Spatial analysis of the number of Covid-19 mortality cases: A regional and economic view in the intermediate geographic region of Cascavel-Paraná[1]

Elizabeth Giron Cima
Western Paraná State University (UNIOESTE), Cascavel-Paraná, Brazil
https://orcid.org/ 0000-0003-3539-4305

Miguel Angel Uribe-Opazo
Western Paraná State University (UNIOESTE), Cascavel-Paraná, Brazil
https://orcid.org/ 0000-0001-8937-4815

Marcos Roberto Bombacini
Technological Federal University of Paraná (UTFPR), Toledo-Paraná, Brazil
https://orcid.org/ 0000-0002-1612-2059

Weimar Freire da Rocha-Junior
Western Paraná State University (UNIOESTE), Toledo-Paraná, Brazil
https://orcid.org/ 0000-0002-3108-6690

Gustavo Henrique Dalposso
Technological Federal University of Paraná (UTFPR), Toledo-Paraná, Brazil
https://orcid.org/ 0000-0003-2097-5748

Abstract
The objective of this article was to present an analysis of spatial correlation of the occurrence of Covid-19 mortality related to socioeconomic variables: Gini Income Concentration Indicator, Municipal Human Development Indicator and the number of formal jobs in the Intermediate Geographical Region of Cascavel-Paraná-Brazil, during the period from January 2020 to December 2021. The data come from the Paraná Health System and the Paranaense Institute for Economic and Social Development. The methodology was based on the analysis of the spatial association, in which the Lee bivariate global index and the Lee bivariate local index were calculated. As a result it was obtained that there were negative spatial correlations between the number of mortality cases due to Covid-19,that are deaths in absolute numbers per municipality and were reported by the State Health Secretariat of Paraná and the Gini indicator and with the number of formal employment in the 2 years studied. The results showed that the number of deaths caused by Covid-19 presented similar characteristics in the two years studied. This information shows the importance of spatial analysis of area data, and the need for implementation of public

---

[1] Tradução para o inglês por Antonio Marcos G dos Santos.

policies provides the best allocation of resources favoring the minimization of the impacts generated by the epidemic, thus favoring the prevention of future occurrences, in the immediate geographical region of the municipalities of Pato Branco, Francisco Beltrão, Cascavel and Foz do Iguaçu. This result directly reflects the impacts of the economic system of the municipalities that make up the intermediate geographic region of Cascavel-Paraná.

Keywords: Control actions. Social inequality. Income. Lee local bivariate index.

Análise espacial do número de casos de mortalidade da Covid-19: Uma visão regional e econômica na região geográfica intermediária de Cascavel-Paraná

Resumo

Este artigo teve por objetivo apresentar uma análise de correlação espacial da contagem de ocorrência de mortalidade por Covid-19 relacionada as variáveis socioeconômicas: indicador de concentração da renda de Gini, indicador de Desenvolvimento Humano Municipal e o número de empregos formais, na Região Geográfica Intermediária de Cascavel-Paraná-Brasil, durante o período de janeiro de 2020 a dezembro de 2021. Os dados são provenientes do Sistema de Saúde do Paraná e do Instituto Paranaense de Desenvolvimento Econômico e Social. A metodologia foi pautada na análise da associação espacial, em que foi calculado o índice global bivariado de Lee e o índice local bivariado de Lee. Como resultado obteve-se que houve correlações espaciais negativas entre o número de casos de mortalidade por Covid-19, que são óbitos em números absolutos por município e foram relatados pela Secretaria da Saúde do estado do Paraná e o indicador de Gini e com o número de emprego formal nos 2 anos estudados. Os resultados mostraram que o número de óbitos causados pela Covid-19 apresentou características similares nos dois anos estudados. Essa informação mostra a importância da análise espacial de dados de áreas, sendo que a necessidade de implementação de políticas públicas oportuniza a melhor alocação de recursos favorecendo a minimização dos impactos gerados pela epidemia, favorecendo dessa forma a prevenção de futuras ocorrências, na região geográfica imediata dos municípios de Pato Branco, Francisco Beltrão, Cascavel e Foz do Iguaçu. Esse resultado reflete diretamente nos impactos do sistema econômico dos municípios que compõem a região geográfica intermediária de Cascavel-Paraná.

Palavras-chave: Ações de controle. Desigualdade social. Renda. Índice bivariado local de Lee.

Análisis espacial del número de casos de mortalidad por Covid-19: un análisis regional y económico en la Región Geográfica Intermedia de Cascavel-Paraná

Resumen

Este artículo presenta un análisis de correlación espacial del conteo del número de ocurrencia de mortalidad por Covid-19 relacionado con variables socioeconómicas indicador de concentración de renta de Gini, el indicador de Desarrollo Humano Municipal y el número de empleos formales, en la Región Geográfica Intermedia de Cascavel-Paraná-Brasil, durante el período de enero de 2020 a diciembre de 2021. Los datos provienen del Sistema de Salud de Paraná y del Instituto de Desarrollo Económico y Social de Paraná. La metodología se basó en el análisis de asociación espacial, en el que se calculó el índice bivariado global de Lee y el índice bivariado local de Lee. Como resultado, se encontró que existieron correlaciones espaciales negativas entre el número de casos de mortalidad por Covid-19, que son muertes en números absolutos por municipio y fueron reportados por el Departamento de Salud del estado de Paraná con el indicador de Gini y con el número de empleos formales en los años estudiados. Los resultados mostraron que el número de muertes causadas por el Covid-19 tuvieron características similares en los dos años estudiados, en la región geográfica inmediato de Pato Branco, Francisco Beltrão, Cascavel y

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

Foz do Iguaçu. Este escenario se refleja directamente en los impactos del sistema económico de los municipios que conforman la región geográfica intermedia de Cascavel-Paraná.

Palabras clave: Acciones de control. Ingreso de individuos. Desigualdad social. Índice bivariado local de Lee.

1 Introduction

The article aims to analyze the spatial correlation of the Covid-19 mortality occurrence count related to socioeconomic variables such as the Gini Indicator (G), Municipal Human Development Indicator (*MHDI)*and the number of formal jobs (NEF), to verify if there is a spatial association among these variables in the Intermediate Geographical Region of Cascavel-Paran from January 2020 to December 2021.

This region according to IBGE (2022) has more than 2 million inhabitants having an intense flow of people and goods because it is a great producer of grains and animal protein, which are exported to the international market via Paranaguá Port. In 2022 Paraná exported approximately 9.7 billion in chicken to 145 countries and 2.5 billion in pigs to 88 countries (Brazilian Association of Animal Protein – ABPA, 2023). According to the National Supply Company (CONAB) (2023), in the 2022/23 harvest the state produced 12.2 million tons of soybeans and 13.4 million tons of maize. With this volume of grains, agro-industrial activities concentrate a contingent of people and organizations, which favor the free movement and mobility of people from various parts of Brazil and the world. According to Cima et al. (2021), all this dynamic fosters economic growth and development, but generates challenges of great magnitude, such as pollution and human and animal health problems, in which diseases such as COVID-19 affected the region.

The first cases of COVID-19 death in Paraná occurred in mid-March 2020, which were linked to international trips by the Paraná state dwellers who returned from abroad (SIQUEIRA-Jr et al., 2021).

In this sense, Silva et al. (2024) report that it is necessary to understand the spatial profile of the spread of COVID-19 for the understanding of areas more prone to contagion risks.

The guidelines adopted to address the pandemic aimed at prioritizing the economic aspect of the regions and the well-being of the general population taking into account factors such as social vulnerability (ARAÚJO et al., 2023).

In this context Silva et al. (2023) believe that the decision-making of public and private managers made in their organizational structures were insufficient and the health effects caused by the pandemic were immense and unequal, so it is important to adopt strategies and mitigate the deleterious effects in the regional context.

Costa et al. (2023) verified that different methodologies were developed to contribute to the reduction of the advance of the spread of the pandemic caused by the SAR-COV-2 virus, called Covid-19 and the minimization of the economic impacts associated with its location.

The proposal of the bivariate spatial association measure of this study is to identify the existence of a global and local spatial relationship between the two

phenomena, such as the joint distribution of a case of viral disease (Covid-19), considered as a variable of interest associated with socioeconomic variables: Indicator of Gini-G income concentration, indicator of population development by municipality-*MHDI* and the number of formal employment-NEF .

These methods adapted to spatial data analysis take into account the locations where possible events can occur and most often present a certain pattern, considering their spatial distribution. It is also sought to identify if there is correlation between the variables in these locations (ANSELIN, 2019; 2020).

There are many situations in which a relationship of spatial proximity between the events of two phenomena can be reasons of suspicion of an eminent risk factor, in this sense it is necessary to demonstrate a correlation between two variables in pairs of individuals with a spatial relationship between them. These spatial relationships among different phenomena occur in this study among economics, planning and health (MATA et al., 2021).

Lee (2001) developed and analyzed a new bivariate spatial association measure, which has been cited by many authors (REN et al. 2021; ARAL, 2023; MARANZANO and PELEGATTI, 2023). In his studies the author realized that a measure of global spatial association and bivariate local should be composed of the following elements: bivariate spatial associations of two variables collected in the same location. The bivariate Lee statistic (L_{xy}) integrates the Pearson linear coefficient(r) and the bivariate Moran indicator (I_{xy}), depending heavily on an initial scalar softener, so informs Anselin (2019). In this context, it is coherent to understand the geographic space profiles in which events and phenomena are inserted so that it can be better understood and analyzed possible behaviors, as well as to strategically verify these events (MELLO et al., 2023).

The article sought to explore a relevant aspect approached by Buller (2020a), which evidenced the need for accurate information to evaluate spatial relations on the propensity of contagion due to possible diseases. The respective investigation and the scenario experienced in the period of the pandemic justified this study.

The organization of this study is structured in four stages: The first stage includes the introduction, in the second stage the materials and methods are presented, then the analysis and discussion of the results are presented and finally the conclusions obtained are presented.

2 Material and Methods

The methodology of the study as to the nature is an applied research; as to the object: descriptive and explanatory, as to the approach: qualitative and quantitative. A literature review on the subject studied was initially carried out from articles published in national and international journals that allowed to guide the purposes and objectives that grounded a critical reflection on the subject under analysis.

In this study, the focus was to analyze the spatial correlation of the Covid-19 mortality occurrence count related to socioeconomic variables such as the Gini Indicator, Municipal Human Development Indicator (*MHDI*)and the number of formal jobs, to verify if there is a spatial association among these variables in the Intermediate Geographical Region of Cascavel-Paraná. From this information, the

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

study was carried out. Statistical methods were used through Lee bivariate global spatial correlation analysis and Lee bivariate local spatial correlation analysis.

They are part of the Intermediate Geographic Region of Cascavel - Paraná 100 municipalities are part of the Intermediate Geographical Region of Cascavel, classified in 8 spatial locations, namely: Cascavel, Foz do Iguaçu, Toledo, Francisco Beltrão, Pato Branco, Laranjeira do Sul, Dois Vizinhos and Marechal Cândido do Rondon. The total residents of this area are approximately 2,036,267inhabitants, ordered in a total area of 44 711.218 km². The municipality of has the largest population, approximately 324,476inhabitants , (IBGE, 2018), (Figure 1).

Figure 1 - Map of intermediate geographic region of Cascavel-Paraná
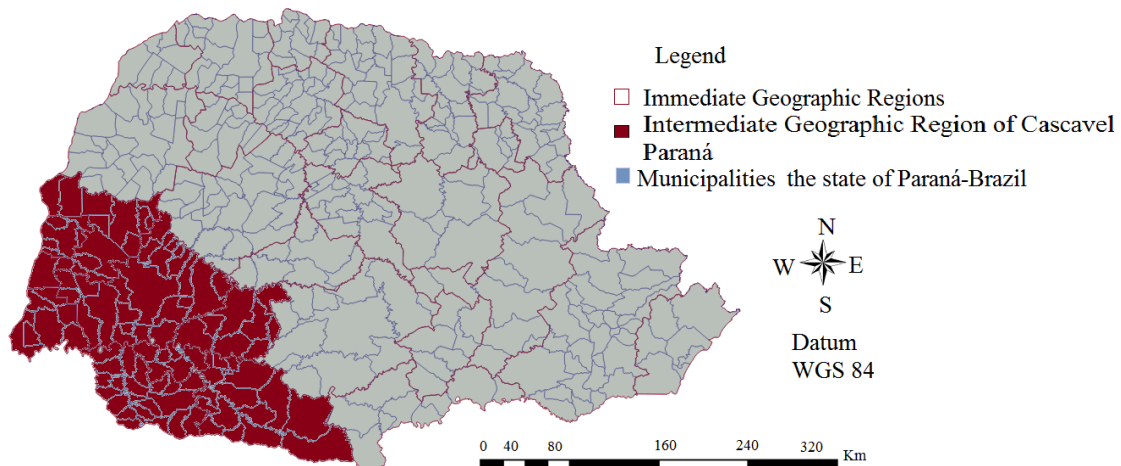
Source: Adapted from IBGE (2018).

All the 100 municipalities were the units of analysis. The choice of the variable of interest: Number of Covid-19 mortality cases, also known as the new coronavirus (SESA, 2021) and socioeconomic variables were due to the fact that they are highly informative variables to explain the spatial profile of the spread of occurrences of mortality due to Covid-19, with the possible spatial association of the indicators presented, because the profiles of these economic indicators represent significant relevance for the understanding of the number of mortality cases during the period from January 2020 to December 2021 (IPARDES, 2023).

As a measure of the degree of income concentration in a given group of individuals, the indicator developed by Gini(G) was used, which shows the inequality between the purchasing power of the poorest people and the retribution of people with higher purchasing power, obtained from Ipardes (2023), and the calculation is obtained according to equation 1:

$$G = \frac{\sum_{i=1}^{n}\sum_{i=1}^{n}|x_i - x_j|}{2n^2 \bar{x}},$$ (1)

where,
x_i : income of the$i$municipality x_j: ; income of the $j$municipality ;
n: total number of municipalities;

$\bar{x}$: mean total income divided by the number of regions in the studied area.

Because it is considered a metric of difference in revenue distribution that varies between 0 and 1, and 0 corresponds to full income equality, the Gini indicator that is an estimate of the year 2010 is used in the present day, it shows that all people have the same income and 1 indicates the complete difference in which only a part of the population holds all revenue, that is, the higher the index, the more unequal that locality in terms of income (Thomas et al., 2001).

The indicator of population development by municipality -*MHDI* is a metric developed to measure the social condition of the countries population, is measured from three dimensions: access to culture and education, standard of living and adequate income. The indexes used to measure this dimension are: literacy rate, expectation of live births and mean remuneration of residents. Equation 2 shows the *MHDI formula* that was adapted from the United Nations Development program UNDP, 2023).

$$IDHM = \frac{IDHM_S + IDHM_E + IDHM_R}{3}, \qquad (2)$$

where,
$IDHM_S$: healthy life index;
$IDHM_E$: index of access to education and culture;
$IDHM_R$: adequate income index.

The MHDI, according to Ipardes (2023) varies from 0, indicating total lack of access to culture, education and infrastructure to 1, which informs the full presence of population progress.

Ipardes understands that *the MHDI* is a presupposition of each municipality in the year 2010, which is currently used, which admits to verify the population progress of the same country, as a way to leverage public policy initiatives for the development of less-favored locations.

The variable number of formal employment (*NEF*) *was used* because it was relevant in the study. The number of formal employment favors the economic understanding associated with the conditions of work imposed by the pandemic process that reached the employment framework in considerable scope. Data on the number of formal jobs by municipalities were obtained from Ipardes (2023).

The idea of the analysis of the number of mortality cases of the new coronavirus, studied here, is of interest to understand the distribution of spatial data in the Intermediate Geographic Region of Cascavel-Paraná, which is composed of 100 municipalities.

In order to analyze the spatial correlation among the indicators, Lee bivariate global index(L_{xy}) was calculated according to Lee (2001), who proposed a parametric bivariate spatial association metric to verify bivariate spatial dependence. The index assumes the values from -1 to 1, the closer to 1 the more efficient the positive spatial association among the variables (LEE, 2001; 2009). The Lee bivariate global index (L_{xy}) is presented in equation 3:

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

$$L_{xy} = \frac{n}{\sum_{i=1}^{n}(\sum_{j=1}^{n} w_{ij})^2} \frac{\sum_{i=1}^{n}[(\sum_{j=1}^{n} w_{ij}(x_i-\bar{x}))(\sum_{j=1}^{n} w_{ij}(y_j-\bar{y}))]}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2} \sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}}, \quad (3)$$

where,

n : number of space units;

x_i and y_i : are the values of the X and Y attributes observed in the municipality A_i ($i = 1, \ldots, n$);

w_{ij}: is a measure of spatial proximity between municipalities A_i and A_j ($i, j = 1, \ldots, n$) calculated by the *Queen* contiguity criterion (ANSELIN ,1995);

$\bar{x}, \bar{y}$: are the mean values of the X and Y attributes considering all the geographic units.

The Lee bivariate local index (L_i) was also calculated according to Lee (2001) and Buller (2020b) is presented in Equation 4:

$$L_i = \frac{n(\bar{x}_i-\bar{x})(\bar{y}_i-\bar{y})}{\sqrt{\sum_{j=1}^{n}(x_j-\bar{x})^2} \sqrt{\sum_{j=1}^{n}(y_j-\bar{y})^2}}, \quad (4)$$

where,

x_k: k-th element of variable X k , = $1, \ldots, n$;

y_k: k-th element of variable Y k , = $1, \ldots, n$;

Lee bivariate local index (L_i)of spatial association indicates the relative contribution that an individual area presents and seeks to identify the associations of observations with its neighbors in terms of the point-to-point association between the two variables under study (LEE, 2001; 2009). The data conversion was performed so that the assumption of normality was satisfied, according to Box and Cox (1964), as seen in Equation 5:

$$V_i = \begin{cases} \ln(U_i), & se\ \lambda = 0, \\ \frac{U_i^{\lambda}-1}{\lambda}, & se\ \lambda \neq 0, \end{cases} \quad (5)$$

where,

λ: is the criterion that defines the conversion of values;

U_i: corresponds to the original values, i = 1,...,n;

V_i: corresponds to the transformed values, i = 1,...,n;

Data on the number of deaths from Covid-19 were obtained from SESA (2021) and socioeconomic indicators were obtained from Ipardes (2023). It was used interactively the free program R version 4.5.0 (R DEVELOPMENT CORE TEAM, 2023) and QGIS software version 3.10(QGIS.ORG, 2023) .

3 Results and Discussion

In this article, concepts, definitions and the importance of socioeconomic variables associated with the number of death cases due to Covid-19 were worked,

aspects that are relevant to the understanding of spatial distribution and for the forms of spread of the epidemic in the intermediate geographic region of Cascavel-Paraná.

The structuring of this section dealt with the results obtained through statistical methods, which were applied in the studied data and their relationships with the revised literature.

Thus, Table 1 shows that there was a negative and significant Lee bivariate spatial association L_{xy}) (between the number of death cases due to Covid-19 with the Gini indicator; and among the number of death cases due to Covid-19 with the number of formal jobs (NEF) in 2020.

Table 1. Lee Bivariate Global Spatial Correlation(L_{xy}) of the number of death cases due to Covid -19 with the Gini-G income concentration indicator, with the Municipal Human Development Indicator -*MHDI and* the number of formal employment -NEF , during the period from January to December 2020 of the municipalities that belong to the Intermediate Geographical Region of Cascavel- Paraná-Brazil

Variables	Lee bivariate index value (L_{xy})	p-value
Mortality index due to covid-19 and Gini Index(G)	-0.062	0.001*
Mortality index due to covid-19 and *MHDI*	-0.054	0.090*NS*
Death index due to covid-19 and number of formal employment-*NEF*	-0.233	0.012*

*: Statistically significant at the level of 5% probability; NS : not significant.
Source: Elaborated by the Authors 2023.

The findings showed that the municipalities belonging to the Intermediate Geographical Region of Cascavel in Paraná showed a high number of cases of mortality due to Covid-19, which are surrounded by neighbors with both low indicator of Gini income concentration, and surrounded by neighbors with low numbers of formal jobs. At the same time, it was observed that the presence of regions with lower mortality rate due to Covid-19 are surrounded by neighbors who have a high indicator of Gini income concentration (G) and a high number of formal employment (NEF).

In the same logic, it was observed the presence of a negative and significant spatial correlation between the number of mortality cases of the new coronavirus and the Gini indicator, indicating an inverse relationship between social inequality and the number of mortality cases of the new coronavirus in different regions. This means that areas with greater social inequality tend to have more cases of Covid-19 mortality. Thus, a population with higher purchasing power will have greater chances of access to preventive and control agents, such as access to alcohol gel, face protection masks, among others. This negative correlation may be counterintuitive, but may reflect several factors, such as the quality of the health

system, effective public policies in more unequal regions, or other socioeconomic variables that may influence the spread and mortality of the virus. It is essential to deepen the analysis to understand the underlying causes of this relationship and consider other social and economic indicators that may be interconnected.

This scenario indirectly allowed an influence of this correlation among the municipalities associated with their immediate geographic region, according to the studies of Sesa (2021).

However, the number of cases of mortality due to covid-19 and *MHDI* did not present significant spatial correlation in the analyzed period (Table 1), and this fact may be associated with the process of growth and economic development of each municipality, which does not occur equally (less spatial expression) and as a direct consequence of this behavior, the social condition of the population as: access to basic infrastructure of survival, education, basic sanitation and aspects related to well-being are affected.

The result found indicated the presence of a negative and significant spatial correlation between the number of covid-19 mortality cases associated with the number of *formal employment-NEF* (Table 1). This behavior suggests that the number of people employed in the pandemic in 2020 was affected due to the fact that the precautionary measures led to fewer hiring numbers, i.e. fewer people active in the labor market, in the analyzed period. Many companies have significantly reduced their functional staff to minimize the number of people circulating in the same environments and avoid the levels of contention of the new coronavirus and reduction of costs with employees, since sales have plummeted, which corroborates Oit (2022).

Still in this analysis view, the significant negative spatial correlation indicates a high count of the occurrence of Covid-19 mortality related to the drop in the number of formal occupation and low number of mortality cases associated with the high number of formal employment. These effects have impacted local, regional economies that have somehow been directly affected as it is the case of the fall in the formal employment level of their population.

Hecksher (2021), reports that local, regional and national economies have been widely affected by Covid-19 mortality and the slowdown related to people employed in the labor market.

Figure 2 shows the analysis of the spatial distribution of the death count from Covid-19 in the intermediate geographic region of Cascavel-Paraná, during the period from January to December 2020, and it was observed that the number of mortality cases between 143 and 286 cases predominated in the municipalities of Palmas, Pato Branco, Francisco Beltrão, Foz do Iguaçu and its closest neighbors, Cascavel and much of the intermediate region of Toledo (Figure 2).

Figure 2 - Spatial ordering of the number of occurrences of mortality due to Covid-19 of the municipalities that make up the Intermediate Geographical Region of Cascavel-Paraná during the period from January to December 2020
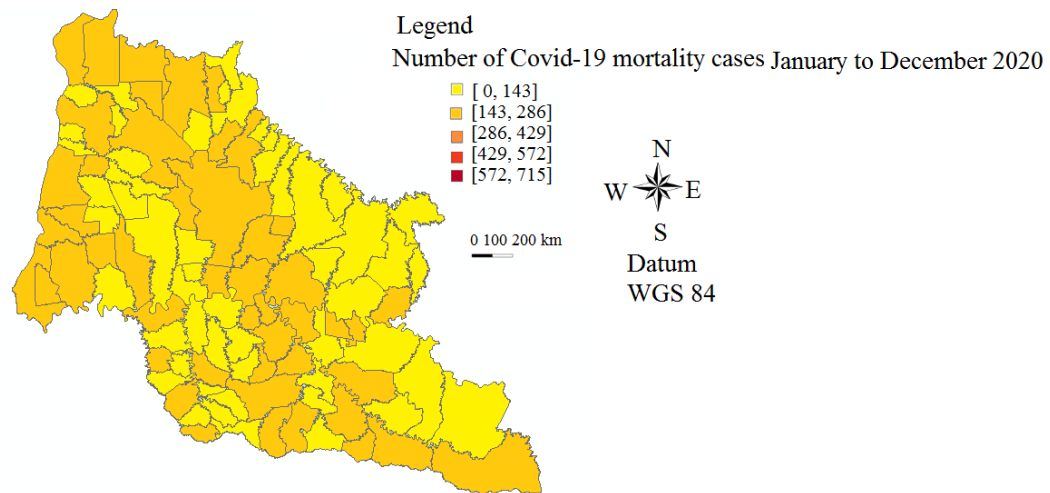
Source: Elaborated by the Authors (2023).

In the spatial analysis of the number of mortality cases due to Covid-19 and the Gini indicator in 2020, a local spatial association was found among the municipalities. This was confirmed by Lee Bivariate Local Index (L_i) , which indicated a positive and significant bivariate local spatial correlation, with a significance level of 5%, with higher values, between [0.406 to 0.672] which corresponds approximately to 17% of the municipalities. The presence of significant clusters was observed in the municipalities near Palotina, Jesuítas, Marechal Cândido Rondon and Laranjeira do Sul (Figure 3A). The result suggests that these regions presented similar characteristics, considering the spatial association of the number of death cases due to covid-19 associated with the Gini indicator.

Figure 3 – Map of the Lee bivariate local index L_i) (of the number of mortality cases due to Covid-19 with Gini indicator (A) and case number of mortality due to Covid-19 with the number of formal employment (B),of the municipalities that make up the Intermediate Geographical Region of Cascavel-Paraná during the period from January to December 2020
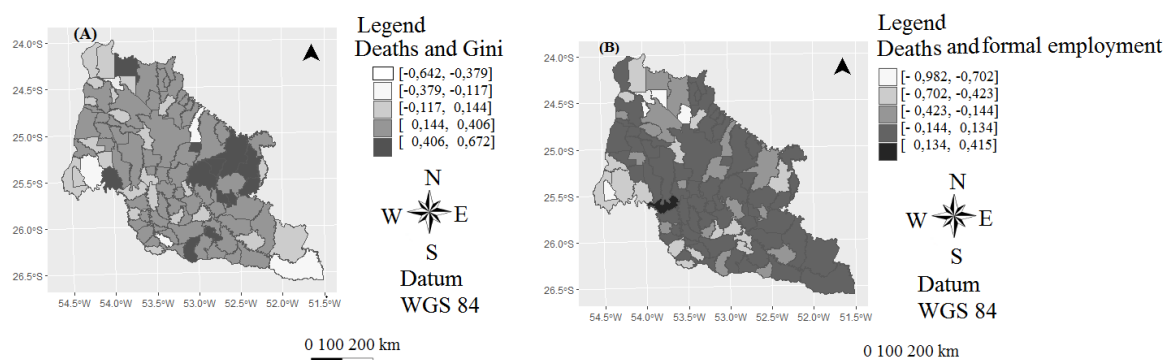
Source: Elaborated by the Authors (2023).

On the other hand, a negative and significant spatial correlation was observed, with a 5% level of significance in 4% of the municipalities between the values of [-0.642 to -0.379] of the number of cases of mortality due to covid-19 associated with the Gini indicator (Figure 3A).

Also regarding the spatial association between the number of cases of mortality due to covid-19 with the Gini indicator, it was observed municipalities that presented values of the Lee bivariate local index $-L_i$ in the correlation interval between - 0.117 and 0.144, in 2% of the municipalities presented a non-significant correlation, 26% of the municipalities had a significant negative correlation and 28% of the municipalities had a positive and significant correlation with a 5% level of significance between the number of cases of mortality due to Covid-19 and the Gini-G income concentration indicator .

In this sense, considering the total of the municipalities analyzed, it was observed that there was a non-significant correlation in 2%of the municipalities, 54% of the municipalities had a significant negative correlation and 44% of the municipalities had a positive and significant correlation with a level of 5% of significance (Figure 3A).

The result suggests that the inequality between the income of the rich and poor classes associated with a given location can drive the increase in mortality due to Covid-19, this condition when accompanied by the lack of access in prevention control measures such as access to mask and alcohol gel can contribute in representative proportions in the advances of contamination, similar results were found in Demenech et al. (2020).

Regarding the spatial distribution of the variables, number of cases of mortality due to Covid-19 with the number of formal jobs, it was observed in (Figure 3B) that 3% of the municipalities had a non-significant correlation, 68% of the municipalities had a significant negative correlation and 29% of the municipalities had a positive and significant correlation with a 5% level of significance among the variables Number of mortality cases due to Covid-19 and number of formal employment.

The result suggests the presence of municipalities with a high number of mortality cases surrounded by municipalities with low number of people employed, and regions with low mortality rates surrounded by regions with high numbers of people employed and municipalities with low number of cases of mortality due to Covid-19 surrounded by municipalities with low number of people employed as well as municipalities with high number of mortality cases surrounded by municipalities with a high number of formal employment was also observed the presence of municipalities, with a non-significant correlation, which corroborates Alberti et al. (2021).

Table 2 shows that the results are similar to the year 2020, since there are regions with low number of cases of mortality due to Covid-19, which are related to the presence of the disease, with a tendency to be surrounded by regions with a high indicator of Gini income concentration and with a high number of formal employment, whereas regions with a high number of covid-19 mortality cases are neighboring regions with low Gini income concentration indicator and low number of formal jobs. Similar to 2020, the number of covid-19 mortality cases with *MHDI* showed a non-significant result.

This result is justified, according to Buller (2020a) and Buller (2020b) who inform that the bivariate local measure between two variables that involve a spatial distribution allows the researcher to investigate the presence of spatial heterogeneity, and this search can show the local instability in the relationships between two variables.

Table 2. Lee Bivariate Global Spatial Correlation(L_{xy}) of the number of death cases due to Covid -19 with the Gini-G income concentration indicator, with the Municipal Human Development Indicator -*MHDI and* the number of formal employment -NEF , during the period from January to December 2021 of the municipalities that belong to the Intermediate Geographical Region of Cascavel- Paraná-Brazil

Variables	Lee bivariate index value (L_{xy})	p-value
Mortality index due to covid-19 *and Gini Index*	-0.008	0,050*
Mortality index due to covid-19 *and* MHDI	-0,005	0.060NS
Death index due to covid-19 and number of formal employment-*NEF*	-0.185	0,032*

*: Statistically significant at the level of 5% probability; NS : not significant.
Source: Elaborated by the Authors (2023)

Moreover, the findings are justified by the fact that the presence of association between the elements investigated in the studied region SESA (2021) is included, suggesting that the heterogeneity of the municipalities can be derived from several factors, such as the temporality of the onset of the contagion of the new coronavirus, infrastructure, and the development of the new coronavirus. economic and social condition and emergency adoption of security protocols such as social distancing applied to the population of municipalities that comprise the intermediate geographic region of Cascavel-Paraná, similar results were found in Ramos et al. (2020).

Recent research shows that as the impacts of the pandemic have become world-wide the economy of countries in a way have been proven, the employment sector has been significantly achieved in this scenario (OIT,2021).

The findings suggest that the social and economic impacts recorded by the pandemic scenario were very evident in the intermediate geographic region of Cascavel-Paraná-Brazil, in which the population was generally reached considering the different age groups. Similar results were found in the European Union (EU) and the United States (USA) as presented in the studies by Michelozzi et al. (2020), that there was a significant increase in the number of mortality cases, associated with economic factors. They suggest that the younger population presented lower risk of death than the elderly population, with high geographic variability, and that most deaths occurred among people with pre-existing diseases.

Moreover, the result of the present study also showed the presence of a significant negative spatial association between the mortality number of Covid-19

cases with the Gini income concentration indicator, thus suggesting that income concentration inequality has a spatial association with the number of deaths in Covid-19 cases.

Finally, Rocha et al. (2021) report that groups that are in condition of social exposure and that do not have access to basic rights, such as right of sanitation and right, housing are the most affected by the pandemic.

It is observed the spatial distribution of the number of cases per covid-19 during the period from January to December 2021 (Figure 4), the result shows that the highest numbers of cases (572 to 715) were observed in the municipalities of Toledo, Cascavel, Francisco Beltrão, Foz do Iguaçu and Pato Branco, because they are regions with greater population density and because they are more industrialized.

Figure 4 - Geographic ordering of the number of occurrences of mortality due to Covid-19 of the municipalities that make up the Intermediate Geographical Region of Cascavel-Paraná during the period from January to December 2021
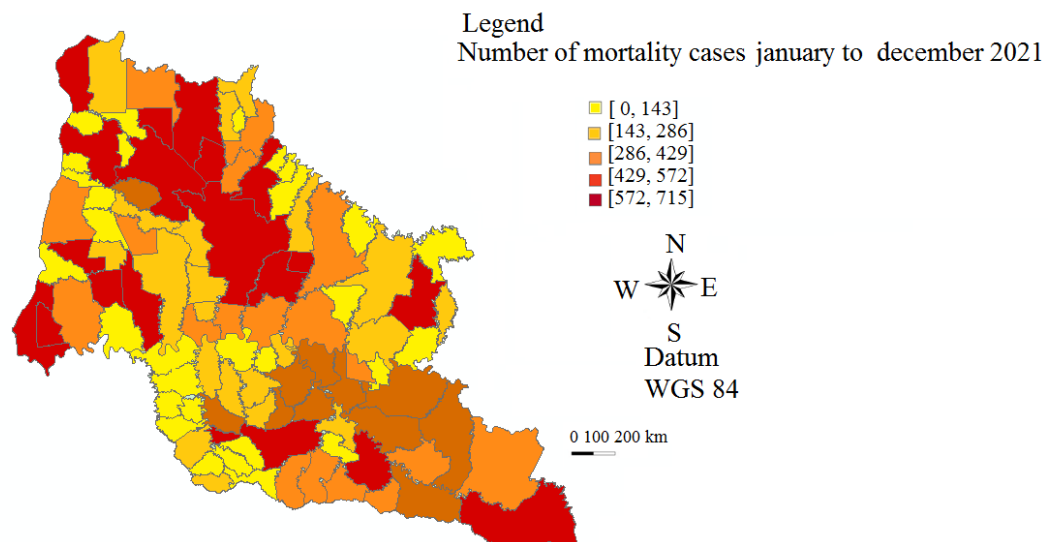
Source: Elaborated by the Authors (2023)

Figure 5 shows the graphical analysis of the maps of spatial grouping of the Lee bivariate local index L_i) (of the municipalities that make up the Intermediate Geographical Region of Cascavel-Paraná of the year 2021.

Figure 5 – Map of the Lee bivariate local index L_i) (of the number of mortality cases with the Gini income concentration indicator (A) and the case number of mortality due to Covid-19 with the number of formal employment (B),of the municipalities that make up the Intermediate Geographical Region of Cascavel-Paraná during the period from January to December 2021
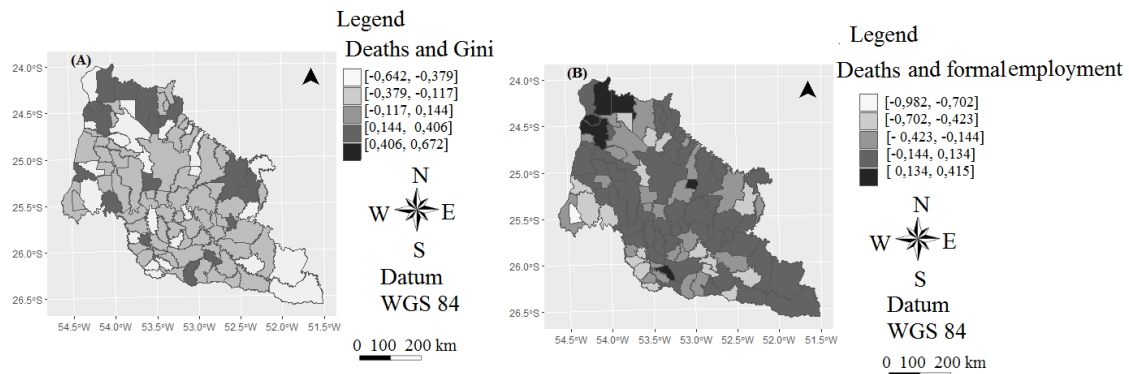
Source: Elaborated by the Authors (2023).

In the Lee bivariate local spatial distribution map for the covid-19 mortality index with the Gini-G income *concentration indicator* (Figure 5A), it presented a positive and significant spatial association, with a level of 5% significance, with values ranging from [0.406 to 0.672] in approximately 15% of the municipalities, indicating that regions with high occurrence of mortality are surrounded by municipalities with high income concentration indicator Gini-G and regions with low mortality rate surrounded by municipalities with low income concentration indicator Gini- G and regions with low mortality index, in the municipalities of the intermediate geographic region of Cascavel-Paraná, namely: Quedas do Iguaçu, Nova Laranjeira, Laranjeira do Sul, Porto Barreiro and Espigão do Alto Iguaçu, followed by Assis Chateaubriand, Tupãssi, Terra Roxa and Palotina.

Moreover, in Figure 5A considering the total of municipalities it was observed that 1% had a non-significant correlation,58% had a significant negative correlation and 41% of the municipalities had a positive and significant correlation with a 5% level of significance between the variables number of mortality cases due to Covid-19 and the Gini-G income concentration indicator .

Thus, these regions presented high and/or low mortality rate due to Covid-19 associated with a high or low concentration of Gini-G income, which corroborates Cima et al. (2022).

Figure 5B shows that 5% of the municipalities presented the Lee local bivariate index -L_i not significant, 66% of the municipalities presented the Lee local index negative and significant and 29% of the municipalities presented the Lee local index positive and significant with a level of 5% significance among the variables: number of mortality cases due to Covid-19 and number of formal employment.

Studies such as that of Buller (2022b) presented the importance of the analysis of bivariate global and local spatial correlation applied in the area of economics and health, as it is the case of Cima et al. (2022). The analysis by means of the spatial association revealed the regions that presented similar attributes in relation to the count of occurrence of mortality due to Covid-19 with the

socioeconomic variables analyzed here, which corroborates Cardoso (2021) and Michelozzi et al. (2020).

To analyze the geographical distribution of a possible viral infection it is important to invest in preventive action and corrective action. It is suggested in this case to consider the political, economic and social aspects. Zhang and Schwartz (2020) evaluated the spatial patterns of the new coronavirus (Covid-19) in the United States (USA) in relation to socioeconomic variables, concluded that the spatial distribution of the spread of the virus was unequal, considering the neighboring metropolitan areas, the result showed significant positive correlations between the number of mortality cases and the socioeconomic factors (population density and population in poverty) analyzed.

The study of Lee global and local geographic association L_{xy} (L_i e , respectively) showed the regions that presented similar spatial patterns among themselves in relation to the number of mortality cases of the new coronavirus with the socioeconomic variables, suggesting the need to adopt public policy measures, humanitarian actions, health protection and adoption of security protocols. Similar results were found in Polastrini et al. (2023).

The findings in the Intermediate Geographical Region of Cascavel-Paraná-Brazil showed that the advances in the death toll due to Covid-19 occurred unevenly in the different municipalities and that question how the infrastructure allied to social inequality can contribute to the advances of contagion followed by the number of death cases due to Covid-19.

Similar results were found in Villa et al. (2022) who evidenced in their studies the impact of social and municipal inequalities identified in the pandemic period by Covid-19 in regions of Mexico.

The study of spatial data analysis is important in order to present diagnoses for society for a better management in decision making, which corroborates Cima et al. (2023).

4 Conclusion

The study of Lee global bivariate and local spatial association allowed us to verify the spatial association between the Covid-19 mortality rate and socioeconomic indexes: indicator of Gini income concentration and number of formal employment of the municipalities that compose the Intermediate Geographical Region of Cascavel-Paraná in the years analyzed. The results pointed to the positive and negative spatial association, respectively, of the analyzed variables, thus, it can be inferred that the municipalities that exhibit high or low number of death cases due to Covid-19 are surrounded by municipalities with a high or low indicator of Gini income concentration and number of formal employment (NEF), respectively.

The results showed that Lee global spatial correlation and local spatial correlation revealed to regions that presented similar attributes of the Covid-19 mortality occurrence count with the socioeconomic variables analyzed here (GINI and NEF).

The results found in the analyzed period (January 2020 to December 2021) suggest that the consequences of the new coronavirus epidemic although it is a

phenomenon of wide scope, its effects did not start simultaneously in the studied regions.

It was noticed the propensity of the mortality trend due to the new coronavirus in the immediate regions of Foz do Iguaçu, Cascavel, Toledo and Francisco Beltrão.

Through the investigation of Lee global bivariate geographic associationL_{xy}) (and Lee local bivariate geographic associationL_i) (that the spatial distribution of the number of death cases due to Covid-19 associated with socioeconomic variables was unequal, considering the areas of the geographic intermediate geographic region of Cascavel in Paraná, the spatial analysis showed significant positive and negative correlations between the number of mortality cases and socioeconomic factors (Gini and NEF income concentration indicator).

The result of the research suggests that a spatial distribution of L_i site may allow researchers to explore a bivariate spatial heterogeneity in the sense that it may reveal local instability in the relationships between two variables.

REFERENCES

ALBERTI, A.; SILVA, B.B.; JESUS, G.A.; ZANONI, E.M.; GRIGOLLO, L.R. Associação do maior número de mortes por COVID-19 e o Índice de Desenvolvimento Humano (IDH) de Cidades Catarinenses. **Revista Multidiciplinar e de Psicologia**, v. 14, n. 54, p. 427-434, 2021. DOI:https://doi.org/ 10.14295/idonline. v15i54.2973

ANSELIN, L. Local Indicators of Spatial Association — LISA. **Geographical Analysis**, 27, 93–115, 1995.

ANSELIN, L. A Local Indicator of Multivariate Spatial Association, Extending Geary's c. **Geographical Analysis**, v. 51, n.2, p. 133–50, 2019. DOI: https://doi.org/10.1111/gean.12164

ANSELIN, L.; XUN, L. Tobler's Law in a Multivariate World. **Geographical Analysis**, v. 52, n. 4, p. 494–510, 2020. DOI: https://doi.org/10.111/gean.12237.

ARAUJO, A. M.; SPANHOL FINOCCHIO, C. P.; BRUN, H. M.; MASCHIO, H. A. Efeitos iniciais da pandemia sobre o agronegócio brasileiro em reportagens nacionais. **Informe GEPEC**, v. 27, n. 1, p. 142–161, 2023. DOI: 10.48075/igepec.v27i1.29443

ARAL, N.; BAKIR, H. Spatial differentiation of covid-19 in turkeytürkiye'de covid-19'un mekânsal farkliliklari, **Dicle University Journal of Economics and Adminstrative Science**, v.13, n.26, p.747-763, 2023. DOI: 10.53092/duiibfd.1243565

ASSOCIAÇÃO BRASILEIRA DE PROTEINA ANIMAL. **Relatório Anual 2023**. Disponível em: https://abpa-br.org/wp-content/uploads/2023/04/Relatorio-Anual-2023.pdf. Acesso em: 05 dez. 2023.

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

BAUMGRATZ, D.; BRATTI, B.R.; TERRE, F.; ALVES, L.R. Análise da correlação espacial da COVID-19 nos municípios brasileiros de fronteira. **Revista Tecnologia e Sociedade**, v.19, n.56, p.226-249, 2023. DOI: 10.3895/rts.v19n56.16367

BULLER, I.D.; BROWN, D.W.; MACHIELA, M.J.; MYERS, T.A. 2020a. SparrpowR: Power Analysis to Detect Spatial Relative Risk Clusters. revised 2021 August. In: Internet. Version v0.2.4. Vienna, Austria: The Comprehensive R Archive Network. Disponível em https://CRAN.R-project.org/package=sparrpowR. DOI: 10.5281/zenodo.5347998. Acessado em 13 de janeiro de 2023.

BULLER, I.D. 2020b. Map of bivariate spatial correlation in R (Lee's L statistic). Disponível em https://gist.github.com/idblr/edf3ee7fb6fca58062da9304076ea4c5. Acessado em 15 de janeiro de 2023.

CARDOSO, B. B. A implementação do Auxílio Emergencial como medida excepcional de proteção social. **Revista de Administração Pública**, v. 54, n. 4, p. 1052-1063, 2020. DOI: https://doi.org/10.1590/0034-761220200267x

CIMA, E. G.; ROCHA JR, W. F.; DALPOSSO, G. H.; URIBE-OPAZO, M. A.; BECKER, W. R. Forecasting Grain Production and Static Capacity of Warehouses Using the Natural Neighbor and Multiquadric Equations. **AGRIS on-line Papers in Economics and Informatics**, v. 13, n. 3, p. 3-14, 2021. DOI: 10.7160/aol.2021.130301

CIMA, E. G.; URIBE-OPAZO, M. A.; BOMBACINI, M. R.; ROCHA JR, W. F.; GUEDES, L. P.C. Spatial analysis: a socioeconomic view on the incidence of the new coronavirus in Parana-Brazil. **Journal Stats MDPI**, v.5, n.1, p. 1029–1043, 2022. DOI: https://doi.org/10.3390/stats5040061

COMPANHIA NACIONAL DE ABASTECIMENTO – CONAB. **12° Levantamento da safra 2022/23**. Disponível: https://www.conab.gov.br/info-agro/safras/graos/boletim-da-safra-de-graosAcesso em: 06 set. 2023.

COSTA, T.F.A. MENDONÇA, V.F. SANTOS, T.G. PÁDUA, K.M. Atualização Diagnóstica para a Covid-19. **Id on Line Revista de Psicologia**, v.17, n.68, p.351-384, 2023.

DEMENECH, L.M.; DUMITH, S. De C.; VIEIRA, M.E.C.D.; SILVA, L. Desigualdade econômica e risco de infecção e morte por Covid-19 no Brasil. **Revista brasileira de epidemiologia**, v.23, p. 1-12, 2020. DOI: https://doi.org/10.1590/1980-549720200095

HECKSHER, M. Mortalidade por Covid-19 e Queda do Emprego no Brasil e no Mundo. Instituto de Pesquisa Econômica Aplicada (IPEA), 2021. 13p.

IBGE. Instituto Brasileiro de Geografia e Estatística. 2022. **Estimativa populacional 2018**. Disponível em https://pt.wikipedia.org/wiki/Regi%C3%A3o_Geogr%C3%A1fica_Intermedi%C3%A1ria_de_Cascavel. Acessado em 10 de novembro de 2022.

IBGE. Instituto Brasileiro de geografia e estatística. Censo Demográfico 2022. Disponível em https://www.ibge.gov.br/estatisticas/sociais/trabalho/22827-censo-demografico-2022.html. Disponível em:06 dez. 2023.

IPARDES. Instituto Paranaense de Desenvolvimento Econômico e Social. 2023. População e grau de urbanização segundo os municípios do Paraná. Disponível em http://www.ipardes.gov.br/anuario_2019/estrutura.html. Acessado em 10 de março de 2023.

LEE, S. Developing a bivariate spatial association measure: an integration of Pearson's r and Moran's I. **Journal of Geographical Systems**, v.3, p. 369-385, 2001. DOI: https://doi.org/10.1007/s101090100064

LEE, S. A Generalized Randomization Approach to Local Measures of Spatial Association. **Geographical Analysis**, v.41, n. 2, p.221-248, 2009. DOI: https://doi.org/10.1111/j.1538-4632.2009.00749.x

MARANZANO, P.; PELEGATTI, M. Spatiotemporal Event Studies for Environmental Data Under Cross-Sectional Dependence: An Application to Air Quality Assessment in Lombardy. **Journal of Agricultural, Biological, and Environmental Statistics**, v.28.n.2,p. 1-22, 2023. DOI: https:// doi.org/ 10.1007/ s13253-023-00564-z

OIT. Organização Internacional do Trabalho. 2021. Impacto da pandemia no emprego é mais forte do que o esperado. Disponível em https://www.ilo.org/brasilia/noticias/WCMS_824987/lang--pt/index.htm. Acessado em 13 dez. 2022.

MATA, G.C.; REGO, S.; SOUTO, E.P.; SEGATA, J. *Os impactos sociais da Covid-19 no Brasil: populações vulnerabilizadas e respostas à pandemia*. Rio de Janeiro: Fiocruz, 2021. 221 p.

MELLO, L. H.C.; DIAS, D. E.D.; BUTTENBENDER, P. L.; ALLEBRANDT, S. L. Gestão estratégica da cadeia de insumos para mitigação da pandemia Covid-19: O caso de Ipatinga/MG. **Informe GEPEC**, v. 27, n. 1, p. 78-99, 2023.

MICHELOZZI, P.; DONATO, F.; SCORTICHINI, M.; SARIO, M.; NOCCIOLI, F.; ROSSI, P.; DAVOLI, M. Mortality impacts of the coronavirus disease (COVID-19) outbreak by sex and age: rapid mortality surveillance system, Italy, 1 February to 18 April 2020. **Euro Surveill. Rapid communication**, v. 25, n.9, 2020. DOI: https://doi.org/10.2807/15607917.ES.2020.25.19.2000620

MINISTÉRIO DO TRABALHO. Portal de Trabalho e Emprego. 2023. Disponível em: http://acesso.mte.gov.br/portal-pdet/o-pdet/registros administrativos/caged/apresentacao.htm. Acesso em 30 jan. 2023.

POLASTRINI, A.; SARAIVA A. F. da S.; SILVA, M. A. da R. Políticas públicas direcionadas às micro e pequenas empresas no Brasil na pandemia da covid-19

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

pandemic. **Informe GEPEC,** v. 27, n. 1, p. 100–122, 2023. DOI: 10.48075/igepec. v27i1.29518

PNUD. Brasil-Programa das Nações Unidas Para o Desenvolvimento. Objetivos do desenvolvimento sustentável. Disponível em https://www.undp.org/pt/angola/objetivos-de-desenvolvimento-sustent%C3%A1vel?utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_P aidSearch_Brand_English&utm_campaign=CENTRAL&c_src=CENTRAL&c_src2=GSR &gclid=CjoKCQjwuO6WBhDLARIsAIdeyDJ3XZLXCRqBOoIfJ2s-IqdEu8UIVNFfkiklA5TqtTcKXKbjwM7n-E0aAhIeEALw_wcB. Acesso em 11 maio 2023.

QGIS. Org. Qgis 3.10. Geographic Information System Installation Guide. QGIS Association, Electronic document. Disponível em https://github.com/qgis/QGIS/blob/master/INSTALL.md. Acesso em 10 jun. 2023.

R DEVELOPMENT CORE TEAM, R. A language and environment for statistical computing, Vienna, Austria: R Foundation for Statistical Computing. ISBN 3-90005107-0. Disponível em http://www.R-project.org. Acesso em 10 maio 2023.

RAMOS, H.; BATISTA, O. J.; ANDRADE, M.M.C.R. **O papel da arquitetura e urbanismo diante do covid-19,** Maceió, 2020. 142p.

REN, CH.; XI, CH.; WIANG,J.; Feng, Z.; NASIRI,F.; CAO,S-J.; HAGHAIGHAT, F. Mitigating COVID-19 Infection Disease Transmission in Indoor Environment Using Physical Barriers. **Sustainable Cities and Society**, v.7, n.9, 103175, 2021. DOI: https://doi.org/10.1016/j.scs.2021.103175

ROCHA, R.; ATUN, R.; MASSUDA, A.; RACHE B.; SPINOLA, P.; NUNES, L.; LAGO, M.; CASTRO, M.C. Effect of socioeconomic inequalities and vulnerabilities on health-system preparedness and response to COVID-19 in Brazil: a comprehensive analysis. **Lancet Glob Health**, v.9, n. 6, p. 782-792, 2021. DOI: https://doi.org/10.1016/ S2214-109X(21)00081-4

SESA. Secretaria de Estado de Saúde do Paraná. 2021. **Boletins epidemiológicos da COVID-19**. Disponível em https://www.saude.pr.gov.br/Pagina/Coronavirus-COVID-19. Acessado em 27 de setembro. 2022.

SIQUEIRA JR, D.; MORAIS, T.C.; PORTUGAL, I.; CAVALCANTE, M. P.E.; DABOIN, B.E.G.; RAIMUNDO, R.D.; JACINTHO, L.C.; ECHEIMBERG, J.O.; ELMUSHARAF, K.; SIQUEIRA, C.E. Tendências da mortalidade e letalidade por COVID-19 no Estado do Paraná, Sul do Brasil: análise espaço-temporal de um ano de Pandemia. **Journal of Human Growth and Development**, v.31, n. 1, p. 549-561, 2021. DOI: 10.36311/jhgd.v31.12792

SILVA, M. A. da R., COSTA e SILVA, M. da V., RODRIGUES, W., CORREIA, I. S., BAZZOLI, J. A. A institucionalização da agenda 2030 em tempos de covid-19: uma

revisão sistemática de literatura. **Redes,** v.*28, n.*1, p.24, 2023. DOI: https://doi.org/10.17058/redes.v28i1.17171

SILVA, A. L. G., DALPOSSO, G.H., URIBE-OPAZO, M.A., CIMA, E.G. Análise da Distribuição Espacial Do Número De Casos De Covid-19 No Município de Toledo-Paraná. **Informe GEPEC,** v.28, n.1, p. 128-143, 2024. DOI: 10.48075/igepec.v28i1.31804

THOMAS, V.; WANG, Y.; FAN, X. **Measuring education inequality** – Gini coefficients of education. The World Bank, 2001. 42p.

VILLA, N.E.A.; CHIRINO, L.F.; ALATORRE, J.P.; GALINDO, J.M.; GARCÍA, A.K.; VÁZQUEZ, A.V.; DÍAZ, A.G.; MARTÍNEZ, F.M.; SALINAS, A.M.; GUERRA, E.C.; LÓPEZ, J.P.B.; Reza, M.V.; SÁNCHEZ, J.M.; MOLINA, M,E,J.; ROBLEDO, L.M.G.; CHAVOLLA, O.Y.B. Comprehensive Evaluation of the Impact of Sociodemographic Inequalities on Adverse Outcomes and Excess Mortality During the Coronavirus DISEASE (COVID-19) Pandemic in Mexico City. **Clinical Infectious Diseases**, v. 74, n. 5, p. 785–792, 2009. DOI: https://doi.org/10.1093/cid/ciab577

ZHANG, C.H.; SCHWARTZ, G.G. Spatial Disparities in Coronavirus Incidence and Mortality in theUnited States: An Ecological Analysis as of May 2020. **The Journal of Rural Health,** v. 36, n. 3, p. 281-456, 2020. DOI: https://doi.org/10.1111/jrh.1247.

CONTRIBUTION OF EACH AUTHOR – All authors contributed in all stages of the article.

Conceptualization: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Data curation: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Formal analysis: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Funding acquisition: Weimar Freire da Rocha-Junior and Miguel Angel Uribe-Opazo
 Investigation: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Methodology: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Project administration: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Resources: Weimar Freire da Rocha-Junior and Miguel Angel Uribe-Opazo
Software: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Supervision: Weimar Freire da Rocha-Junior and Miguel Angel Uribe-Opazo
Validation: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso

Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos Roberto Bombacini, Weimar Freire da Rocha-Junior, Gustavo Henrique Dalposso

Visualization: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso
Writing – original draft: Elizabeth Giron Cima
Writing – review & editing: Elizabeth Giron Cima, Miguel Angel Uribe-Opazo, Marcos R. Bombacini, Weimar Freire da Rocha-Junior and Gustavo Henrique Dalposso