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Socioeconomic variables and dengue transmission

ABSTRACT

OBJECTIVE: To evaluate the relationship between risk of occurrence of dengue and socioeconomic level.

METHODS: All confirmed autochthonous cases of dengue between September 1990 and August 2002 were geocoded and grouped according to the urban census tracts of the municipality of São José do Rio Preto, Southeastern Brazil. A socioeconomic factor generated by principal component analysis was used to group census tracts into four socioeconomic levels. Incidence rates were calculated for each year and four-year period for each of the census sectors, considering the period from September of one year to August of the next. Thematic maps of sectors, grouped into each of the four socioeconomic levels and their respective disease incidences, are presented.

RESULTS: Principal component analysis generated a socioeconomic factor that accounted for 87% of total variation. This factor was associated with dengue incidence only for the 1994-95 period.

CONCLUSIONS: The lack of an association between risk of occurrence of dengue and socioeconomic levels in almost all years studied indicates that this issue deserves further study, and may vary depending on the settings found in each municipality. It will be important to determine the spatial relationship between dengue transmission and other variables, such as degree of immunity in the population, effectiveness of control measures, degree of infestation by the vector; and population habits and behaviors, among others.

KEY WORDS: Dengue, epidemiology. Risk factors. Socioeconomic factors. Geographic information systems.

INTRODUCTION

Dengue, an infectious disease whose most severe form is dengue hemorrhagic fever, is regarded as being in intense expansion around the globe.[16] Roughly three billion people are at risk of contracting the dengue virus and annually 50-100 million cases of classical dengue and 500 thousand cases of hemorrhagic fever are registered, with mortality reaching 5% of the latter.* Dengue is therefore a problem also from the viewpoint of public health, generating millions of dollars in expenditures every year.[16]

The dengue virus is numerically the most important human arbovirus. It comprises four different serotypes (DENV 1, 2, 3, and 4), transmitted in the urban environment by the *Aedes aegypti* mosquito.[18] This vector is widely associated with human activity, which, by generating artificial oviposition sites, allows for infestation to be maintained. Given the influence of organized social space on the interaction among vector, virus, and man, urban centers favor dispersion and increased density of mosquitoes.[20]

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* World Health Organization. Dengue factsheet, 2005. Geneva; 2005. [6/6/2006] Available from: http://www.who.int/mediacentre/factsheets/fs117/en/

Several risk factors are associated with the presence of both vector and disease. Tauil[21] highlights as fundamental factors in defining transmission patterns populational growth, migrations, air travel, inadequate urbanization, poor health care systems, and high population density.

Brazil accounted for 56% of all dengue cases notified in the Americas between 2001 and 2005.* In 2005, 241,796 cases of classical dengue and 43 deaths due to dengue hemorrhagic fever were registered. In relation to the previous year, there was an approximately 95% increase in national average.** The pattern of dengue in Brazil is cyclic, with higher incidence in some years and lower incidence in others. Such a trend also seen in the state of São Paulo, where 3,049 and 5,433 cases of dengue were registered in 2004 and 2005, respectively, and 5,767 cases were registered between January and April 2006.***

A study**** conducted in the Northwestern region of the state which included the municipality of São José do Rio Preto confirmed both this cyclic trend and the importance of medium-sized cities as sites with greater probability of occurrence of the disease, playing the role of radiators of transmission. Mondini et al[13] characterized the process of endemization of dengue in São José do Rio Preto, showing that disease transmission is not uniform throughout the municipality. Further investigation is required to determine the role of human populations and their socioeconomic conditions in maintaining vector infestation and viral circulation.[20] Thus, the objective of the present study was to evaluate the relationship between risk of occurrence of dengue and socioeconomic level in urban census tracts.

METHODS

São José do Rio Preto is one of the Brazilian cities where quality of life is comparable to that of developed countries. The city is located in the northwest of the state of São Paulo, distant 452 km from the state capital, and at 489 m above sea level (20º49'1" latitude South and 49º22'46" longitude West). The total area of the municipality is 434.10 km^2, and that of the urban area, 96.1 km^2. The city's estimated population for 2006 was 406,863 inhabitants. The climate in São José do Rio Preto is tropical, with a mean temperature of 25ºC and annual rainfall of about 1,410 mm.

The dengue vector reappeared in the municipality in 1985 and, in this year and in 1989, only imported cases of the disease were recorded. The first autochthonous cases of the disease occurred in 1990, when the DEN 1 virus was introduced. Serotypes DEN2 and DEN 3 were introduced in 1997 and 2003, respectively.*****

The database included all autochthonous dengue cases notified to the Municipal Secretariat of Health and Hygiene of São José do Rio Preto between September 1994 and August 2002 and confirmed by laboratory diagnosis by the Instituto Adolfo Lutz. We considered the date of onset of symptoms as the case date.

Geocoding of autochthonous dengue cases was done using ArcGis 9.0 software (ESRI) and the São José do Rio Preto Cartographic Base (in Universal Transverse Mercator (UTM) projection) with street axes provided by the Municipal Government. After geocoding, cases were grouped into the 432 census tracts in the urban area, according to the *Instituto Brasileiro de Geografia e Estatística* (IBGE – Brazilian Institute for Geography and Statistics).****** We chose to use census tracts as the clustering level for evaluating transmission because these are geographically limited and show homogeneous characteristics.

Socioeconomic variables included in the principal component analysis were selected according to a study carried out by Sposati******* and modified by Vendramini et al.[24] Variables were provided by IBGE****** and are related to income and mean years of schooling of heads of household; income and mean years of schooling of women heads of household; proportion of illiterate persons and women; and proportion of households with five or more members. The choice of using socioeconomic data pertaining to the year 2000 was a methodological strategy employed to minimize any errors that might arise from the incompleteness of data for analysis. This was due to the increase in the number of census tracts between 1990 and 1994; therefore, the use of data from before this period would not contemplate new regions that were created in the municipality.

Principal component analysis using Stata 7.0 software generated a number of factors, from which we selected that which accounted for the greatest proportion of total variance; this was termed the socioeconomic factor. This factor was used to characterize census tracts, so that the higher its value, the better the socioeconomic

* Pan American Health Organization. 2005: Number of reported cases of dengue & dengue hemorraghic fever (DHF), region of Americas (by country and subregion). [6/6/2006] Available from: http://www.paho.org/English/AD/DPC/CD/dengue-cases-2005.htm
** Ministério da Saúde. Secretaria de Vigilância em Saúde. Brasília; 2007: Gráficos de evolução das doenças (1980 – 2005). [29/10/2007] Available from: http://portal.saude.gov.br/portal/saude/visualizar_texto.cfm?idtxt=25340
*** Secretaria de Estado da Saúde de São Paulo. Centro de Vigilância Epidemiológica "Prof. Alexandre Vranjac", unpublished data.
**** Pereira CA. Transmissão de dengue na região noroeste do estado de São Paulo [master's dissertation]. São Paulo: Faculdade de Medicina de São José do Rio Preto; 2005.
***** Instituto Adolfo Lutz, unpublished data.
****** Statcart. Version 1.1 [software in CD ROM]. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2002.
******* Sposati A. Mapa da exclusão/inclusão social da cidade de Santo André. Santo André: Pontifícia Universidade Católica de São Paulo; 2000. [Accessed on 8/4/2005] Available from: http://www.dpi.inpe.br/geopro/exclusao/oficinas/mapa2000.pdf

level of its inhabitants. Its value for a given census tract was calculated by multiplying the value of each of the variables by their respective factorial weights obtained through principal component analysis and by the sum of the results obtained. Based on the factor generated, census tracts were grouped into quartiles. Tracts with the highest values were defined as level 1, and those with the lowest, as level 4, representing the best and worst socioeconomic groups, respectively. Tracts showing intermediate values were defined as levels 2 and 3, representing intermediate socioeconomic strata.

Each one-year period extended from September of one year to August of the next. This division allows for adequate representation of the seasonality of the disease, since August and September are the months in which the incidence of dengue is lowest in relation to the remaining months of the year. The period from January to April shows the greatest disease incidence, coinciding with the increase in rainfall.

Annual incidence coefficients were calculated by dividing the total number of cases in each period by the respective population estimates and multiplying the result by 100,000. We thus obtained a time series of annual incidences for each of the groups of census tracts.

Quadrennial incidence coefficients were calculated by dividing the total number cases in each group of years by the respective estimated population and multiplying the result by 100,000. We obtained a quadrennial series of dengue coefficients for September-August periods between 1994 and 2002 for the four groups of census tracts. All annual population estimates were obtained from Datasus.*

Finally, we generated thematic maps using ArcGis 9.0 software (ESRI) based on the network of census sectors, showing the four groups of sectors and their respective disease incidence coefficients.

RESULTS

Of a total 14,431 autochthonous cases of dengue occurred in the urban area, 13,998 were geocoded. The reasons for our inability to geocode 433 cases (3%) were the lack of an address or discrepancy between address and the cartographic base.

Principal component analysis with the socioeconomic variables used produced a socioeconomic factor which accounted for 87% of the total variation. This factor may be interpreted as a score comprising the following components: 0.97 x (mean years of schooling of heads of household) + 0.94 x (mean years of schooling of women heads of household) + 0.85 x (mean income of heads of household) + 0.85 x (mean income of women heads of household) + (-)0.89 x (proportion of illiterate persons) + (-) 0.89 x (proportion of illiterate women) + (-)0.56 x (proportion of household with five or more members). Table 1 presents the characteristics of each of the groups of census tracts obtained based on the socioeconomic factor.

Figure 1 shows the maps generated using the socioeconomic factor and the respective disease incidences for each of the levels, for two distinct time periods. We highlight the fact that, in 1994-95, the socioeconomic component was relevant for the incidence of dengue in a number of sectors, risk of disease in level 4 tracts being approximately 2.7-fold greater than in level 1 tracts. Figure 1 also shows the incidences for the four-year period between 1994 and 1998, which includes the 1994-95 period. In this first four-year period, the socioeconomic component did not emerge as a predominant factor in dengue incidence in the municipality's different census tracts.

Figure 2 shows the map for 2000-2001, which showed the greatest incidence of dengue within the studied time-series, as well as the study's final four-year period (1998-2002). In 1998-2002, incidences were not related to the socioeconomic component, given that the highest incidences were found in levels 2 and 1, groupings corresponding to medium and high socioeconomic levels, respectively.

Table 2 presents incidences for all periods between 1994 and 2002, as well as for the two four-year periods, according to the division of the municipality into quartiles. A similar trend is seen across all periods (with the exception of 1994-95), with dengue transmission being independent of socioeconomic strata and even showing higher incidence in higher level sectors, as seen for 1997-98, 1999-2000, 2000-01, and 2001-02.

DISCUSSION

Organized social space is of great importance for the study of disease incidence and prevalence. Upon the identification of homogeneous areas, collective measures for the prevention of disease can be emphasized, increasing their impact on the affected areas.[6,8]

The construction of an indicator of urban risk of dengue transmission is of great importance in terms of control strategies. Braga et al[3] and Marzochi[11] highlight the influence of a variety of elements in the transmission process and the consequent need for a holistic evaluation of the phenomenon in endemic areas such as São José do Rio Preto.[13] One of these elements is the socioeconomic level of the population. Studies on this topic show conflicting results, for the relationship between

* Ministério da Saúde. DATASUS. Brasília; 2007: Informações de Saude – Demograficas e Socioeconomicas. [Accessed on 10/29/2007] Available from: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?ibge/cnv/popsp.def

Table 1. Socioeconomic and sanitation characteristics of the four groups of urban census tracts. São José do Rio Preto, Southeastern Brazil, 2000.

Variable	Census tract grouping			
	I	II	III	IV
Mean years of schooling of heads of household	10.8	7.9	6.5	5.3
Mean years of schooling of women heads of household	10	7.2	5.8	4.6
Mean income (in reais*) of heads of household	2,401.42	1,046.99	690.03	465.20
Mean income (in reais*) of women heads of household	1,510.40	687.20	453.60	298.50
Proportion of illiterate heads of household (%)	3.2	5.8	8.1	11.3
Proportion of illiterate women heads of household (%)	3.6	6.6	9.2	12.4
Proportion of households with 5 or more members (%)	13.7	15.5	17.2	23.5
Proportion of households with piped water (%)	100.0	99.8	99.9	99.9
Proportion of households with sewage (%)	99.9	99.8	99.3	99.2
Proportion of households with regular garbage collection (%)	99.9	99.9	99.3	99.7

* Values as of September 2000

Table 2. Dengue incidence coefficients* according to period and socioeconomic grouping. São José do Rio Preto, Southeastern Brazil, 1994-2002.

Period	Socioeconomic grouping			
Year/Four-year period	Level 1	Level 2	Level 3	Level 4
1994-1995	245.8	349.8	398.8	658.8
1995-1996	564.8	520.7	438.2	582.3
1996-1997	61.5	37.0	73.8	72.6
1997-1998	232.0	223.9	167.7	195.0
1998-1999	761.5	864.0	678.3	1,001.6
1999-2000	160.4	183.4	126.1	66.6
2000-2001	1,919.5	2,210.1	1,906.4	1,762.5
2001-2002	282.2	332.1	280.7	218.7
1994-1998	1,104.5	1,125.3	1,067.7	1,485.7
1998-2002	3,169.1	3,642.6	3,038.1	3,083.8

* per 100,000 population

dengue transmission, measured either as incidence or prevalence, and socioeconomic level is controversial.

Pontes,* in Ribeirão Preto, SP, Medronho,[12] in Rio de Janeiro, RJ, Caiaffa et al,[4] in Belo Horizonte, MG, and Siqueira et al,[19] in Goiânia, GO, showed a positive association between greater risk of dengue and worse socioeconomic level among the population. Costa & Natal,[7] in an evaluation of dengue transmission in São José do Rio Preto, SP, in 1995, identified a similar relationship, which is in agreement with the results of the present study for the period between September 1994 and August 1995.

Reiter et al,[17] in a study of two neighboring cities (Nueva Laredo, in Mexico, and Laredo, in the United States), identified greater incidence of dengue in the Mexican city, even though abundance of the *Aedes aegypti* vector was greater in the American city. These authors attributed such a paradox to economic factors, such as greater use of air conditioning in Laredo. Oliveira & Valla[15] discussed the relationship between popular mobilization and dengue control, indicating a relationship between precariousness of basic sanitation services Rio de Janeiro slums and the emergence of dengue epidemics.

However, other studies show discrepant results. Vasconcelos et al[23] found greater prevalence of dengue in the population with higher income and schooling in Fortaleza, CE. The authors explained this finding as a consequence of the habit, among people from more favored classes, of growing aquatic plants and using disposable items. Similar results were reported by Vasconcelos et al[22] in São Luís, MA. Teixeira et al,[20] studying the city of Salvador, BA, found high rates of seroincidence across all areas and socioeconomic levels studied, concluding that the risk of contracting dengue is similar in all areas of the city. Bartley et al,[2] in a study of the seroprevalence of dengue and Japanese encephalitis in South Viet Nam, failed to detect an association between these diseases and educational levels or owning a television set. Espinoza-Gomés et al[10] also failed to find a correlation between recent dengue infection and socioeconomic level in the city of Colima, Mexico.

In the case of São José do Rio Preto, socioeconomic variables were explanatory for the incidence of dengue in the period between 1994 and 1995, a result which is coherent with that of Costa & Natal.[7] However, this relationship did not hold true for subsequent years.

* Pontes RJS. Estudo da epidemia de dengue no município de Ribeirão Preto, SP, 1991-1992 [Doctorate thesis]. Ribeirão Preto: Faculdade de Medicina de Ribeirão Preto da USP; 1992.

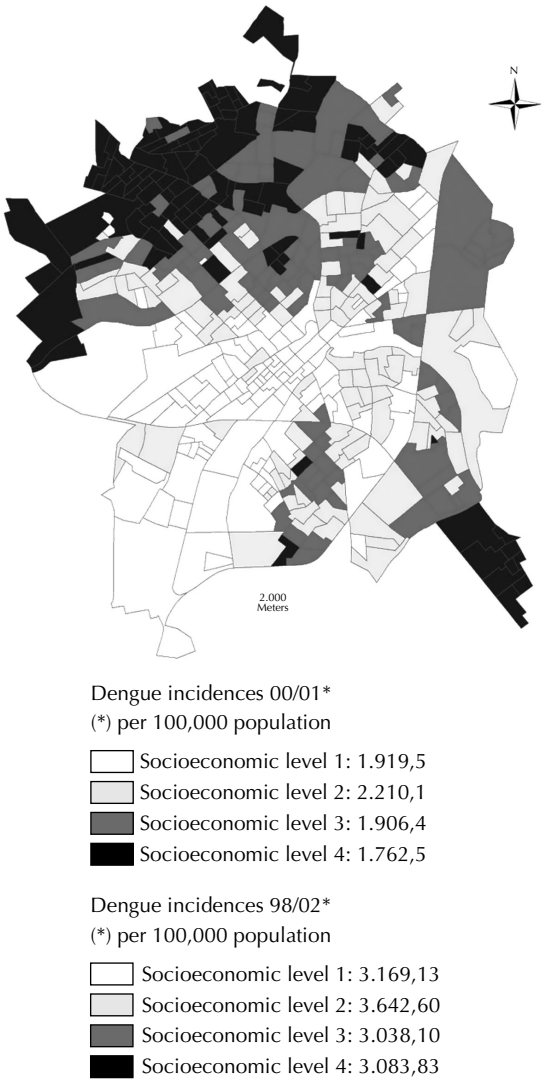

Figure 1. Map of dengue incidence coefficients according to socioeconomic grouping. São José do Rio Preto, Southeastern Brazil, 1994/1995 (year) and 1994/1998 (quadrennium).

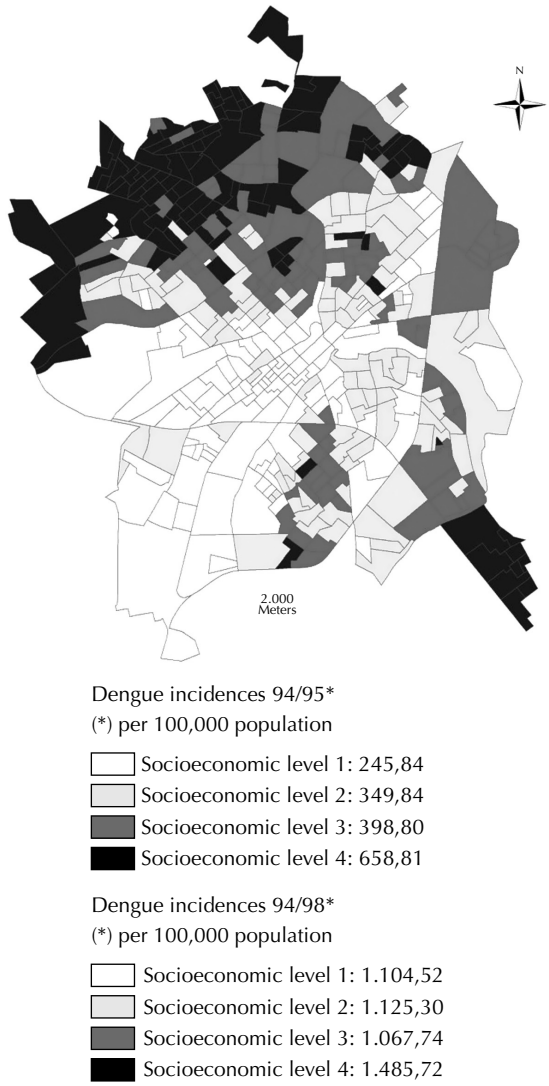

Figure 2. Map of dengue incidence coefficients according to socioeconomic grouping. São José do Rio Preto, Southeastern Brazil, 2000/2001 (year) and 1994/1998 (quadrennium).

A first issue to be raised is whether the four groupings of census tracts indeed represent distinct socioeconomic areas. An analysis of Table 1 shows that the socioeconomic characteristics of the four groupings are coherent with the classification adopted. Such a division is also found in a study of the incidence of tuberculosis in São José do Rio Preto, a disease acknowledgedly associated with socioeconomic factors. This study[24] used the same groupings of census tracts used here, and showed that the highest rates could be found in areas with worse socioeconomic status. Thus the problem is not related to the division adopted.

Table 1 itself may reveal the reasons why socioeconomic level was not an explanatory factor for the occurrence of dengue in São José do Rio Preto. In spite of the differences in terms of socioeconomic characteristics between the four groups, from the standpoint of variables representing basic sanitation, all sectors show favorable conditions, the proportion of households with water, sewage, and regular garbage collection being above 99%. Such high coverage could explain both the similarity in dengue incidence between tracts in São José do Rio Preto and the emergence of dengue epidemics in Rio de Janeiro slums.[15] However, they do not account, for instance, for the lack of a relationship between socioeconomic level and dengue incidence in Salvador, as the study by Teixeira et al[20] included 30 sentinel areas, five of which had less than 50% of households with minimal sanitation conditions. In any case, this is an issue that requires further investigation.

A possible explanation for the discrepancies among the results of the above mentioned studies could be that

some of them are based on information from compulsory notification charts from epidemiological surveillance systems whereas others are based on data from serological studies. However, this seems not to be the case, since all studies were based on both notification data and serology.

An important issue to be discussed are the possible differences in levels of *Aedes aegypti* infestation according to socioeconomic level. Unfortunately, few studies have been conducted in this field. Costa* investigated the relationship between dengue transmission, larval infestation, and socioeconomic levels in São José do Rio Preto, in 1995. Despite having found an association between incidence of dengue and socioeconomic level, infestation, as measured by the Breteau index, did not differ between the different socioeconomic areas investigated.

A study carried out in São José do Rio Preto[9] based on infestation data collected in January 2005 for the urban area of the municipality also failed to identify differences in Breteau indices in regions of varying socioeconomic level. The results of the studies conducted by Costa* and Ferreira & Chiaravalloti-Neto[9] are coherent with the lack of a relationship between dengue and socioeconomic level in the present study.

Still regarding the vector, homes in groupings of sectors with higher socioeconomic level have larger total and constructed areas, which may render more thorough care by residents more difficult. Although homes in level 3 and 4 tracts have smaller total areas, the presence of potential recipients for vector proliferation is greater, since many of these are not discarded for still being useful for the residents, especially for sale or donation.[5]

An issue in need of further clarification is the reason why differences according to socioeconomic level could only be detected in 1994-95, when the first major dengue epidemic took place in São José do Rio Preto. Mondini et al[13] concluded that, in the first quadrimester of that period, dengue transmission began to occur in a few tracts in the north region, later expanding to the rest of the municipality. It is likely that the control measures implemented after the onset of transmission were less effective in this region. Thus, the finding of greater incidence of dengue in tracts of lower socioeconomic level was expected in this period. This would be related to the fact that the north of São José do Rio Preto concentrates the municipality's poorest population, and is where the virus was first introduced.

In any case, the relationship between socioeconomic level and dengue transmission deserves further study, and may vary according to the settings of each municipality. In the case of São José do Rio Preto, it is possible that differences in incidence may be related to other factors of non-socioeconomic nature.

For Barcellos & Bastos,[1] "space is of intrinsic value in the analysis of relationships between health and environment and in its control; knowing the spatial structure and dynamics allows for a characterization of the settings in which health-related events occur." In the present case, this applies to the different incidence rates for dengue found in São José do Rio Preto and other locations. Thus, it will be important to ascertain the presence of spatial relationships between dengue transmission and other variables in addition to socioeconomic level, including degree of population immunity to the circulating viral strain;[14] place of infection (home, school, work); effectiveness of control measures; degree of populational clustering; levels of vector infestation; degree of verticalization of urban constructions; indicators of environmental sanitation; and population habits and attitudes, among others.

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