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METRICS, PUBLIC INDICATORS AND DEATHS BY HOMICIDE: AN ANALYSIS OF POSSIBLE RELATIONS IN MUNICIPALITIES IN SOUTHERN MINAS GERAIS BETWEEN 2010 AND 2021

MÉTRICAS, INDICADORES PÚBLICOS E MORTES POR HOMICÍDIO: UMA ANÁLISE SOBRE POSSÍVEIS RELAÇÕES EM MUNICÍPIOS SUL MINEIROS ENTRE 2010 E 2021

MÉTRICAS, INDICADORES PÚBLICOS Y MUERTES POR HOMICIDIO: UN ANÁLISIS DE LAS POSIBLES RELACIONES EN LOS MUNICIPIOS DEL SUR DE MINAS GERAIS ENTRE 2010 Y 2021

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André Silveira Barbosa[1], Gabriel Rodrigo Gomes Pessanha[2]

ABSTRACT

The objective of this research is to analyze possible relationships between metrics or indicators related to social assistance, citizenship, education, infrastructure, GDP per capita, total population, health, and urbanization in municipalities in southern Minas Gerais and their homicide death rates between 2010 and 2021. To this end, a quantitative methodological approach was employed, initially through a bibliometric study of the literature on the subject and subsequently through descriptive statistical analysis and linear regression. One of the results of this study was that homicide death rates decrease when there is an increase in budgetary effort for activities focused on population health, based on the figures presented by the southern Minas Gerais cities selected in this study.

Keywords: Deaths. Homicide. Infrastructure. Urbanization.

RESUMO

O objetivo da presente investigação se direciona a analisar possíveis relações de métricas ou indicadores ligados à assistência social, à cidadania, à educação, à infraestrutura, ao PIB per capita, à população total, à saúde e à urbanização em municípios sul mineiros com a incidência em suas taxas de mortes por homicídio entre os anos de 2010 e 2021. Para tanto, uma perspectiva metodológica de base quantitativa foi empregada, inicialmente por meio de um estudo bibliométrico da literatura sobre a temática e, após, através de análise estatística descritiva e por regressão linear. Como um dos resultados deste trabalho, foi possível verificar que as taxas de mortes por homicídio indicam redução quando ocorre aumento no esforço orçamentário em atividades voltadas à saúde da população, tomando por base os números apresentados pelas cidades sul mineiras selecionadas neste trabalho.

Palavras-chave: Mortes. Homicídio. Infraestrutura. Urbanização.

[1] Master's student in Public Management and Society (PPGPS). Universidade Federal de Alfenas (Unifal). E-mail: andrebcadpm@yahoo.com.br Lattes: http://lattes.cnpq.br/7696761542990326
[2] Dr. in Business Administration. Universidade Federal de Lavras (UFLA). Universidade Federal de Alfenas (Unifal). E-mail: gabrielrgp@yahoo.com.br Lattes: http://lattes.cnpq.br/8249746486373025

RESUMEN
El objetivo de esta investigación es analizar las posibles relaciones entre métricas o indicadores relacionados con la asistencia social, la ciudadanía, la educación, la infraestructura, el PIB per cápita, la población total, la salud y la urbanización en municipios del sur de Minas Gerais y sus tasas de mortalidad por homicidio entre 2010 y 2021. Para ello, se empleó un enfoque metodológico cuantitativo, inicialmente mediante un estudio bibliométrico de la literatura sobre el tema y, posteriormente, mediante análisis estadístico descriptivo y regresión lineal. Uno de los resultados de este estudio fue que las tasas de mortalidad por homicidio disminuyen cuando aumenta el presupuesto destinado a actividades enfocadas en la salud de la población, según las cifras presentadas por las ciudades del sur de Minas Gerais seleccionadas en este estudio.

Palabras clave: Muertes. Homicidio. Infraestructura. Urbanización.

1 INTRODUCTION

Public security in Brazil is a current and relevant issue, especially because it is described in the text of the Magna Carta, which provides for its implementation as a duty of the State, in addition to being a right and responsibility of all (Brasil, 2015). There is a perspective that public initiatives in this segment will have a more reactive character, with generic approaches, according to Zanetic *et al*. (2016). Other strands, on the other hand, discuss the possibility of solutions that can impact the reduction of the incidence of various crimes, viewing such demands as social phenomena, which expands the analysis, such as the one that establishes interventions in urban infrastructure (Souza, 2006).

In this context, crime emerges as a diffuse institute, present in different regions of the world, in Brazil and in its federated units, such as Minas Gerais, in addition to the cities that are located in its territory, for example, in the south of the state, including the municipalities of Boa Esperança, Campo Belo, Lavras, Oliveira, Três Corações, Três Pontas and Varginha. located in the 6th Integrated Region of Public Security (6th RISP) and with an estimated population of more than 50000 (fifty thousand) inhabitants (IBGE, 2025; SEJUSP, 2025).

In this context, it is emphasized that the Brazilian legal system establishes a vast collection of conducts to be repressed by criminal legislation, so the investigation in question proposes to delimit deaths caused by homicide (Brasil, 1940). A small number of studies published in the territory of Minas Gerais, with more careful quantitative analyses, on possible relationships between the crime in question and investments or budgetary efforts in social and infrastructure policies, discuss the contribution of such fronts of action to the reduction of levels of violence (Peres *et al*. 2011; Souza, 2006).

In addition, increases or decreases in homicide death rates (MHR) may also be influenced by socioeconomic variables, such as GDP per capita or urbanization rate (Ervilha and Lima, 2019; Lucas *et al*., 2020). Based on the assumptions indicated so far by the approach exposed in the introduction, the following research question is proposed: to what extent did the indicators linked to budgetary efforts in social assistance, citizenship, education, infrastructure, health, and urbanization, as well as to the metrics linked to GDP per capita and the total population, influence the incidence of homicide deaths in southern Minas Gerais cities between 2010 and 2021?

In this sense, the objective of the present investigation is to analyze possible relationships between the metrics and indicators researched on the municipalities of southern Minas Gerais with the incidence of their homicide death rates between the years 2010 and

2021. The general hypothesis considers that the metrics and indicators researched influenced the incidence of homicide death rates in the selected municipalities in the south of Minas Gerais in the period from 2010 to 2021. The theme is important to be studied and explored, because, among some fronts, there is the possibility of subsidizing analyses capable of guiding the proposition of diffuse public policies, with a multidisciplinary character, which can avoid the resurgence of crime in the highlighted municipalities.

It is relevant to emphasize that a metric corresponds to a set of measurable data; the indicator, on the other hand, is presented as a measure of performance, obtained through a range of measurable results (Mandelli and Lemos, 2020).

The theoretical framework with the selected theory continues in the next section, followed by the methodology with the path outlined by methods and procedures in conducting the work. The analysis and discussion of the results follows and, after the final considerations and references, complement the study.

2 THEORETICAL FRAMEWORK

Some studies suggest that crime is more prevalent in societies with greater disparities in social standards related to the material order, which generates differentiation among its citizens and, consequently, in the opportunities for criminal acts to occur with violation of rights (Kawachi *et al.*, 1999; Gove *et al.*, 1985). In countries where citizenship is protected from the vicissitudes of market forces, there is an immunity to deaths by homicide, which may derive from economic inequality (Savolainen, 2000).

The resources provided by public policies to people through social protection, which help to promote citizenship, should be seen as rights for those who are unable to maintain their basic needs and those of their families, with an impact on the reduction of inequality, discrimination and violence (Lopes, 2008). The best way to prevent people who go through the painful experience of loss would be to enable strategies to reduce homicides, which requires a profound change in public awareness about the importance of social interventions in the individual, family, social and legal spheres (Costa *et al.*, 2017).

When debating the right to life and inclusion, some aspects need to be remembered, such as mortality, access to school, employment and income, and economic inequality (IPEA, 2025). A study shows that reductions in social assistance opportunities can contribute to the growth of criminal recidivism. It is noteworthy that in a society of social welfare the economic problem related to crime is more linked to the social one, while in the third world it is more

linked to the economic aspect (Marino, 2002).

The fundamental causes of poverty may be located in the economic structure of some localities and in the failures of the policies employed in them, which is opposed to deficiencies or individual attitudes (Rank, 2004). Complementing this aspect, the confrontation of violence needs a policy of promotion of life, with a multidisciplinary character and an inclusive profile, as in the area of health, focused on the main risk factors for deaths and injuries, increasing effective action in favor (of the health) of the entire population (Malta *et al.*, 2017).

Some studies highlight the relevance of criminal justice institutions in the fight against crime, as well as that considered violent. The slowness of the time that justice elapses, the inefficiency of the system, and the deficit of the prison system are representations of the precariousness of the judicial situation, which can contribute to an upsurge in criminal practice (Porto, 2023).

From another perspective, Schraiber *et al.* (2006) already expose that the increase in deaths (due to external causes), especially due to homicide rates, shows that it is one of the greatest public health demands today. With a more diversified approach, Moran *et al.* (2021), in turn, add that healthier environments, such as green spaces, can contribute to the reduction of risks related to violence.

In other cases, tolerance policies aimed at not applying punishments for infractions of the law at the same time offer support to people harmed by their governments and perpetuate welfare policies that can be exclusionary (Holland, 2017). There are also studies that focus on the relationship between social organization and crime, with an emphasis on deaths by homicide, suggesting that economic disadvantages influence the causes of the offense in question (Aron and Woolf, 2013).

Higher incomes are estimated to have a protective effect on overall mortality, but with substantial variation among causes of death, and there is some evidence that homicides decrease in favorable economic times (Gerdtham and Ruhm, 2006). On the other hand, the negative evolution of GDP per capita in the 80s and 90s, combined with the increase in demographic growth, increased social inequality, concentrating poverty in urban areas, which resulted in an escalation in the number of homicides (Maricato, 2000).

In this sense, an increase in violent deaths was noticed, due to the interaction of various aspects, which involve the functioning of the justice system, crime-business or underground economy in times of globalization, in addition to the vulnerability and inequality among poor young people (Zaluar and Leal, 2001). There is also the absence of opportunities

on the legal work fronts and the concentration of income, increasing the incentives for participation in criminal activities (Cerqueira, 2014).

On the other hand, infant mortality rates, among other aspects, reflect the infrastructure of child care and provide a good idea of youth mortality rates, especially those attributable to violent causes, even indicating the various modes of sociability and the political and economic circumstances that express specific mechanisms of denial of citizenship (Waiselfisz, 2012).

Going back to the 80s and the economic stagnation that occurred there, an accelerated urbanization process developed, which took many people to the outskirts of several cities, without adequate services and infrastructure at the same time; In addition to this issue, the unprecedented growth of the youth population, high unemployment rates and informal work of this public, specifically in the lower levels of formal education, may also have favored the increasing homicide rates (Reichenheim, 2015). The population increase, in turn, found a precarious infrastructure in terms of services and public policies, with a different reality from previous times, which gave rise to a dynamic, growing and propagating character of violence (Silva and Vieira, 2008).

There are currents that support that the increase in violence is closely related to the metropolises, with a clear relationship between homicides and social inequalities, spatiality and violence, with a predominance of some factors, such as low levels of income and education, higher unemployment, a greater number of favela residents, as well as worse social and urban housing conditions (Maricato, 2000). Specifically, with regard to schooling/education, it is appropriate to highlight the perspective of Ellis (2012), when he points out that adolescents are more susceptible to involvement with deviant behaviors in relation to people at any other stage of life.

On the one hand, there are currents that defend that policies to improve education, generate job opportunities and reduce social inequality would be the main ways to reduce homicides and violence. On the other hand, there is the view that income and inequality do not seem to have a clear effect on homicide rates in Brazilian states, but that, in another sense, it is urbanization that seems to act with a strong influence, which establishes a warning about the way in which such interpretations should be considered (Cano and Santos, 2007).

Deaths due to the crime of homicide, according to the preliminary exposition, are the targets of diversified studies, given their possibility of occurrence in any part of the world, as

well as in the southern cities of Minas Gerais selected for this study, which are located in the southern region of the federated entity in question.

3 METHODOLOGY

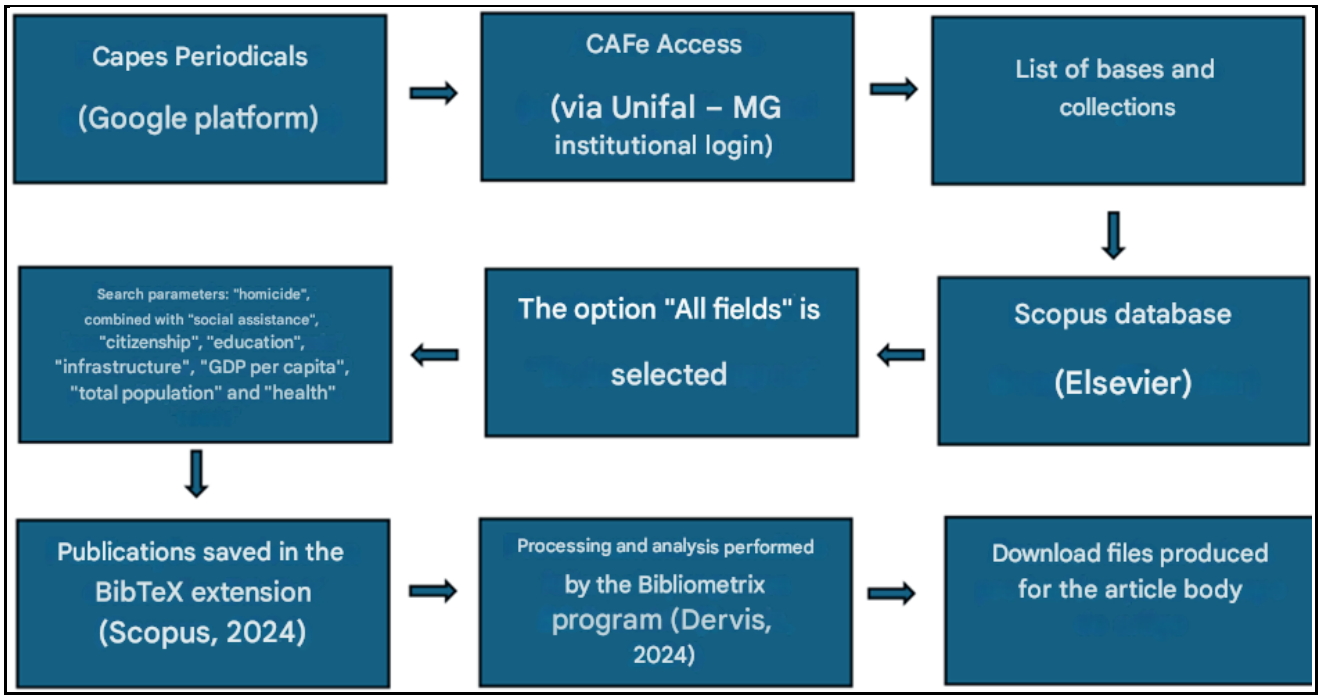
To achieve the objective proposed for this study, the path was made through a quantitative approach, initially by the use of bibliometrics with regard to the literature on the subject, by the collection of secondary data on pages with content about the municipalities indicated in this study, and by the use of descriptive statistical treatment and with the help of regression analysis.

The technical contribution related to bibliometrics alluded to a set of mathematical and statistical analyses with a focus on evaluating the patterns derived from the publications and documents researched (Diodato, 1994). The descriptive nature is aimed at presenting and analyzing specific bibliographic patterns, with the aim of establishing possible relationships between the variables evaluated, capable of elucidating information on a given theme. In this context, the bibliometric study of scientific publications on deaths by homicide was outlined by a quantitative approach.

Evaluations through bibliometrics can characterize tools in favor of science, which makes the analysis of new perspectives of knowledge feasible, in addition to providing opportunities for other works, to the extent that gaps may give rise to new investigations (Koseoglu *et al*., 2016; Bem Maracajá *et al*., 2021). The search for publications was carried out through the *Scopus* and *Google Scholar* databases, used from the *Harzing's Publish or Perish - HPP* platform (Scopus, 2024; Bensman, 2011). Initially, the methodological path followed for the selection of publications on the theme of violent deaths was as follows:

Figure 1

Publications on "violent deaths" - Scopus Base

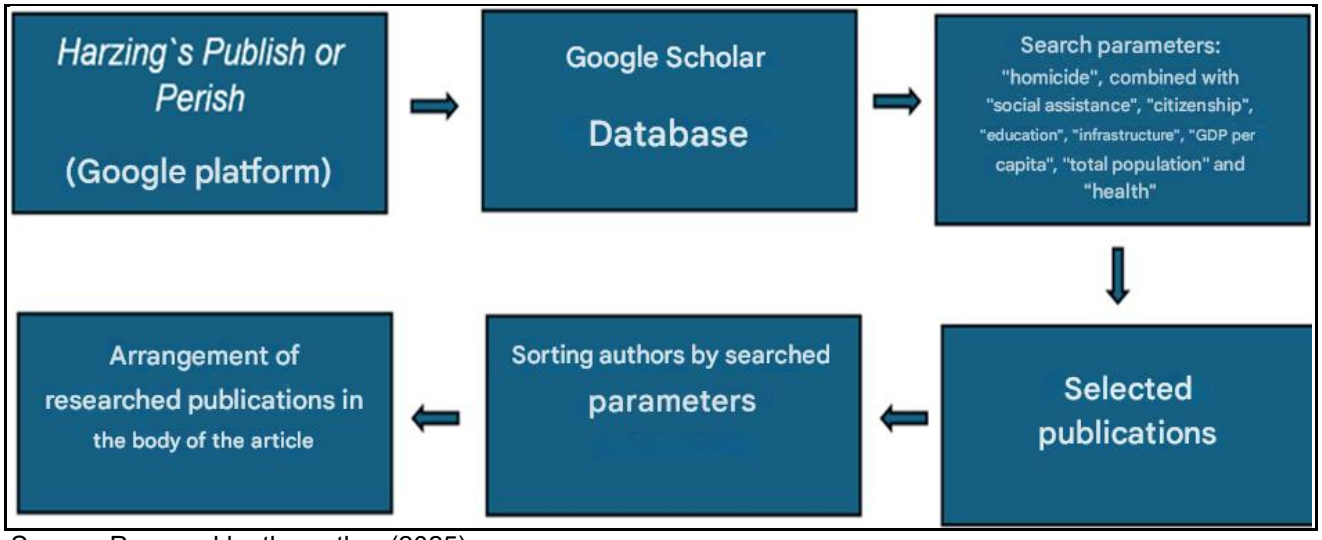


Source: Prepared by the author (2025).

Regarding the literature searched through the *Google Scholar database,* the route used was as follows:

Figure 2

*Publications on "violent deaths" - Google Scholar Database**



Source: Prepared by the author (2025).
*Note: base obtained from *Harzing's Publish or Perish - HPP platform.*

The national database of publications was searched using the path available in the HPP, subsidized by *Google Scholar*, with the best H index. This parameter establishes the impact of individual or group research by the number of citations, which were selected for the present study (Bensman, 2011).

For the collection of numerical data, the time lapse chosen in this investigation is indicated between the years 2010 and 2021, and it was not possible to obtain more recent updates that synchronized the metrics and indicators chosen. As for the municipalities surveyed, the Gross Domestic Product (GDP) *per capita* was surveyed with the public consultation at the Brazilian Institute of Geography and Statistics (IBGE, 2025).

On the other hand, the homicide death rates of the total population (TMHPT), the urbanization rate (TU), the budgetary effort in infrastructure (EOI), the budgetary effort in social assistance and citizenship activities (EOAASC), the budgetary effort in education activities (EOAE), the budgetary effort in health activities (EOAS) and the total population were obtained from data for public consultation from the Minas Gerais Institute of Social Responsibility (IMRS) of the João Pinheiro Foundation (FJP, 2025). Internet access is public and without any type of restriction. The parameters used are as follows:

Table 1

Parameters surveyed

Parameter (unit of measure)	Concept
Homicide death rate of the total population - TMHP (absolute number)	Ratio between the number of deaths due to homicide of residents and the total number of residents, multiplied by 100 thousand
Gross Domestic Product per capita - GDP per capita (R$)	GDP is the sum of all final goods and services produced by a country, state, or city, usually in a year. All countries calculate their GDP in their respective currencies
Urbanization rate (%)	Ratio between the total number of people residing in the urban area of the municipality and its total resident population. For the years 2000 and 2010, the data were census-based. For the inter-census years, the population was estimated by interpolation
Infrastructure budget effort	Participation of budget expenditures in the annual accounts made in the subfunctions urban infrastructure, urban services, urban public transport, postal communications, telecommunications, air transport, road transport, rail transport, waterway transport and special transport

Budgetary effort in social assistance	Participation of budget expenditures in the annual accountability carried out in the subfunctions Assistance to the Elderly, Assistance to the Disabled, Assistance to Children and Adolescents, Community Assistance, Custody and Social Reintegration, Individual, Collective and Diffuse Rights, and Assistance to Indigenous Peoples
Budgetary effort in education activities	Participation of budget expenditures in the annual accountability carried out in the subfunctions Elementary Education, High School, Vocational Education, Higher Education, Early Childhood Education, Youth and Adult Education and Special Education in total expenditures
Budgetary effort in health activities	Participation of budget expenditures in the annual accountability carried out in the subfunctions Primary Care, Hospital and Outpatient Care, Prophylactic and Therapeutic Support, Health Surveillance, Epidemiological Surveillance and Food and Nutrition in the total expenditures
Total Population	Total resident population

Source: Adapted by the author from IBGE (2025) and FJP (2025).

The literatures consulted in this work outlined diversified points of view, making the present investigation important to analyze some relationships between deaths by homicide and other aspects. In this sense, a theoretical arrangement is available, where some hypotheses are proposed:

Table 2

Study hypotheses formulated

Hypothesis	Description	Source
H1	The TMHP decreases with the increase in public investment in social assistance and citizenship activities	Lopes *et al*. (2008) Marino (2002) Rank (2004) Holland (2017) Costa *et al*. (2017) Kawachi *et al*. (1999) Gove *et al*. (1985) Savolainen (2000)
H2	TMHP decreases with increased public investment in infrastructure	Waiselfisz (2012) Reichenheim *et al*. (2011) Silva and Vieira (2008)
H3	The TMHP increases with the growth of the urbanization rate	Maricato (2000) Cano and Santos (2007)
H4	The AMPR decreases with the increase in GDP	Aron and Woolf (2013)

	per capita	Gerdtham and Ruhm (2006) Zaluar and Leal (2001) Cerqueira (2014) Waiselfisz (2012)
H5	The AMPR does not seem to be influenced by parameters related to income, as well as to inequality	Cano and Santos (2007)
H6	The TMHP increases with the growth of the total population of the municipality	Waiselfisz (2013)
H7	The TMHP reduces with the increase in actions related to the health of the population	Malta *et al.* (2017) Schaiber *et al.* (2006)
H8	HPRR increases with low levels of education/education	Maricato (2000)

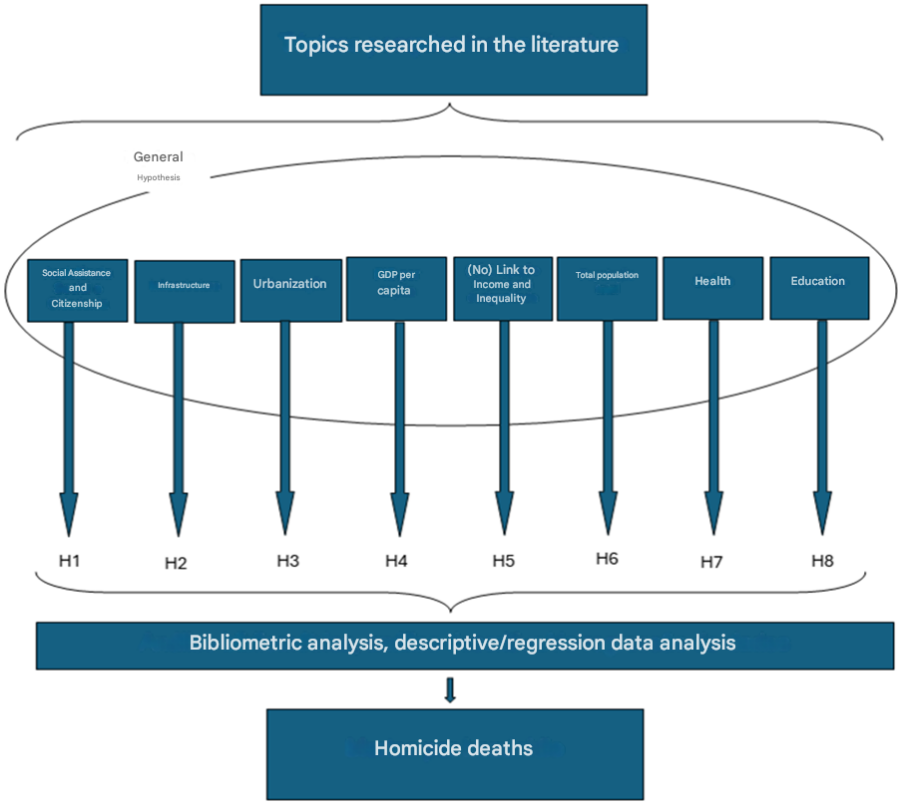
Source: Adapted by the author from *Harzing's Publish or Perish*/*Google Scholar* and from *Scopus* (2025).

The proposal of this study also highlights the existence of a dependent variable, represented by the homicide death rate - MHRR, and independent variables, illustrated by social assistance/citizenship, education, infrastructure, GDP per capita, total population, health and urbanization rate. Based on the researched literature, these parameters, in theory, can exert influence on the behavior of the HMRR in cities in the south of Minas Gerais, so a descriptive analysis was established and the use of the multiple linear regression method, which proposes a statistical modeling to understand how the studied variables of a given population behave, in adjustment to the search for a standard regarding trends evaluated in relation to a given theme (Chein, 2019).

To this end, the *Gnu Regression Econometrics and Time-Series Library* - GRETL - program was used for the application of the regression, specifically to obtain the model proposed in this study by the method of ordinary least squares - OQM and for robustness tests (collinearity, normality of the residuals, autocorrelation and heteroscedasticity), being able, among other functionalities, to implement hypothesis tests for the performance of analyses (Gujarati and Porter, 2011). A representation that summarizes the paths taken for the development of the present study is as follows:

Figure 3

Methodological synthesis



Source: prepared by the author (2025).

Consequently, some results and analyses were presented, both about the researched publications and about the secondary data collected, which will be described in the next section.

4 RESULTS AND DISCUSSION

This section will present some analyses and discussions on the results resulting from the bibliometric study carried out from two databases related to the research theme.

The modeling proposed in the present study and the descriptive and multiple linear regression analyses related to the secondary data collected will be presented below. Initially, for a search on publications, through the platforms *Harzing's Publish or Perish* – HPP/*Google Scholar*, which relate deaths by homicide and possible correlations, some works stood out for the H index obtained, and the results were synthesized:

Table 3

*Publications on homicides with the greatest impact – HPP**

Keywords	H-Index	Ranking	Authorship
"Homicide" "social assistance" "citizenship"	171	1	Lopes *et al*. (2008)
	73	2	Marino (2002)
	44	3	Costa *et al*. (2017)
"homicide" "GDP per capita"	538	1	Maricato (2000)
	366	*2*	Zaluar and Leal (2001)
	267	3	Cerqueira (2014)
"Homicide" "Infrastructure"	232	1	Waiselfisz (2012)
	185	2	Reichenheim (2011)
	155	3	Silva and Vieira (2008)
"Homicide" "Urbanization"	538	1	Maricato (2000)
	466	2	Sapori (2007)
	294	3	Cano and Santos (2007)
"Homicide" "total population"	336	1	Waiselfisz (2013)
	331	2	Waiselfisz (2012)
	232	3	Waiselfisz (2010)
"Homicide" "Health"	1236	1	Minayo (1994)
	1194	2	Minayo (2006)
	742	3	Krug *et al*. (2002)
"Homicide" "Education"	365	1	Blonde (2007)
	239	2	Galvão (2017)
	208	3	Pochmann (2004)

Source: Adapted by the author from *Harzing's Publish or Perish* – HPP (2025).
*Note: keyword searches limited to the number of 200 (two hundred) publications.

The works that guide the theory presented in this study endorsed some of these publications, which had the classification of the highest H indexes, with a broader impact on individual and collective research due to the amount of citations made by other authors. The period used for each conjugate of words researched was between the years 2000 and 2025, a period that partially coincides with the secondary data collected for each metric or indicator researched, whose time lapse was established between the years 2010 and 2021.

On the other hand, the international publications collected from the *Scopus* database and processed via *Bibliometrix* characterized the other part of the bibliometric study carried out on some correlations between deaths by homicide and other segments. Table 4 illustrates the synthesis of the literature in general collected (including foreign literature), which provided theoretical support for this study:

Table 4

Publications on the relationship between homicides and other segments

Keywords	Quotes	Citations by year	Authors/Sources	Results/ Filters
"Homicide" "Assistance social"	169	11,27	Rank (2010)	137/week Filters
	151	18,88	Holland (2017)	
	117	6,5	Clasen (2007)	
"Homicide" "Citizenship"	451	17,35	Kawachi (1999)	296/Subject: C. Social
	266	6,65	Gove (1985)	
	237	9,48	Savolainen (2000)	
"homicide" "GDP per capita"	723	60,25	Aron and Woolf (2013)	150/No filters
	386	20,32	Gerdtham (2006)	
	308	14,67	Mueller (2004)	
"Homicide" "Urbanization"	667	74,11	Li (2016)	148/Period: 2015/2024 Subject: C. Social Type: Articles
	262	35,43	Li (2018)	
	213	53,25	Usman (2021)	
"Homicide" "Infrastructure"	156	22,29	Passi (2018)	446/Period: 2015/2024 Subject: C. Social Type: Articles
	109	15,57	Muller (2018)	
	102	12,75	Aradau (2017)	
"Homicide" "population total"	308	61,60	Fazel (2020)	276/week Filters
	268	38,29	Peterson (2018)	
	199	33,17	Too ls (2019)	
"Homicide" "Health"	65	13,00	Lima (2021)	120/Period: 2020/2025 Subject: C. Social Type: Articles Country: Brazil
	31	6,20	Moran (2021)	
	28	4,67	Alcadipani (2020)	
	552	39,43	Ellis (2012)	470/Period: 2020/2025

	375	34,09	Massoglia (2015)	Subject: Social C. Type: Articles
"Homicide" "Education"	347	38.56	Petrosky (2017)	Countries: Brazil/USA Access: free

Source: Adapted by the author from *Scopus/Bibliometrix* (2025).

Among the publications included in Table 5, which were partially referenced in this study, those in which the period was not endorsed in the results/filters comprised the files searched between 2000 and 2025. In the other cases, the periods are delimited by some filters, which were applied for convenience, to reduce the number of publications during the investigation.

The theme of deaths by homicide and its possible relationships with aspects such as social assistance and citizenship, GDP per capita, infrastructure, among others, searched for international studies, as well as national literature, and it is noticeable that the diversified references, to a certain extent, complement each other in the present investigation (Aveline *et al*., 2019).

Further, the research intended to carry out other quantitative analyses through the treatment of the collected data, so initially a brief statistical description of the selected variables was carried out, which can be seen according to the table below:

Table 5

Statistical Description of Variables - Cities in the South of Minas Gerais - 2010/2021

Variables	Average	Minimum	Maximum
TMHPT	10,15	1,76	30,02
GDP *per capita*	22936,09	10186,60	58817,87
Urbanization rate	89,53	41,65	99,09
Total Population	71496	38516	137608
EOI	7,16	1,72	16,02
EOAASC	1,93	0,31	4,92
EOAE	19,76	14,01	25,25
EOAS	28,45	5,32	47,45

Source: Prepared by the author (2025).
Legend: TMHP – Homicide Death Rate of the Total Population; EOI – Budget Effort in Infrastructure; EOAASC: Budgetary Effort in Social Assistance and Citizenship Activities; EOAE: Budgetary Effort in Education Activities; EOAS: Budgetary Effort in Health Activities.

The information in this research covered the period between 2010 and 2021 (Table 3). For comparison purposes, some data presented by the United Nations Office on Drugs and Crime (UNODC) were described in a study with reference to the year 2021.

Brazil appears in 14th place in the list of countries around the world, with a rate of 21.26 homicides per 100 thousand inhabitants, according to Estadão (2024), which represents almost double the historical average recorded by the municipalities in the south of Minas Gerais selected for the present study, as shown in Table 3. In comparison with homicide rates per inhabitant, in continental terms, the average value of the municipalities studied is below, but close in numerical terms, in relation to the Americas and Africa, with 15.0 and 12.7, respectively (Estadão, 2024). However, it is above Oceania (2.9), Asia (2.3) and Europe (2.2), which is close to the minimum value expressed in Table 3.

The average values of the TMHPT are closer to the minimum value than to the maximum, as well as the averages of the GDP per capita (R$ 22,936.09), the EOI (7.16) and the EOAASC (1.93). This question suggests that the distribution of the data collected for these parameters is more concentrated in the lower portion of the analyzed interval, which may indicate that the AHRMTs of the selected municipalities in the south of Minas Gerais are at reduced levels (when considering minimum and maximum values), even though the average amounts of GDP per capita, EOI and EOAASC have not been as expressive (or broader) over the period.

These results may represent a counterpoint to the literature studied on the relationship between the MWLR and GDP per capita. Homicide rates were, on average, close to the minimum values, even without the growth of the parameter in question, which does not agree with the approaches proposed by Zaluar and Leal (2001), Gerdtham and Ruhm (2006), Waiselfisz (2012), Aron and Woolf (2013) and Cerqueira (2014). On the other hand, because no clear effect of GDP per capita on this rate is detected, the proposal by Cano and Santos (2007) proves to be more acceptable, based on the data researched.

The analysis of the relationships between the TMHPTs and the budgetary efforts in social assistance/citizenship and infrastructure activities move in the same direction, which also contrasts, in the analyzed period (2010/2021), the perspectives foreseen in the related literature, according to Marino (2002), Rank (2004), Holland (2017) and Costa *et al*. (2017), for the first parameter analyzed, and by Silva and Vieira (2008) and Reichenheim *et al*. (2011), in relation to the second.

As for the urbanization rate, the average value is much closer to the maximum value

than to the minimum, which infers, in a preliminary analysis, that the selected municipalities in the south of Minas Gerais, on average, showed an expansion of urbanization between 2010 and 2021. The literature indicates that homicide rates increase with the growth of this indicator, according to Maricato (2000), in addition to Cano and Santos (2007). However, based on the data analyzed, it can be seen that the MSTDs, on average, remained closer to the minimum value, which does not agree with the cataloged literary perspectives on the binomial urbanization and violent deaths.

The total population presents its average value closer to the minimum value (than in relation to the maximum). By parameterizing this metric with the behavior of the AMPR, for the same period, it is perceived that the results followed in similar directions. This analysis is in line with the literature, according to Waiselfisz (2013), as smaller populations can lead to lower homicide rates. Regarding the budgetary effort in education activities, the average value is practically equidistant between the minimum and maximum references collected in the research, and it is not possible, at this moment, to infer a possible relationship of dependence with the HMR, based on Table 3. Finally, the average value of the budgetary effort in health activities is closer to the maximum value, while the average value of the HPR is closer to the minimum. This perspective is in harmony with Malta *et al.* (2017) and Schaiber *et al.* (2006), at a time when the homicide rate decreases as there is an increase in actions linked to people's health.

On another spectrum, according to the elaborated regression analysis model, the ordinary least squares method, processed by the Gretl program, according to Gujarati and Porter (2011), employed 84 (eighty-four) observations. Table 6 expresses the following results:

Table 6

Ordinary Least Squares - Cities in the South of Minas Gerais - 2010/2020 - Dependent Variable - Homicide Death Rate (TMHPT)

Variables independ.	Coefficient	Standard Error	Reason t	P-Value
Constant	33,1409	10,7094	3,095	0,0028***
GDP Per Capita	-6.5337e-05	0,00012032	-0,543	0,5887
T. Urbanization	-0,0364711	0,0615888	−0.5922	0,5555
Total Population	2.51197e-05	3.1676E-05	0,7930	0,4302
EOI	0,275523	0,222633	1,238	0,2197

EOAASC	−1.67594	0,588291	−2,849	0,0056***
EOAE	−0.726052	0,319475	−2,273	0,0259**
EOAS	−0.154611	0,0890993	−1,735	0,0867 *

Source: Prepared by the author (2025).
Legend: EOI/EOAASC/EOAE/EOAS – Budget Effort in Infrastructure/Social Assistance and Citizenship Activities/Education Activities/Health Activities.

Table 6 presents some information, among which the statistical significance of the variables "constant" and "EOAASC" at 1%, the EOAE at 5% and the EOAAS at 10% stands out, which is indicated by the number of asterisks (***), (**) and (*) respectively, a legend adopted by Gretl to facilitate the interpretation of the tests (Perez and Lopez, 2019). Regarding the EOAASC, when its value increases, the THMPT decreases, which is corroborated by the literature, in the terms of Kawachi *et al*. (1999), Gove *et al*. (1985) and Savolainen (2000).

It is also noted that if the value of the total population increases, the TMHP grows, which is in line with Waiselfisz (2013).

The panorama related to GDP per capita indicates that its increase incurs in the decrease of THMPT, which is supported by Aron and Woolf (2013), Gerdtham and Ruhm (2006), Zaluar and Leal (2001) and Cerqueira (2014). The budgetary efforts in education and health activities, based on Table 4, when the value increases, the AHRR is reduced, reverberating the forecasts of Maricato (2000), as well as Malta *et al.* (2017) and Schaiber *et al.* (2006).

As for the budgetary effort in infrastructure, the TMHP shows an increase, as this parameter also increases, which is not supported by the theoretical basis researched, according to Silva and Vieira (2008) and Reichenheim *et al*. (2011). The urbanization rate, in turn, according to the result obtained in Table 4, presents a value that indicates an increase, as the homicide rate decreases; this provision contrasts with the approaches presented by Maricato (2000) and by Cano and Santos (2007).

Other results obtained concern some statistical parameters that indicate the validity of the adopted model and the significance of its numbers. In this sense, the method of ordinary least squares produced the following:

Table 7

Statistical parameters - Cities in the South of Minas Gerais - 2010/2021

Parameter	Value
R – Square	0,245216
R – Adjusted Square	0,1757
P-Value	0,002480

Source: Prepared by the author (2025).

The analysis of the regression modeling used also indicates, through the calculation of the R – Adjusted Square, that approximately 17.57% of the dependent variable, which alludes to the homicide death rates of the total population, in the selected cities in the south of Minas Gerais, are explained by the relationship of dependence with the independent variables selected for this study (as shown in Table).

After the regression, the value of the R – Square is 0.245216, approximately 24.52%. To verify the reliability of the data worked, some robustness tests, according to Resende and De Figueiredo (2010), were carried out, and the following results were obtained:

Table 8

Robustness Tests

Test	Parameter	Result
Collinearity	GDP	2,860
	TURB	1,164
	POPTOT	2,659
	EOAASC	1,031
	EOAE	1,559
	EOAS	1,442
	EOI	1,930
Normality of waste	Null hypothesis	The error has normal distribution
Autocorrelation	Null hypothesis	No autocorrelation
Heteroscedasticity	White's Test	No heteroscedasticity

Source: prepared by the author (2025).
Legend: GDP – GDP Per Capita; TURB – Urbanization Tax; POPTOT – Total Population;
Legend: EOI/EOAASC/EOAE/EOAS – Budget Effort in Infrastructure/Social Assistance and Citizenship Activities/Education Activities/Health Activities.

Based on the information in Table 8, after the data have been processed in Gretl, the variance inflation factor – VIF detected indicates the existence of a variable that has an impact on the others. As all factors recorded values below 10, according to Table 6, no

variable artificially inflated the results, validating the model (Ferreira, 2012).

As for the normality of the residuals and heteroscedasticity, the model can also be considered valid by the results obtained, after processing by Gretl, which indicates the usefulness of estimating the regression model adopted, given the compliance with the indicated tests (Pino, 2014).

Finally, the model also indicated the absence of autocorrelation, as it infers that none of the error terms of the observations were impacted by the error term of any of the other observations (Noce, 2008). After the analyses carried out, resuming the hypotheses presented in Table 9, some notes were summarized in the following representation:

Table 9

Inferences about the hypotheses tested

Hypothesis	Descriptive statistics	Regression Analysis
H1	Unconfirmed	Confirmed
H2	Unconfirmed	Unconfirmed
H3	Unconfirmed	Unconfirmed
H4	Unconfirmed	Confirmed
H5	Confirmed	Unconfirmed
H6	Confirmed	Confirmed
H7	Confirmed	Confirmed
H8	Unconfirmed	Confirmed

Source: Prepared by the author (2025).

According to Chart 3, it can be said that the homicide death rates of the total population in the southern cities of Minas Gerais selected for the present study are in line with the researched literature, when their reduction is verified when the budgetary effort in health activities and the total population increases.

On the other hand, with regard to the budgetary effort in infrastructure and the urbanization rate, the stipulated study hypotheses were not confirmed, when the researched literature on the respective themes and their relationships with homicide rates (or violent deaths) was taken as a basis.

On a different point, the hypotheses related to the budgetary effort in social assistance and citizenship activities, to the GDP per capita and income, as well as to the budgetary effort

in activities related to schooling/education, presented different analyses for descriptive and regression statistics. Such results make it impossible to confirm at this time about possible relationships with the incidence of violent deaths (such as homicides) brought by the literature, when considering the cities in the south of Minas Gerais selected in this research.

5 FINAL CONSIDERATIONS

The purpose of this study was to carry out a quantitative analysis of the relationships between metrics and indicators with deaths by homicide in the southern Minas Gerais municipalities of Boa Esperança, Campo Belo, Lavras, Oliveira, Três Corações, Três Pontas and Varginha, between the years 2010 and 2021.

The bibliometric analysis indicated that the national and international literature, to a certain extent, were complementary in terms of the presentation of their results, which point to the reduction of deaths by homicide at a time when there are greater budgetary efforts in social assistance, citizenship, education, infrastructure and health. The same perception correlates the increase in GDP per capita with the decrease in HMR, although part of the literature understands the relationship between the two parameters as indifferent. On the other hand, the publications surveyed direct the advance of the urbanization rate and the total population to the increase in deaths by homicide.

The value of the historical average presented by the highlighted cities corresponds to approximately half of the Brazilian parameter, and is still below the values of the Americas and Africa, but with numbers higher than the European, Asian and Oceanic continents.

The descriptive statistics in this article assessed that the budgetary efforts in social assistance and citizenship activities, infrastructure and health, in addition to the GDP per capita and the total population suggest consonance with the researched literature, since the mean value of the TMHP and the aforementioned parameters are closer to the minimum values than to the maximum. The average value of the budget effort in education did not show a significant association with the increase or reduction of the TMHP over time. The mean value of the urbanization rate, in turn, was closer to the maximum value, which may indicate a low interference in the TMHP studied.

During the linear regression analysis, the results indicated harmonious behaviors with part of the researched literature, since the BMR reduces as the budgetary efforts in social assistance and citizenship, education and health, in addition to the GDP per capita and the total population increase. However, unlike the literature consulted in this investigation, the

TMHP increases as the budgetary effort in infrastructure grows. The same rate, after linear regression analysis, indicated growth with the reduction of the urbanization rate, which is out of step with the literature researched.

Some issues limited the present research, such as the unavailability of more recent data related to the variables researched and the complex analysis of crime in general and, in particular, in this study, with a focus on deaths by homicide, which may even explain the restriction of the proposed model in 17.57% of the cases related to the municipalities of southern Minas Gerais chosen between the years 2010 and 2021.

The increase in the number of municipalities, the expansion of the annual period to be considered, statistical analysis through other forms of data association, and the extension of the list of metrics or indicators may be aspects to be evaluated for future investigations.

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