






Comparing covid-19 positivity rates and contextual factors across municipalities in a metropolitan area of Northeast Brazil



Comparação das taxas de positividade para covid-19 em função dos fatores contextuais entre os municípios de uma região metropolitana do Nordeste do Brasil

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Abstract

Objective: To compare covid-19 positivity and mortality rates and contextual factors across municipalities in a metropolitan area of Recife between 2020 and 2021. **Methods:** This ecological study examined covid-19 positivity (measured by reverse transcription polymerase chain reaction test) and mortality rates. Epidemiological data were extracted from the DataSUS system, while socioeconomic data were obtained from IBGE and the Pernambuco State Health Department databases, covering March 2020 to December 2020. Data were analyzed using Spearman's correlation test and considering a 5% significance level. **Results:** Severe covid-19 cases were positively correlated with high household income per capita ($U = 0.832$; $p < 0.001$) but inversely correlated with illiteracy ($U = -0.879$, $p < 0.001$) rates. **Conclusion:** Contextual factors were correlated with increased covid-19 positivity and mortality rates during the study period.

Keywords: Covid-19; Social epidemiology; Pandemics; Covid-19 testing

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Resumo

Objetivo: Comparar as taxas de diagnóstico positivo e de óbitos para covid-19 entre os municípios da Região Metropolitana do Recife em função de fatores contextuais, no período de 2020-2021. **Métodos:** Um estudo ecológico para o qual foram utilizados dados da positividade na testagem com RT-PCR (transcrição reversa seguida de reação em cadeia da polimerase) e de óbitos para covid-19. Os dados utilizados foram obtidos a partir dos registros do sistema DataSUS; os dados relativos aos contextos dos municípios foram obtidos na página do IBGE e da Secretaria de Saúde do Estado de Pernambuco no período de março de 2020 a dezembro de 2020. Foram realizadas análises descritivas e analíticas utilizando teste de correlação de Spearman. Para todas as análises, foi utilizado o nível de significância de 5%. **Resultados:** Em relação a casos graves, a maior renda domiciliar per capita ($U = 0,832$; $P < 0,001$); e inversamente correlacionado a taxa de analfabetismo ($U = -0,879$, $P < 0,001$). **Conclusão:** Os fatores contextuais estiveram correlacionados à maior taxa de positividade e óbitos pela C-19 no período investigado.

Palavras-chave: Covid-19; Epidemiologia social; Pandemia; Teste covid-19

INTRODUCTION

The covid-19 pandemic has exacerbated global social inequalities. In Brazil, the health crisis and government inaction worsened consequences of the pandemic¹⁻⁴.

Masks, social distancing, hand hygiene, and early testing for covid-19 detection were among the diverse effective measures used to control the pandemic. Testing was particularly important for isolating infected individuals in the absence of an effective vaccine^{5,6}.

Some countries massively tested their population. For instance, Germany performed 37,584 tests per million inhabitants early in the pandemic, representing a benchmark for combating covid-19, and this approach underscored the relevance of expanding the testing capacity for covid-19 to control the pandemic. The challenges and effectiveness of mass testing as a control strategy have been extensively debated globally^{7,8}.

On the other hand, Brazil faced a shortage of tests, which were almost exclusively limited to severe cases, leading to expressive underreporting. This scenario led to inaccurate assessments of the actual conditions of the pandemic, hindering effective disease control and management of severe cases⁹.

A total of 222,166 positive cases and 9,654 deaths related to covid-19 were reported in Pernambuco state (Brazil) until December 31, 2020^{9,10}. Therefore, this study aimed to compare the covid-19 positivity and mortality rates and contextual factors across the metropolitan area of Recife in Pernambuco between March 2020 and December 2021.

METHODS

This ecological study employed an epidemiological approach, which includes aggregated or spatial correlation studies within population groups rather than individuals. Ecological studies focus on describing and analyzing the average exposure, prevalence, or disease rates (isolated or combined) within geopolitical units or groups of interest¹¹. This study considered the covid-19 positivity rate within the metropolitan area of Recife (Pernambuco, Brazil).

Covid-19 positivity rates, based on reverse transcription polymerase chain reaction test, were obtained from the Pernambuco State Health Department database. Mortality rates were extracted from the Mortality Information System available on DataSUS. Contextual data from municipalities between March and December 2020 were obtained from the IBGE database. Data were collected from 15 municipalities in the metropolitan area of Recife: Abreu e Lima, Araçoiaba, Cabo de Santo Agostinho, Camaragibe, Goiana, Igarassu, Ilha de Itamaracá, Ipojuca, Itapissuma, Jaboatão dos Guararapes, Moreno, Olinda, Paulista, Recife, and São Lourenço da Mata.

Data were organized in Microsoft Excel spreadsheets. Dependent variables included the number of mild and severe covid-19 cases; the latter referred to cases that required hospitalization and resulted in death due to covid-19. The explanatory variables consisted of the population size of municipalities, gross domestic product per capita, percentage of households without basic sanitation, percentage of Family Health Strategy coverage, illiteracy rate, average household income per capita, and unemployment rate.

Data were analyzed using descriptive and analytical statistics. For the former, central tendency and dispersion measures were used, whereas the latter was calculated using Spearman's correlation coefficient, considering the non-normal distribution of data. All analyses were performed considering a 5% significance level. Correlation tests are suitable for ecological studies with clustered units of analysis, especially when no specific hypothesis testing is required. Approval by the research ethics committee was not needed because only public and secondary data were used according to the guidelines and standards for research involving human beings stated in the resolution 466/12 of the Brazilian National Health Council (National Health Council, 2012).

RESULTS

Data on covid-19 positivity rates are shown in Tables 1, 2, and 3. A correlation was found between the population size of municipalities and the outcomes investigated: larger populations were associated with positivity and mortality rates. However, no correlation was observed involving municipal gross domestic product. Severe cases were positively correlated with a low percentage of areas without sanitation ($U = 0.643$, $p = 0.010$) and high household income per capita ($U = 0.832$, $p = 0.001$). Severe cases were also inversely correlated with illiteracy rates ($U = -0.879$, $p = 0.001$) (Table 1).

Table 1. Correlations between positivity rates of severe cases and contextual factors in a metropolitan area of northeast Brazil.

Variables	Population	GDP per capita	Area without basic sanitation	Family Health Strategy coverage	Illiteracy rate	Average household income per capita	Unemployment rate	Severe Cases
Population	1	-	-	-	-	-	-	-
GDP per capita	U = 0.225 p = 0.420 N = 15	1	-	-	-	-	-	-
Area without basic sanitation	U = 0.707 p = 0.003 N = 15	U = 0.189 p = 0.499 N = 15	1	-	-	-	-	-
Family Health Strategy coverage	U = -0.209 p = 0.455 N = 15	U = -0.357 p = 0.192 N = 15	U = -0.256 p = 0.357 N = 15	1	-	-	-	-
Illiteracy rate	U = -0.882 p = 0.001 N = 15	U = -0.175 p = 0.533 N = 15	U = -0.643 p = 0.010 N = 15	U = -0.153 p = 0.586 N = 15	1	-	-	-
Average household income per capita	U = 0.843 p = 0.001 N = 15	U = 0.411 p = 0.128 N = 15	U = 0.611 p = 0.016 N = 15	U = -0.497 p = 0.059 N = 15	U = -0.771 p = 0.001 N = 15	1	-	-
Unemployment rate	U = -0.482 p = 0.069 N = 15	U = -0.418 p = 0.121 N = 15	U = -0.314 p = 0.254 N = 15	U = 0.249 p = 0.372 N = 15	U = 0.482 p = 0.069 N = 15	U = -0.543 p = 0.037 N = 15	1	-
Severe cases	U = 0.982 p = 0.001 N = 15	U = 0.168 p = 0.550 N = 15	U = 0.643 p = 0.010 N = 15	U = -0.196 p = 0.483 N = 15	U = -0.879 p = 0.001 N = 15	U = 0.832 p = 0.001 N = 15	U = -0.475 p = 0.074 N = 15	1

GDP: Gross domestic product; U: Spearman's correlation coefficient; p: p-value; N: number of municipalities.

Similarly, mild cases were positively correlated with low basic sanitation ($U = 0.589$, $p < 0.021$) and high average household income per capita ($U = 0.893$, $p < 0.001$). Moreover, mild cases were inversely correlated with illiteracy rate ($U = -0.786$, $P < 0.001$) and unemployment rate ($U = -0.550$, $p = 0.034$) (Table 2).

Table 2. Correlations between positivity rates of mild cases and contextual factors in a metropolitan area of northeast Brazil.

Variables	Population	GDP per capita	Area without basic sanitation	Family Health Strategy coverage	Illiteracy rate	Average household income per capita	Unemployment rate	Severe Cases
Population	1	-	-	-	-	-	-	-
GDP per capita	U = 0.225 p = 0.420 N = 15	1	-	-	-	-	-	-
Area without basic sanitation	U = 0.707 p = 0.003 N = 15	U = 0.189 p = 0.499 N = 15	1	-	-	-	-	-
Family Health Strategy coverage	U = -0.209 p = 0.455 N = 15	U = -0.357 p = 0.192 N = 15	U = -0.256 p = 0.357 N = 15	1	-	-	-	-
Illiteracy rate	U = -0.882 p = 0.001 N = 15	U = -0.175 p = 0.533 N = 15	U = -0.643 p = 0.010 N = 15	U = -0.153 p = 0.586 N = 15	1	-	-	-
Average household income per capita	U = 0.843 p = 0.001 N = 15	U = 0.411 p = 0.128 N = 15	U = 0.611 p = 0.016 N = 15	U = -0.497 p = 0.059 N = 15	U = -0.771 p = 0.001 N = 15	1	-	-
Unemployment rate	U = -0.482 p = 0.069 N = 15	U = -0.418 p = 0.121 N = 15	U = -0.314 p = 0.254 N = 15	U = 0.249 p = 0.372 N = 15	U = 0.482 p = 0.069 N = 15	U = -0.543 p = 0.037 N = 15	1	-
Mild cases	U = 0.918 p = 0.001 N = 15	U = 0.257 p = 0.355 N = 15	U = 0.589 p = 0.021 N = 15	U = -0.342 p = 0.212 N = 15	U = -0.786 p = 0.001 N = 15	U = 0.893 p = 0.001 N = 15	U = -0.550 p = 0.034 N = 15	1

GDP: Gross domestic product; U: Spearman's correlation coefficient; p: p-value; N: number of municipalities.

Mortality rate was correlated with a high average household income per capita (U = 0.804, p < 0.001) but inversely correlated with illiteracy rate (U = -0.840, p < 0.001) (Table 3).

Table 3. Correlations between the number of covid-19 deaths and contextual factors in a metropolitan area of northeast Brazil.

Variables	Population	GDP per capita	Area without basic sanitation	Family Health Strategy coverage	Illiteracy rate	Average household income per capita	Unemployment rate	Severe Cases
Population	1	-	-	-	-	-	-	-
GDP per capita	U = 0.225 p = 0.420 N = 15	1	-	-	-	-	-	-
Area without basic sanitation	U = 0.707 p = 0.003 N = 15	U = 0.189 p = 0.499 N = 15	1	-	-	-	-	-
Family Health Strategy coverage	U = -0.209 p = 0.455 N = 15	U = -0.357 p = 0.192 N = 15	U = -0.256 p = 0.357 N = 15	1	-	-	-	-
Illiteracy rate	U = -0.882 p = 0.001 N = 15	U = -0.175 p = 0.533 N = 15	U = -0.643 p = 0.010 N = 15	U = -0.153 p = 0.586 N = 15	1	-	-	-
Average household income per capita	U = 0.843 p = 0.001 N = 15	U = 0.411 p = 0.128 N = 15	U = 0.611 p = 0.016 N = 15	U = -0.497 p = 0.059 N = 15	U = -0.771 p = 0.001 N = 15	1	-	-
Unemployment rate	U = -0.482 p = 0.069 N = 15	U = -0.418 p = 0.121 N = 15	U = -0.314 p = 0.254 N = 15	U = 0.249 p = 0.372 N = 15	U = 0.482 p = 0.069 N = 15	U = -0.543 p = 0.037 N = 15	1	-
Mortality rate	U = 0.850 p = 0.001 N = 15	U = 0.250 p = 0.369 N = 15	U = 0.621 p = 0.013 N = 15	U = -0.097 p = 0.730 N = 15	U = -0.750 p = 0.001 N = 15	U = 0.607 p = 0.016 N = 15	U = -0.600 p = 0.018 N = 15	1

GDP: Gross domestic product; U: Spearman's correlation coefficient; p: p-value; N: number of municipalities.

DISCUSSION

This study provided an overview of the covid-19 pandemic onset in the metropolitan area of Recife during the period evaluated and showed that covid-19 positivity and mortality rates were associated with contextual factors. The results showed positive correlations with more favorable socioeconomic conditions, such as improved sanitation, high average household income per capita, low unemployment, and low illiteracy rate. In contrast, the mortality rate was associated with a high illiteracy rate.

We hypothesized that covid-19 testing during the study period (March 2020 to December 2021) was more prevalent in areas with higher purchasing power, private initiatives, and limited availability of public health services; thus, potentially skewing the analysis.

The number of mild and severe cases was correlated with areas of high purchasing power. A similar finding in a study conducted in the United States described an association between high household income and elevated positivity rates¹². In this case, the widespread availability of rapid and accurate tests is essential for effective covid-19 control and should not be restricted to certain segments of society.

Sanitation was identified as an important variable in establishing social inequalities, including in populations of large cities, given the correlations found between the absolute number of deaths and population size and between low sanitation and all outcomes studied. Approximately 988,844 households in the metropolitan area of Recife have sanitation (518,090 in Recife and 470,794 in other municipalities of the region).

Studies in the Brazilian context showed that the poorest population segments were more severely affected by the covid-19 pandemic, evidenced by the highest mortality rates^{13,14}. This corroborates the findings indicating that municipalities with higher illiteracy rates experienced more deaths due to covid-19 and reflects a hallmark of social inequalities. Furthermore, testing was limited during the study period, especially in more illiterate segments.

The typical limitations of ecological studies must be considered in the present findings; thus, cause-and-effect relationships between exposure and disease cannot be established. Nevertheless, ecological studies have been efficient in analyzing issues related to covid-19¹⁵.

CONCLUSION

The increased positivity rate was associated with contextual factors in more developed areas, potentially leading to the misinterpretation that these areas were more affected by the covid-19 pandemic. However, testing was limited in public health services at the onset of the pandemic. In addition, despite the high positivity rate in affluent areas, the highest mortality rates occurred in less affluent areas. The Brazilian Unified Health System was overwhelmed due to lack of resources and required the establishment of partnerships to expand testing capacity. Thus, educational and research institutions played central roles in producing tests to combat the covid-19 pandemic.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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AUTHOR CONTRIBUTIONS

PPRG: Conceptualization, Data acquisition, Data curation, Writing - review and editing. **PT:** Data acquisition, Writing - review and editing. **PHLC:** Data acquisition, Writing - review and editing. **PSAG:** Project administration, Methodology, Data curation, Writing - review and editing. All authors read and agreed with the final version of the manuscript.

REFERENCES

1. Barreto ML, Barros AJD de, Carvalho MS, Codeço CT, Hallal PRC, Medronho R de A, et al. [What is urgent and necessary to inform policies to deal with the covid-19 pandemic in Brazil?]. *Revista Brasileira De Epidemiologia = Brazilian Journal of Epidemiology* [Internet]. 2020;23:e200032. Disponível em: <https://doi.org/10.1590/1980-549720200032>
2. Drummond G, Da Silva M, Andrade De Souza A, Silva M, De Castro M, Debôrtoli De Miranda W, et al. Influence of socioeconomic inequality on the distribution of covid-19 hospitalizations and deaths in Brazilian municipalities, 2020: an ecological study. *Epidemiologia e Serviços de Saúde* [Internet]. [citado 2023 Abr 12];32(1):2023. Disponível em: <https://doi.org/10.1590/S2237-96222023000100021>
3. Entenda as diferenças entre RT-PCR, antígeno e autoteste [Internet]. Ministério da Saúde. Disponível em: <https://www.gov.br/saude/pt-br/assuntos/noticias/2022/fevereiro/entenda-as-diferencas-entre-rt-pcr-antigeno-e-autoteste>
4. World Health Organization. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) [Internet]. www.who.int. 2020. Disponível em: [https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov))
5. World Health Organisation. WHO Director-General's Opening Remarks at the Media Briefing on covid-19 - 11 March 2020 [Internet]. World Health Organization. 2020. Disponível em: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>
6. World Health Organization. Novel Coronavirus (2019-nCoV) situation reports [Internet]. www.who.int. 2020. Disponível em: <https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200202-sitrep-13-ncov-v3.pdf>
7. Magno L, Rossi TA, Mendonça-Lima FW de, Santos CC dos, Campos GB, Marques LM, et al. Desafios e propostas para ampliação da testagem e diagnóstico para covid-19 no Brasil. *Ciência*

- & Saúde Coletiva [Internet]. 2020 Aug 28 [citado 2021 Mai 9];25:3355–64. Disponível em: <https://doi.org/10.1590/1413-81232020259.178120208>. Worldometer. Coronavirus Toll update: Cases & Deaths by Country [Internet]. Worldometer. 2024. Disponível em: <https://www.worldometers.info/coronavirus/>
9. Sávio P, De Goés A. Prevalência e incidência da covid-19 nas macrorregiões de saúde do estado de Pernambuco [citado 2024 Jul 31]. Disponível em: <https://www.lai.pe.gov.br/wp-content/uploads/sites/29/2020/06/PROJ-APQ-0135-20.pdf>
 10. Secretaria Estadual de Saúde de Pernambuco | Secretaria Estadual de Saúde de Pernambuco [Internet]. portal.saude.pe.gov.br. Disponível em: <https://portal-antigo.saude.pe.gov.br/boletim-epidemiologico-covid-19>
 11. Morgenstern H. Ecologic studies in epidemiology: concepts, principles, and methods. *Annu Rev Public Health*. 1995;16:61-81. Disponível em: <https://doi.org/10.1146/annurev.pu.16.050195.000425>
 12. Messner W, Payson SE. Contextual factors and the covid-19 outbreak rate across U.S. counties in its initial phase. *Health Science Reports*. 2021 Feb 2;4(1). Disponível em: <https://doi.org/10.1002/hsr2.242>
 13. Nespolo C, Fernanda Hammes Varela, Sartor S, Márcia Polese-Bonato, Ingrid Rodrigues Fernandes, Gabriela Oliveira Zavaglia, et al. Diagnostic accuracy of a SARS-CoV-2 rapid test and optimal time for seropositivity according to the onset of symptoms. *Cadernos de Saúde Pública*. 2022 Jan 1;38(1). Disponível em: <https://doi.org/10.1590/0102-311x00069921>
 14. Demenech LM, Dumith S de C, Vieira MECD, Neiva-Silva L. Desigualdade econômica e risco de infecção e morte por covid-19 no Brasil. *Revista Brasileira de Epidemiologia* [Internet]. 2020 [citado 2020 Nov 20];23. Disponível em: <https://doi.org/10.1590/1980-549720200095>
 15. Baillet M, Wathelet M, Lamer A, Frévent C, Fovet T, D'Hondt F, Notredame C, Vaiva G, Génin M. Association Between covid-19 and Self-Harm: Nationwide Retrospective Ecological Spatiotemporal Study in Metropolitan France. *JMIR Public Health Surveill*. 2024;10:e52759. Disponível em: <https://doi.org/10.2196/52759>