., McQuillen, J., 2021. Artisanal and small-scale mining, and COVID-19 in sub-Saharan Africa: a preliminary analysis. World Dev. 139 (105315) art. no.

IBGE - Instituto Brasileiro de Geografia e Estatística. (2020). Municipal population estimate. (online). SIDRA / IBGE. Available at: <https://sidra.ibge.gov.br/>. Accessed on: Jul. 10, 2020.

IBGE - Instituto Brasileiro de Geografia e Estatística. (2018). Gross domestic product of municipalities. (online). SIDRA/IBGE.

IBRAM - Instituto Brasileiro de Mineração. Setor mineral - 2º trimestre 2020. (online). IBRAM. 21 de julho de 2020. Available at: <http://portalamineracao.com.br/wp-content/uploads/2020/07/ppt-final-completo-site-e-portal.pdf>. Accessed on: Aug. 1, 2020.

IFDM - FIRJAM Municipal Development Index. (2018). (online). Available at: <https://www.firjam.com.br/ifdm/>. Accessed on: Apr. 4th, 2021.

LAING, Timothy., 2020. The economic impact of the coronavirus 2019 (Covid-19): implications for the mining industry. The Extractive Industries and Society 7 (2020), 584-582.

LOAYZA, Norman V., PENNINGS, Steven., 2020. Macroeconomic policy in the time of COVID-19: a Primer for developing countries. Research and Policy Briefs, No. 28. Banco Mundial, Washington.

MDR – Ministério de Desenvolvimento Regional. (2019). PLANSAB - Plano Nacional de Saneamento Básico. Brasília: ministry of Regional Development, National Sanitation Secretariat. Available at: <https://antigo.mdr.gov.br/images/stories/ArquivosSDRU/ArquivosPDF/Foro_Dia_Acagens_2019/Relatorio_ABA.pdf>. Accessed on: Sep. 6, 2021.

MS – Ministério da Saúde. (2021). Painel Coronavirus. (online). Available at: <https://covid.saude.gov.br/>. Accessed on: Jun. 1, 2021.

OLIVEIRA U., SOARES FILHO B., OVIEDO A., MOREIRA T., CARLOS S., RICARDO J., PIZA A. (2020). Modelagem da vulnerabilidade dos povos indígenas no Brasil ao Covid-19. [In press]. Nota técnica do Instituto Socioambiental (ISA) e Universidade Federal de Minas Gerais (UFGM). Available at: <https://www.socioambiental.org/sites/blog.socioambiental.org/files/nsa/arquivos/nota_tecnica_modelo_covid19.pdf>. Accessed on: sep. 6, 2021.

IMF (2020). Primary commodity pricing system. access to IMF macroeconomic and financial data. (Online). International Monetary Fund. Available at: <https://data.imf.org/?sk=471DDDF8-D8A7-499A-81BA-5B323C01F8B9>. Accessed on: Maio 27, 2020.

PDET – Programa de Divulgação das Estatísticas de Trabalho.(2020). Painel de Informações do Novo CAGED. (online). Ministério do Trabalho. Available at: <http://pdet.mte.gov.br/novo-caged/>. Accessed on: Jul. 7, 2020.

SCARR, Simon. (2020). Amazon gold rush: illegal mining threatens Brazil’s last major isolated tribe. Reuters. Available at: <https://www.reuters.com/article/us-brazil-indigenous-mining-insight-15USKBN23W2W0>. Accessed on: Jul. 25th, 2020.

SQUEIRA-GAY, Juliana, SANCHEZ, Luis E. (2021). The outbreak of illegal gold mining in the Brazilian Amazon boosts deforestation. Regional Environmental Change, 21 (28).

Fig. A1. Conservation Units, Indigenous Lands and Mining Areas in the Brazilian Amazon. Source: IBGE (2018); INPE (2016); ICMBio (2019); FUNAI (2021); ANM (2020), prepared by NETMIN/CETEM.
SISCOMEX (2020). Sistema Integrado de Comércio Exterior. Comex Stat. Available at: http://comexstat.mdic.gov.br/pt/geral/16168 Accessed on: 20 Jan. 2021.

UN – United Nations. (2020). Progress Em Direção às metas De Desenvolvimento Sustentável. [e/2020/57]. Conselho Econômico e Social.

UN – United Nations. 2016. The Sustainable Development Goals Report 2016. United Nations, New York.

UNDP – United Nations Development Program; Columbia University, 2017. Mapping Mining to the SDGs: An Atlas. UNDP, New York. . 2017Available at: <https://www.undp.org/content/dam/undp/library/Sustainable%20Development/Extractives/Mapping_Mining_SDGs_An_Atlas_Executive_Summary_FINAL.pdf> Accessed on: Jul. 15, 2020.

UNCTAD – United Nations Conference on Trade and Development, 2020. World Investment Report 2020 – International production Beyond the Pandemic. UNCTAD, Nova York, pp. 46-50. Available at: <https://unctad.org/en/PublicationsLibrary/wir2020_en.pdf>. Accessed on: Jun. 1, 2020.

WANDERLEY, L.J.; ZUCARELLI,M.C.;FARIAS, M.C.(2021). Essencialidade forjada e danos da mineração na pandemia da Covid-19 [online]. Available at: <http://emdefesadosterritorios.org/wp-content/uploads/2021/08/1_Publicacao_Mineração_Covid_2021_.pdf>. Accessed on: Sep. 11, 2021.

WORLD BANK. (2020). The Sustainable Development Goals Report 2020 – International production Beyond the Pandemic. UNCTAD, Nova York, pp. 46-50. Available at: <https://unctad.org/en/PublicationsLibrary/wir2020_en.pdf>. Accessed on: Jun. 1, 2020.

ZVARIVADZAA, T., NHLEKO,A.S., 2018. Resolving artisanal and small-scale mining challenges: moving from conflict to cooperation for sustainability in mine planning. Resour. Policy 56 (2018), 78–86.