MAPEAMENTO DE DIFERENCIAIS INTRAURBANOS DE VULNERABILIDADE EM SAÚDE

MAPPING INTRA-URBAN DIFFERENTIALS OF HEALTH VULNERABILITY

Heraldo Luiz do Amaral
Mestrado
Programa de Pós-Graduação em Ciências da Saúde
Universidade Federal de São João Del-Rei, CCO, Divinópolis-MG
heraldoamaral@gmail.com

Clareci Silva Cardoso
Pós-doutorado
Programa de Pós-Graduação em Ciências da Saúde
Grupo de Pesquisas em Epidemiologia e Avaliação de Novas Tecnologias em Saúde (GPEANTS)
Universidade Federal de São João Del-Rei, CCO, Divinópolis, MG
clarecicardoso@yahoo.com.br

Hygor Kleber Cabral Silva
Graduação
Grupo de Pesquisas em Epidemiologia e Avaliação de Novas Tecnologias em Saúde (GPEANTS)
Universidade Federal de São João Del-Rei, CCO, Divinópolis, MG
hygorcabral@yahoo.com.br

Mirna de Abreu e Silva
Mestrado
Grupo de Pesquisas em Epidemiologia e Avaliação de Novas Tecnologias em Saúde (GPEANTS)
Universidade Federal de São João Del-Rei, CCO, Divinópolis, MG
mirnabreu@hotmail.com

Cláudia Di Lorenzo Oliveira
Pós-doutorado
Grupo de Pesquisas em Epidemiologia e Avaliação de Novas Tecnologias em Saúde (GPEANTS)
Universidade Federal de São João Del-Rei, CCO, Divinópolis, MG
claudia.dlorenzo@gmail.com

RESUMO

Tendo como unidades de área os setores censitários de situação urbana, o estudo empregou a abordagem ecológica para identificar e mapear diferenciais intraurbanos de vulnerabilidade em saúde de um município de médio porte do Estado de Minas Gerais, Brasil, a partir da construção de escores, com o emprego de diferentes bases secundárias de dados socioeconômicos, indicadores municipais de saúde e achados de pesquisas desenvolvidas na Universidade Federal de São João Del-Rei (UFSJ). Os resultados mostraram elevados índices de cobertura sanitária em contraste com níveis de renda, alfabetização e indicadores de saúde em sua maioria intermediários e baixos. Um mapa permitiu visualizar a distribuição dos diferenciais intraurbanos de acordo com o grau de vulnerabilidade em saúde dos setores avaliados, identificando as áreas que mais demandam priorização da gestão municipal. Concluiu-se que, de modo geral, melhorias sanitárias advindas do desenvolvimento socioeconômico e da urbanização podem não significar, *a priori*, proteção para as populações contra exposição a riscos de saúde. A metodologia de classificação em escores mostrou ser uma ferramenta simples, de ampla aplicabilidade e potencialmente eficaz na identificação de diferenciais intraurbanos de vulnerabilidade em saúde.

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Palavras-chave: Urbanização. Ambiente e Saúde Pública. Avaliação de Risco à Saúde. Condições de Vida. Georreferenciamento.

ABSTRACT

Considering census tracts of urban situation as area units, this study employed an ecological approach to identify and map intra-urban differentials of health vulnerability in Divinópolis, a mid-sized municipality from Minas Gerais State, Brazil. The study evaluated variables from different socioeconomic databases, municipal health indicators and research findings carried out in UFSJ, and classified census tracts in scores. Results showed high sanitary coverage ratios in contrast to health indicators, income-and-literacy levels mostly intermediate and low. It was built a choropleth map for health vulnerability patterns, which made it possible to visualize the distribution of intra-urban differentials and specific urban areas with high health vulnerability that require prioritization of municipal public administration. It was concluded that sanitary improvements gained with socioeconomic development and urbanization policies may not protect populations from unsafe levels of health risk exposure and vulnerability. Score classification methodology seemed to be a fairly simple tool, with wide-range applicability and potentially efficient to identify intra-urban differentials in health vulnerability.

Keywords: Urbanization. Environment and Public Health. Health Risk Appraisal. Living Conditions. Georeferencing.

INTRODUCTION

In the mid-twentieth century, epidemiological profile of populations migrated from infectious-parasitic to chronic-degenerative diseases [1]. In that context, interest in studying health under an environmental and population focus led to a renewal of ecological study and its potential for public health, expressed both in the resurgence of an epidemiological affinity for the territory and by the increasing use of spatial analysis techniques [2, 3].

About 25 to 35% of the global disease burden is due to exposure to environmental factors, including urbanization as one of major health determinants [4]. The formation of modern cities is a historically, socially dynamic process that generated contrasts in the social fabric and designed the occupation of urban space. Intra-urban differentials are understood as the many features that can express or reflect forms of socioeconomic inequality manifested in populations' health and life conditions. Geographical distribution of intra-urban differentials occurs according to certain patterns of population homogeneity in areas that can be seen as similar to each other concerning morbidity situations, living conditions and other disease and health patterns of individuals. Its delimitation, characterization and representation are very important to point to priority risk areas for health planning and acting [5].

Vlahov *et al*. analyzed urbanization process as a determinant of health and observed that areas with high inequity concentration, as agglomerates and slums, show low health levels whatever the urbanity levels of surroundings. They concluded that urban development is associated with the expansion of areas where inequalities predominate [6].

Territory becomes very important in the Brazilian health care model, since it presupposes the division of geographical space into areas of responsibility of primary health care units, the so-called Family Health Strategies (*Estratégias de Saúde da Família,* ESF). This model was officially established in 1994 and nowadays is the main entrance of Brazilian public health system (*Sistema Único de Saúde,* SUS). Although ESF is being the hegemonic model, there are other primary care units (Centros de Saúde, CS) not considered ESF, as there is no defined territories to be met. In addition, its traditional form of service organization is considered fragmented and overpast. Many authors argue that moving of health staff throughout its territory generally leads ESF units to promote more access to health in relation to static and passive performance of CS health staffs [7, 8, 9].

The structuring of health services aims to provide effective coverage to the population of a geographically defined territory. Far beyond a physical space, territory is a living, constantly moving, permanently under construction space where health action is developed. It's been seen also as an economic, geopolitical, cultural and epidemiological territory, with its specific actors and dynamics[10, 11].

Studies had associated expansion of population and territorial coverage promoted by ESF and reducing of those hospitalizations due to sensitive conditions to ambulatory care, or Primary Health Care Sensitive Hospitalizations (PHCSH). In the same way, high tuberculosis (TB) and preventable death incidence rates were related to low rates of territorial coverage and access restriction to health units [7, 12, 13, 14, 15].

The aim of this study was to map intra-urban differentials in health in a Brazilian mid-sized municipality from socio-demographic and health databases of easy access that could led to construct health vulnerability score degrees and ranges. The using of those score degrees allows visualizing a reality potentially hidden by general municipal development indicators and show existing inequities. This reality is probably common to many other cities in Latin America.

METHODS

Study characterization

An ecological study was conducted, whose unit of analysis was the census tract, which is the territorial unit of cadastral control of collecting used by the Brazilian Institute of Geography and Statistics (*Fundação Instituto Brasileiro de Geografia e Estatística,* IBGE) in carrying out the demographic censuses.

Study location

Divinópolis is situated in Midwest region of Minas Gerais State, Southeastern Brazil. Its economy is based on steel mill, metallurgy, clothing and services, and is of great importance for regional development [16].

According to last IBGE National Demographic Census (2010), 276 from 295 census tracts in the municipality were classified as on urban situation, with status codes 1 (urbanized area of town or village), 2 (non-urbanized area of town or village) or 3 (isolated urban area), and were the focus of our study. Those census tracts inscribed 206,606 resident inhabitants, or 97.4% of the municipal population, 64,821 permanent households, with 748 people (between 51 and 2,123) and 235 households (between 19 and 622) of average per census tract [17].

Selection and categorization of indicators and variables

The selection and categorization of indicators and variables considered information from two different data sources: socioeconomic data from the 2010 Census; and health data provided by the Municipal Health Department (Secretaria Municipal de Saúde, SEMUSA) and studies carried out by the Research Group in Epidemiology and Evaluation of New Health Technologies (GPEANTS) of the Federal University of São João del-Rei (UFSJ).

Chart 1 shows the categorization of the analyzed variables, in scores granted according to specific percentiles established for each variable.

Chart 1: Categorization of analyzed variables per census tract, Divinópolis, 2015.

Variable name	Categorization		
	Score value 0	Score value 1	Score value 2
Socioeconomic data from information base per census tract of IBGE			
Sanitation variables			
Households with public system of treated water supply (V012 of "Domicilio01_UF.xls" spreadsheet) (*)	Up to 30% of households	From 31% to 80% of households	More than 80% of households
Households with sanitary sewer collection system (V017 of "Domicilio01_UF.xls" spreadsheet)	Up to 50% of households	From 51% to 80% of households	More than 80% of households
Households with garbage collection service (V036 of "Domicilio01_UF.xls" spreadsheet)	Up to 50% of households	From 51% to 80% of households	More than 80% of households
Income and literacy level variables			
Householders with low income (up to 2 minimum wages) (V001+V002+V003+V010 of "ResponsavelRenda_UF.xls" spreadsheet)	More than 50% of householders	From 21% to 50% of householders	Up to 20% of householders
Householders with intermediate income (from 2 to 5 minimum wages) (V004+V005 of "ResponsavelRenda_UF.xls" spreadsheet)	More than 50% of householders	From 21% to 50% of householders	Up to 20% of householders
Householders with high income (more than 5 minimum wages) (V006+V007+V008+V009 of "ResponsavelRenda_UF.xls" spreadsheet)	Up to 20% of householders	From 21% to 50% of householders	More than 50% of householders
Literate householders with 10 years old or more in private households (V078 of "Pessoa01_UF.xls" spreadsheet)	Lowest tertile	Intermediate tertile	Highest tertile
Health data from SEMUSA databases and GPEANTS studies			
Mortalty incidence rate per tertiles	Highest tertile	Intermediate tertile	Lowest tertile
Primary Health Care Sensitive Hospitalization (PHCSH) incidence rate per tertiles	Highest tertile	Intermediate tertile	Lowest tertile
Tuberculosis (TB) incidence rate per tertiles	Highest tertile	Intermediate tertile	Lowest tertile
Distance of PHCU by location of census tract's centroid	Centroid not included in any *buffer*	Centroid included in *buffer* and closer to a CS-type unit	Centroid included in *buffer* and closer to a ESF-type unit

Socioeconomic data from the information base per census tract of IBGE.

The socioeconomic variables selection methodology followed the model used by Lacerda *et al*. [5], and considered two subgroups: sanitation variables; and income/literacy level variables[17].

Sanitation variables had considered permanent households that had: public system of treated water supply; sanitary sewer collection system; and garbage collection service. Income level variables had considered, per census tract, householders grouped according to three income levels: low (up to 2 minimum wages), intermediate (between 2 and 5 minimum wages) and high (above 5 minimum wages). Literacy level variable has considered, per census tract, literate householders with 10 years old or more.

The criterion of percentiles used by Lacerda *et al*. [5] was adopted to categorize groups of socioeconomic variables. Score value 0 (low/worst) was assigned to census tracts included in lower percentiles, showing worst living conditions; census tracts between lower and higher percentiles, with middle living conditions, had received score value 1 (intermediate); and census tracts of upper percentiles, with better living conditions, had gained the score value 2 (high/better).

Health data provided by the Municipal Health Department and studies developed by GPEANTS.

Based on death certificates and data from the Ministry of Health's mortality information system (*Sistema de Informação de Mortalidade,* SIM), 1,144 deaths occurred in 2010 were georeferenced in a study developed between 2011 and 2012 by a labor education program (*Programa de Educação pelo Trabalho,* PET) on Health Surveillance carried out at UFSJ. Twenty two non-georeferenced deaths (1.91%) were excluded. Municipal data about PHCSH incidence in 2011, analyzed by Cardoso *et al*. [8], and tuberculosis (TB) incidence between 2002 and 2012, studied by de Abreu e Silva [14], were also included.

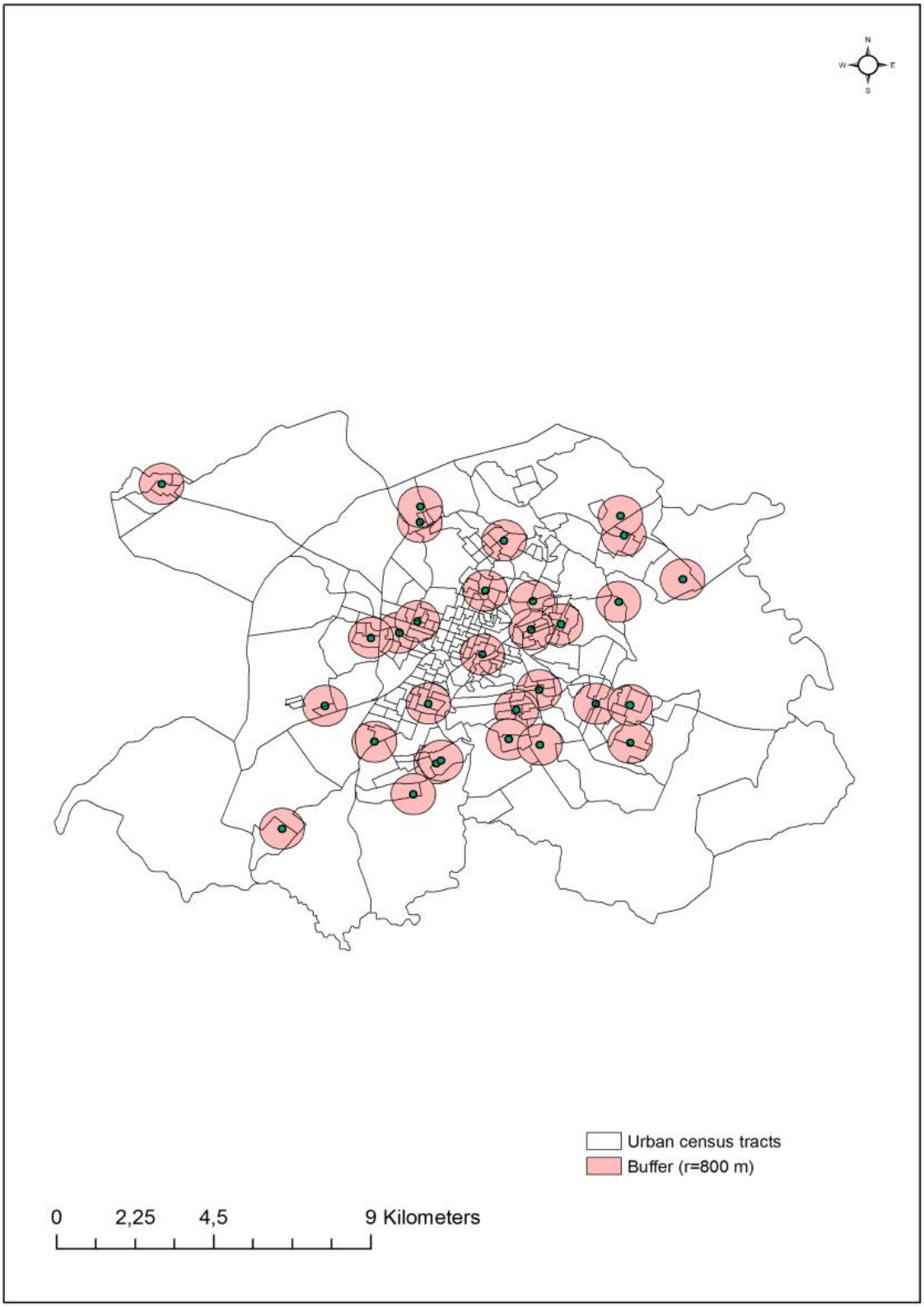
The categorization of census tracts according mortality, PHCSH and TB incidence was the same, first calculating their rates per census tract, and then assigning score values according to percentiles of distribution. Score 0 was given to census tracts included in the higher percentile; score 1 to those ranging between both percentiles; and score 2 to those in the lower percentile.

Although recommended by SUS, most of primary health care units (PHCU) work with no defined territorial and population coverage. So, in order to evaluate provision of primary healthcare services around the household, it was created a variable, named "Distance of PHCU by location of census tract's centroid".

This variable was defined from the point location of each health unit, around which a circular buffer with an 800m radius was demarcated. This criterion was based on the estimation of Souza *et al*. [15], in which it is assumed that this distance can be met without the need of urban public transport, and beyond which it is considered that is difficult for someone who seeks the health unit to access it.

The census tracts were then categorized according to their geographic centroid. Census tracts whose centroid is not included in any buffer have gained score 0 (worst access); those whose centroid is included in at least one buffer, and is closer to a traditional unit (CS) received score 1 (intermediate access); and those whose centroid is included in at least one buffer, and closer to a unit of the Family Health Strategy (ESF), obtained score 2 (better access). Figure 1 shows the buffers distribution according to PHCU location.

Figure 1: Spatial distribution of buffers according to the location of primary health care units (PHCU), Divinópolis, 2014



Final categorization and classification of census tracts

Each census tract obtained a final score equivalent to the sum of the score values assigned to each analyzed variable. Next, the census tracts were arranged in ascending order of final score, from worse to higher socioeconomic and health status. After, they were reassembled according to their health vulnerability degree (higher, intermediate or lower) in class intervals determined by tertiles whose values corresponded to variations of one standard deviation unit above and below the final score average value.

It was possible to determine the number and percentage of census tracts per score value for each variable, and then estimate a measure of the impact of variables in their vulnerability degree. It is assumed that the influence of a given variable on increasing health vulnerability has been as larger as higher is the number of census tracts with score 0 for that variable.

Data were analyzed according to the contribution of each variable for the total of census tracts that make up the different health vulnerability degrees, in number and percentage (percentage ratio) of census tracts grouped according to score values.

Finally, a choropleth map was drawn in GIS setting using ArqGIS ™ software, version 10.1 (Environmental Systems Research Institute, Inc., Esri, California, USA), showing the spatial distribution of census tracts grouped in health vulnerability degree ranges.

RESULTS

Table 1 shows the frequency distribution and classification of census tracts in ascending order of final score, and according to their health vulnerability degree. The expected trend of score values' normal distribution around the average value (μ = 12.25) was confirmed (Figure 2). The calculated values of standard deviation (σ = 0.82) and coefficient of variation (CV = 6.69%) indicate a relative low dispersion of data around the average, and show a predominance of intermediate vulnerability patterns in most of studied census tracts.

Table 1: Frequency and classification of census tracts according to the final score by scores and the health vulnerability degree, Divinópolis, 2015.

Census tract score	Nº census tracts	%	Health vulnerability degree	Nº census tracts	%	Resident population (inhab.)	%
6	1	0,36					
7	5	1,81					
8	5	1,81	Higher	63	22,83	50.743	24,56
9	18	6,52					
10	34	12,32					
11	43	15,59					
12	46	16,67	Intermediate	133	48,20	99.244	48,04
13	44	15,94					
14	32	11,59					
15	23	8,33					
16	21	7,61	Lower	80	28,97	56.619	27,40
17	1	0,36					
18	3	1,08					
Total	***276***	***100,00***		***276***	***100,00***	***206.606***	***100,00***

Census tracts with lower health vulnerability degree were considered those with final scores higher than 13 (μ + σ = 13.07); those with final scores lower than 11 (μ – σ = 11.43) had a higher vulnerability degree; and those with scores 11, 12 and 13 had intermediate vulnerability degree. Thus, 63 census tracts (22.83%) were high-vulnerable; 80 (28.97%) low-vulnerable; and 133 (48.20%) mid-vulnerable.

Figure 2: Histogram of the distribution of census tracts according to the final score by scores and the health vulnerability range, Divinópolis, 2015

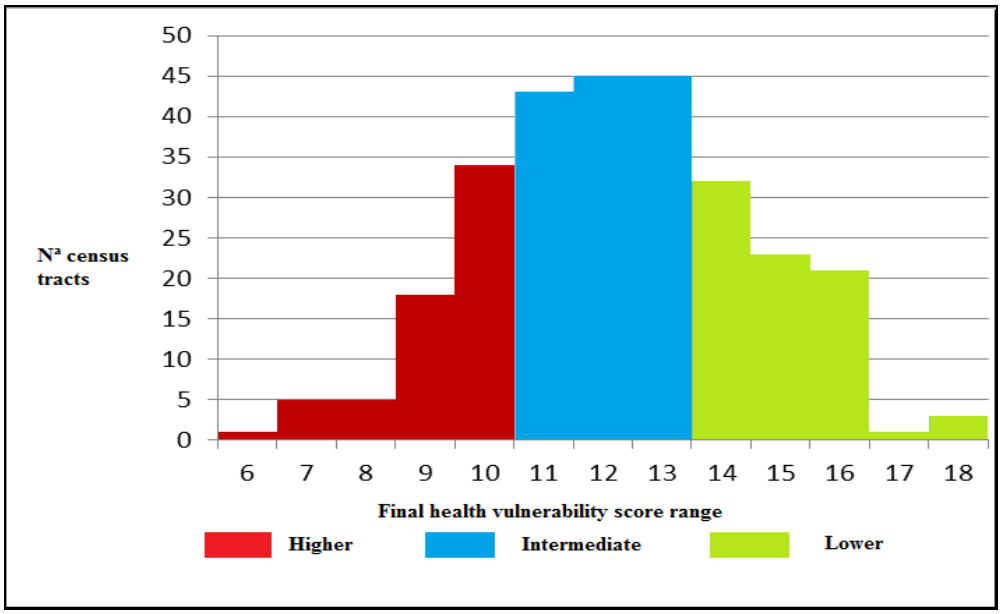


Table 2 shows the frequency and percentage of census tracts according to scores and health vulnerability degrees, in relation to socioeconomic variables. For sanitation variables, it was observed that water supply and garbage collection were not very discriminatory. 97.47% of census tracts had score 2 for water supply, with almost 53% of them with 100% coverage, and in 98.55% garbage collection serves more than 80% of the households. But the same did not occur with the variable sewage collection system, although 87.68% of census tracts had sewage collected in more than 80% of households.

Considering the sanitation variables among the 63 worst census tracts, only one of them showed score 0 for water supply, with percentage ratio of 1.59%. No one of them obtained such classification for garbage collection service. There were, however, 15 census tracts with score 0 for sewage collection system (percentage ratio = 23.81%). On the other hand, all 80 less vulnerable census tracts obtained score 2 for water supply and waste collection, and 78 for sewage collection.

The analysis of income level variables allowed observing the predominance of low income level populations within the studied census tracts. From 212 areas with score 0 for the variable "*Householder with low income (up to 2 minimum wages)*", 62 were among the 63 worst census tracts, comprising 98.41% of those high-vulnerable. On the other hand, there were no census tracts with score 2 for this variable among those worst. At the other extreme of income status, no census tracts with score 2 for the variable "*Householder with high income (more than 5 minimum wages)*" was found in the high-vulnerable group, but 61 census tracts (percentage ratio = 96.82%) with score 0 were within that group.

Regarding the literacy variable, 43 (68.25%) of 92 census tracts evaluated with score 0 for the variable "*Literate householder aged 10 years or more*" are in the group of the 63 high-vulnerable census tracts.

Table 2: Distribution of frequency and respective percentages of census tracts according to the categorization in scores and health vulnerability degrees, in relation to socioeconomic variables, Divinópolis, 2015

Score value	*Nº census tracts*	*% census tracts*	*Census tracts vulnerability degree (% per grade)*			*% census tracts vulnerability degree*		
			Higher	*Intermediate*	*Lower*	*Higher*	*Intermediate*	*Lower*
Households with public system of treated water supply								
0	1	0,36	1 (1,59)	0	0	0,36	0,00	0,00
1	6	2,17	5 (7,93)	1 (0,75)	0	1,81	0,36	0,00
2	269	97,47	57 (90,48)	132 (99,25)	80 (100)	20,65	47,83	28,99
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Households with sanitary sewer collection system								
0	19	6,89	15 (23,81)	4 (3,01)	0	5,44	1,45	0,00
1	15	5,43	8 (12,70)	5 (3,76)	2 (2,50)	2,90	1,81	0,72
2	242	87,68	40 (63,49)	124 (93,23)	78 (97,50)	14,49	44,93	28,26
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Households with garbage collection service								
0	0	0,00	0	0	0	0,00	0,00	0,00
1	4	1,45	4 (6,35)	0	0	1,45	0,00	0,00
2	272	98,55	59 (93,65)	133 (100)	80 (100)	21,38	48,19	28,98
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Householders with low income (up to 2 minimum wages)								
0	212	76,81	62 (98,41)	113 (84,96)	37 (46,25)	22,47	40,94	13,40
1	59	21,38	1 (1,59)	20 (15,04)	38 (47,50)	0,36	7,25	13,77
2	5	1,81	0	0	5 (6,25)	0,00	0,00	1,81
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Householders with intermediate income (from 2 to 5 minimum wages)								
0	0	0,00	0	0	0	0,00	0,00	0,00
1	220	79,71	42 (66,67)	108 (81,20)	70 (87,50)	15,22	39,13	25,36
2	56	20,29	21 (33,33)	25 (18,80)	10 (12,50)	7,61	9,06	3,62
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Householders with high income (more than 5 minimum wages)								
0	234	84,78	61 (96,82)	126 (94,74)	47 (58,75)	22,11	45,65	17,02
1	38	13,77	2 (3,18)	7 (5,26)	29 (36,25)	0,72	2,54	10,51
2	4	1,45	0	0	4 (5,00)	0,00	0,00	1,45
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Literate householders with 10 years old or more in private households								
0	92	33,33	43 (68,25)	44 (33,08)	5 (6,25)	15,58	15,94	1,81
1	92	33,33	17 (26,99)	53 (39,85)	22 (27,50)	6,16	19,20	7,97
2	92	33,33	3 (4,76)	36 (27,07)	53 (66,25)	1,09	13,04	19,20
Total	***276***	***100***	***63***	***133***	***80***	***22,83***	***48,19***	***28,98***

Table 3 shows the frequency and percentage of census tracts according to health score values and vulnerability degrees, considering health indicators variables. In general, it was observed a large influence of census tracts which score is 0 in the group with higher health vulnerability degrees. In the variable "Mortality rate by tertiles", score 0 was assigned to the largest number of census tracts within the variable (98) and contributed with the highest percentage ratio (53.97% or 34 census tracts) among the 63 high-vulnerable census tracts. Of these, 23 had score 0 also for PHCSH rate, 18 also for TB incidence rate, 13 also for both indicators and five also for access to PHCU.

Table 3: Distribution of frequency and respective percentages of census tracts according to the categorization in scores and health vulnerability degrees, in relation to health indicators variables, Divinópolis, 2015.

Score value	*Nº censos tracts*	*% censos tracts*	*Census tracts vulnerability degree (% per grade)*			*% census tract vulnerability degree*		
			Higher	*Intermediate*	*Lower*	*Higher*	*Intermediate*	*Lower*
Mortality incidence rate per tertile								
0	98	35,51	34 (53,97)	45 (33,83)	19 (23,75)	12,32	16,31	6,88
1	97	35,14	19 (30,16)	57 (42,86)	21 (26,25)	6,88	20,65	7,61
2	81	29,35	10 (15,87)	31 (23,31)	40 (50,00)	3,63	11,23	14,49
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
PHCSH incidence rate per tertile								
0	96	34,78	44 (69,84)	44 (33,08)	8 (10,00)	15,94	15,94	2,90
1	56	20,29	11 (17,46)	30 (22,56)	15 (18,75)	3,99	10,87	5,43
2	124	44,93	8 (12,70)	59 (44,36)	57 (71,25)	2,90	21,38	20,65
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
TB incidence rate per tertile								
0	96	34,78	34 (53,97)	51 (38,35)	11 (13,75)	12,32	18,48	3,98
1	65	23,55	13 (20,63)	31 (23,31)	21 (26,25)	4,71	11,23	7,61
2	115	41,67	16 (25,40)	51 (38,35)	48 (60,00)	5,80	18,48	17,39
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***
Distance to PHCU by location of census tract's centroid								
0	100	36,23	35 (55,55)	43 (32,33)	22 (27,50)	12,68	15,58	7,97
1	143	51,82	23 (36,51)	76 (57,14)	44 (55,00)	8,34	27,54	15,94
2	33	11,95	5 (7,94)	14 (10,53)	14 (17,50)	1,81	5,07	5,07
Total	***276***	***100***	***63 (100)***	***133 (100)***	***80 (100)***	***22,83***	***48,19***	***28,98***

Similarly, the variable "*TB incidence rate per tertiles*" concentrated low and intermediate scores in 58.33% of studied census tracts. Score 0 was responsible for the highest percentage in the composition of the most vulnerable group (53.97% or 34 census tracts). Of these, 18 presented the same score value also for PHCSH rate, 18 also for mortality rate, 13 also for both indicators, and 24 also for access to PHCU.

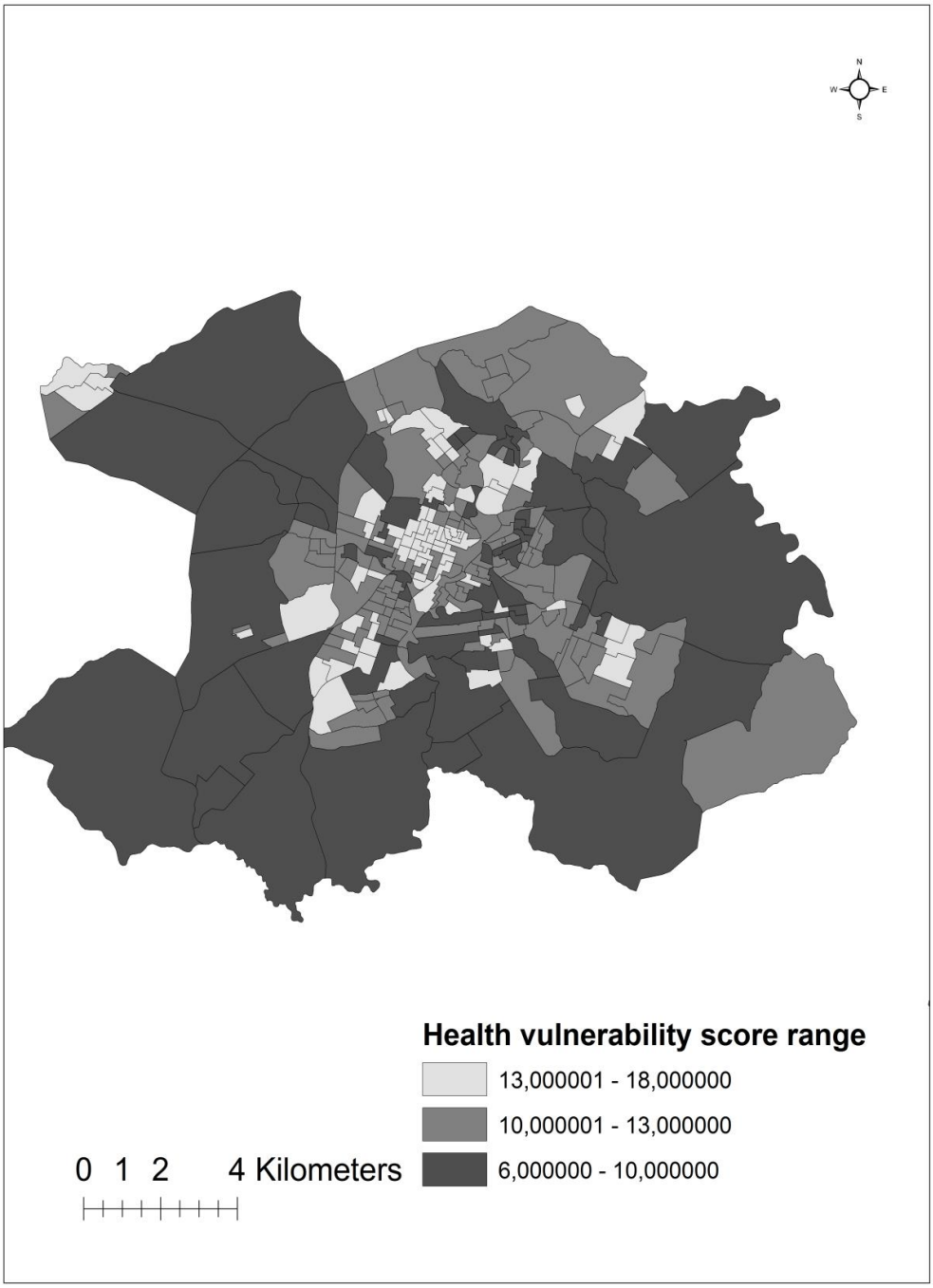
The distribution of PHCSH rates indicated that intermediate and low score values predominated in 152 (55.07%) of the analyzed census tracts. 44 census tracts with score 0 for PHCSH rate represented, in relation to the other health indicators, the highest percentage ratio (69.84%) among the most

vulnerable group; of these, 23 presented score 0 also for mortality rate, 18 also for TB incidence rate, 13 for both indicators and 21 also for access to PHCU.

It was observed, respected to the estimation of access to PHCU by location of census tract's centroid, that 35 census tracts with score 0 (55.55%) are among the 63 of worst group: 24 of them had score 0 also for TB, 21 also for PHCSH; 14 also for both indicators; and five also for mortality as well. Considering 176 census tracts whose centroids are in buffers, there were 33 (18.75%) with centroids closer to ESF-type units (score 2).

The choropleth map in Figure 3 shows the spatial distribution of census tracts of urban situation, grouped according to their health vulnerability degree ranges.

Figure 3: Choropleth map showing the spatial distribution of census tract classes according to their health vulnerability score range, Divinópolis, 2015



DISCUSSION

Regarding the sanitation variables, the results showed, in general, high coverage rates for water supply, garbage collection and, to a lesser extent, for sewage collection. The first two showed similar behavior, with non-discriminatory effect on the configuration of intra-urban differentials, showing that they had little influence on the increasing of health vulnerability degree.

However, the impact of low sewer collection rates on a significant number of census tracts among those most vulnerable should be considered, as a reflection of Brazilian conjuncture in relation to lacks in budget and planning for sanitary policies, even perceived in low coverage rates of sewage collection and treatment services, despite overall increasing of public investments during recent years [18, 19, 20].

High sanitation coverage levels contrast with mostly intermediate, low income levels. Census tracts with score 0 for income and literacy variables were the most frequent among those of higher vulnerability. Lacerda *et al*. [5] showed that 71% of census tracts in Florianópolis (SC) had good sanitation, literacy and income conditions, and that most census tracts in the central region exhibited high levels for income, water supply, and garbage/sewage collection. However, population with worst life conditions was also distributed in those areas. Pazó *et al*.[21] observed population groups in midsized cities (between 100,000 and 300,000 inhabitants) with per capita income of up to R$636.00 (20% with up to half a minimum wage) living within areas with water coverage rates around 88%.

These data are in line to the findings of Vlahov *et al*. [6] on urbanization and health, which pointed out an inconsistency in the understanding of "urban development". High development rates may not necessarily lead to improvements for populations' health. Urbanization is strongly associated with the emergence of inequities in areas such as slums and agglomerates, whose populations, permanently excluded and exposed to social and health risks, live within or close to areas of high socioeconomic and sanitary patterns. Assessing socioeconomic development based on infrastructure and sanitary coverage services may lead to a distortion of perception or difficulties in identifying other aspects and situations of health vulnerability.

Problems for accessing health services are often associated with intra-urban differentials, generating inequities manifested in different aspects: delaying diagnoses; restricting access to PHCU; or reducing adherence to clinical protocols [9, 12, 15, 22]. A significant number of census tracts with score 0 for access to PHCU made this health variable, among all the others, the one that had more census tracts with worst evaluation (100), many of them also bad evaluated for TB, PHCSH and mortality rates, suggesting association between them and access restriction to health units. Souza *et al*. [15] observed in three Brazilian capitals a higher incidence of tuberculosis where health services suffered the negative interference of distance and access restriction to health units.

Low levels of population coverage by primary healthcare may be associated with high rates of PHCSH. According to Cardoso *et al*. [8], Brazil has 27% of hospitalizations classified as PHCSH, surpassing rates such as those of Costa Rica (10.8%), Colombia (21.6%) and the average index (14.3%) of six Latin American countries. Divinópolis had the highest PHCSH rate (41%) among all the thirteen municipalities of its micro-region, and still had a low index of census tracts with access to ESF-type units (18.75%). It was already estimated in 27.5% the percentage of health units in Divinópolis that operate according to ESF precepts, with defined population and territory, which is significantly lower than the macro-regional rate (82.4%).

Marques *et al*. [13] showed a drop of 10.4% in PHCSH rates in the State of Rio de Janeiro between 2000 and 2010, the same period in which ESF coverage increased from 3.6% to 23.6%, and observed a negative correlation between PHCSH and ESF coverage rate. Ceccon *et al*. [9] associated ESF coverage and depletion of PHCSH in ten Brazilian states (38.4%). Macinko *et al*. [7] obtained 13% lower PHCSH rates in Brazilian municipalities where territorial expansion of ESF is higher.

The most vulnerable census tracts invariably showed expressive percentage influences of census tracts with score 0 for all health indicators variables. Many census tracts worst evaluated for mortality, for example, were also for TB, PHCSH, both rates and access to PHCU, as well as for each other in relation to the rest.

The influence of health indicators variables on vulnerability points to structural and conjunctural aspects whose confrontation is crucial to target well-successful health policies. Some health indicators in Divinópolis can be considered as worrying, imposing for municipal administration challenges to expand and spread out the appropriation of health territories by health units and services.

Epidemiologic studies may constitute important tools for formulating, implementing and evaluating public health policies [23]. Based on epidemiologic data, public authorities can formulate and implement health promotion strategies, linking sanitary and environmental policies and actions to socioeconomic, educational, cultural and income-generating ones.

CONCLUSION

The proposed methodology allowed categorizing and classifying the studied census tracts by constructing health vulnerability scores based on available databases, from which it was possible to identify and map intra-urban differentials of health vulnerability. By its relative operational accessibility, score classification methodology seemed to be a fairly simple, adaptable and replicable tool, with wide-range applicability in public administration.

Health vulnerability was greater mainly where low levels of income and householders literacy predominate. Health indicators have also significantly contributed on increasing vulnerability, identified even in areas with high levels of infrastructure and sanitation coverage.

There is evidence of a range of associations between high health vulnerability, low health services coverage, high PHCSH rates and access restriction to PHCU. New studies should deepen knowledge on municipal health and support decisions of public administration and communities.

REFERENCES

1. BARATA, R. B. Causalidade e epidemiologia. *Hist Cienc Saude Manguinhos* 1997; 4(1):31-49. ISSN 0104-5970. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/11625167>. Accessed in: 2014 Aug 23.

2. CARVALHO, M. S. *Aplicação de métodos de análise espacial na caracterização de áreas de risco à saúde*. [thesis]. Rio de Janeiro: COPPE/ UFRJ; 1997.

3. SERAFIM, J. A. *Geoprocessamento no SUS: o que é e como utilizar os sistemas atuais*. [monography]. Rio de Janeiro: IMS/UERJ; 2002.

4. BONITA, R.; BEAGLEHOLE, R,; KJELLSTRÖM, T. *Epidemiologia básica*. São Paulo: Organização Mundial de Saúde (OMS); 2010.

5. LACERDA, J. T.; CALVO, M. C.; FREITAS, S. F. Diferenciais intraurbanos no Município de Florianópolis, Santa Catarina, Brasil: potencial de uso para o planejamento em saúde. *Cad Saude Publica* 2002; 18(5):1331-1338. ISSN 0102-311X. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/12244366>. Accessed in: 2014 Jul 03.

6. VLAHOV, D.; FREUDENBERG, N.; PROIETTI, F.; OMPAD, D.; QUINN, A.; NANDI, V.; GALEA, S. Urban as a determinant of health. *J Urban Health*, 2007; 84(3)(Suppl):16-26. ISSN 1099-3460. Availble from: <http://www.ncbi.nlm.nih.gov/pubmed/17356903>. Accessed in: 2014 Aug 23.

7. MACINKO, J. *et al*. Major expansion of primary care in Brazil linked to decline in unnecessary hospitalization. *Health Aff* 2010; 29(12):2149-2160. ISSN 0278-2715.

8. CARDOSO, C. S.; PÁDUA, C. M.; RODRIGUES-JÚNIOR, A. A.; GUIMARÃES, D. A.; CARVALHO, S. F.; VALENTIN, R. F.; ABRANTES, R.; OLIVEIRA, C. D. L. Contribuição das internações por condições sensíveis à atenção primária no perfil das admissões pelo sistema público de saúde. *Rev Panam Salud Publica* 2013; 34(4):227-234. ISSN 1680-5348. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/24301733>. Accessed in: 2014 Nov 29.

9. CECCON, R. F.; MENEGHEL, S. N.; VIECILI, P. R. Hospitalization due to conditions sensitive to primary care and expansion of the Family Health Program in Brazil: an ecological study. *Rev Bras Epidemiol* 2014; 17(4):968-977. ISSN 1415-790X. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/25388495>. Accessed in: 2015 May 11.

10. MENDES, E. V. A construção social da vigilância saúde no distrito sanitário. In: (Ed.). *Série Desenvolvimento de Serviços de Saúde: Organização Panamericana da Saúde*. [Brasília]: WHO Regional Office; 1993. p.7-19.

11. PAIM, J. S. A reorganização das práticas de saúde em distritos sanitários. In: (Ed.). *Saúde em Debate*: HUCITEC; 1993. p.187-220.

12. KHOONG, E. C.; GIBBERT, W. S.; GARBUTT, J. M.; SUMNER, W.; BROWNSON, R. C. Rural, suburban, and urban differences in factors that impact physician adherence to clinical preventive service guidelines. *J Rural Health* 2014; 30(1):7-16. ISSN 1748-0361. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/24383480>. Accessed in: 2015 May 11.

13. MARQUES, A. P.; MONTILLA, D. E. R.; ALMEIDA, W. S.; ANDRADE, C. L. T. Internação de idosos por condições sensíveis à atenção primária à saúde. *Rev Saude Publica*, v. 48, n. 5, p. 817-826, 2014. ISSN 1518-8787.

14. DE ABREU E SILVA, M. A. *Tendência da tuberculose no município de Divinópolis-MG, de 2002 a 2012*. [dissertation]. Divinópolis: Mestrado em Ciências da Saúde, Universidade Federal de São João del-Rei; 2014.

15. SOUZA, M. S. *et al*. Fatores associados ao acesso geográfico aos serviços de saúde por pessoas com tuberculose em três capitais do Nordeste brasileiro. *Cad Saude Publica* 2015; 31(1):111-120. ISSN 1678-4464. Availble from:

<http://www.ncbi.nlm.nih.gov/pubmed/25715296>. Accessed in: 2015 May 11.

16. DIVINÓPOLIS. SECRETARIA MUNICIPAL DE SAÚDE. *Plano Municipal de Saúde 2014/2017*. Divinópolis: SEMUSA; 2014.

17. FUNDAÇÃO INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). *Base de informações do Censo Demográfico 2010: resultados do universo por setor censitário*. Rio de Janeiro, 2010. Availble from:

<http://downloads.ibge.gov.br/downloads_estatisticas.htm>. Accessed in: 2014 Oct 14.

18. BREVIDELLI, M. M.; FREITAS, F. C. G. D. Estudo ecológico sobre o desenvolvimento da saúde no Brasil. *Cien Saude Colet* 2012; 17(9):2471-2480. ISSN 1413-8123.

19. CARNEIRO, F. F.; NETTO, G. F.; CORVALAN, C.; FREITAS, C. M.; SALES, L. B. F. Saúde ambiental e desigualdades: construindo indicadores para o desenvolvimento sustentável. *Cien Saude Colet* 2012; 17(6):1419-1425. ISSN 1413-8123.

20. REZENDE, S. C.; HELLER, L. *O saneamento no Brasil: políticas e interfaces*. Belo Horizonte: Editora UFMG; 2008.

21. PAZÓ, R. G.; FRAUCHES, D. O.; MOLINA, M. C. B.; CADE, N. V. Modelagem hierárquica de determinantes associados a internações por condições sensíveis à atenção primária no Espírito Santo, Brasil. *Cad Saude Publica* 2014; 30(9):1891-1902. ISSN 0102-311X.

22. BUZZA, C.; ONO, S. S.; TURVEY, C.; WITTROCK, S.; NOBLE, M.; REDDY, G.; KABOLI, P. J.; REISINGERH, S. Distance is relative: unpacking a principal barrier in rural healthcare. *J Gen Intern Med* 2011; 26(Suppl 2):648-654. ISSN 1525-1497. Availble from: <http://www.ncbi.nlm.nih.gov/pubmed/21989617>. Accessed in: 2014 May 11.

23. BARATA, R. B. Epidemiologia e políticas públicas. *Rev Bras Epidemiol* 2013; 6(1):3-17**.** ISSN 1415-790X.