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Infestation of an urban area by *Aedes aegypti* and relation with socioeconomic levels

ABSTRACT

OBJECTIVE: To assess the association between *Aedes aegypti* larvae infestation rates and socioeconomic factors.

METHODS: Infestation rates in the urban area of the city of São José do Rio Preto, Southeastern Brazil, were calculated in January of 2005 and subsequently geocoded by address. The urban census tracts were grouped by means of main component analysis, thus producing four socioeconomic clusters (1–4, in a decreasing order of socioeconomic level) and a fifth cluster (5) with a level below the others and not belonging to the urban census tracts (new districts and irregular residential development projects). The Breteau index (BI), the house index (HI), and the container index (CI), as well as the averages of existing containers surveyed per home, were calculated for each cluster.

RESULTS: The values of infestation indices did not show significant differences among socioeconomic clusters 1 to 4, even though they were lower than the indices obtained for cluster 5. The averages of existing containers surveyed were higher for cluster 1 in relation to clusters 2 to 4, but did not show significant differences when compared to cluster 5.

CONCLUSIONS: Larval indices did not show association with the different socioeconomic levels of the cluster that corresponds to the urban census tracts. Nonetheless, new districts, irregular residential development projects and locations adjacent to those with the worst basic sanitary conditions showed the highest values for these indicators.

KEY WORDS: ***Aedes aegypti*. Larva, growth & development. Indicators. Insect vectors. Urban zones.**

INTRODUCTION

Effective control of *Aedes aegypti* is feasible, yet difficult. A better understanding of the ecology of the disease could lead to practical results, especially regarding prioritization of vector control in high-risk areas.[17] Some factors influence the mosquito density, such as sanitary conditions and the communities' socioeconomic and cultural aspects. Donalísio & Glasser[5] affirmed that knowledge about these factors is crucial to understand the dengue epidemics and to direct control practices.

The utilization of the Geographical Information Systems (GIS) techniques has enabled to identify high-risk areas more accurately, as long as notified data on suspected dengue cases and vector presence are constantly updated. The greatest potentiality of these systems is to permit the joint analysis of data found in the highest transmission areas, most vulnerable to vectors, as well as the planning of control practices, seeking to optimize the epidemiological and entomological surveillance actions.[2]

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There are few published studies on the association between larval infestation levels and socioeconomic characteristics. This, in addition to the endemic context of dengue fever and urban infestation by *Aedes aegypti* in the city of São José do Rio Preto,[10] enabled to raise the hypothesis that this infestation may occur in distinct regions of the city in different manners, possibly related to socioeconomic factors. By stratifying environments according to larval infestation indices, different strategies could be adopted.

The objective of the study was to analyze the association between spatial variations of larval infestation indices by *Aedes aegypti* and socioeconomic factors.

METHODS

The study was carried out in the city of São José do Rio Preto, in the state of São Paulo's northwest region, at 20º49'11" south latitude and 49º22'46" west longitude, with an area of 434.10 km^2 and a population of 415,509 inhabitants. The local climate is tropical and the average temperature is 25.4ºC, with an average precipitation of about 200mm in the period between October and March.

The city's urban area is comprised of 432 census tracts, according to the division conducted by the *Fundação Instituto Brasileiro de Geografia e Estatística* – IBGE (Brazilian Institute of Geography and Statistics Foundation).* There are also some districts that are within the city's urban boundaries, even though they are not included in the census tracts (new districts), and irregular residential development projects, located in rural areas, adjacent to the urban boundaries.

New districts are characterized by the presence of low income families and, in some cases, slums that were turned into housing projects, though with the minimum basic sanitary conditions (water, sewage system and garbage collection). Irregular residential development projects, despite their being located outside the urban boundaries, are inhabited by low income people, have urban characteristics, and are constituted by plots of land that are generally larger than those in urban areas. Their homes are only provided with (shallow or deep) well water, having neither a collective sewage disposal system (septic tank or untreated open sewage) nor regular garbage collection. Furthermore, the streets are unpaved.

In January of 2005, São José do Rio Preto's Municipal Dengue Control Team conducted a survey on the infestation rate by two-stage cluster sampling[9] (block and building).[1] Municipal team members visited all the houses on the randomly selected blocks, surveyed existing containers, and collected mosquito larvae when these were present. Larva samples were sent to the laboratory of the *Superintendência de Controle de Endemias – Sucen* (Superintendence of Endemic Disease Control) for identification and count. The samples were considered positive if *Aedes aegypti* larvae were found. The data were recorded in bulletins and input into the Aedes 7 program.** After this, all this information was grouped per block and geocoded by block address with the help of the MapInfo program*** and also São José do Rio Preto's Cartographic Basis, in the UTM (Universal Transverse Mercator projection), provided by the City Hall.

The infestation indices utilized were the following:

- Breteau Index (BI) – number of containers with *Aedes aegypti* larvae per 100 homes surveyed;[3]
- House Index (HI) – relation, in percentage, between the number of homes where *Aedes aegypti* larvae were found and the number of homes surveyed;
- Container Index (CI) – relation, in percentage, between the number of containers with water and the positive ones, that is, with the presence of *Aedes aegypti*;[8]
- Average number of existing containers per home – potential recipients for vector breeding, found in a home, with or without water;
- Average number of containers surveyed per home – containers that, at the moment of visit, were found with water, in a home.

All the 432 census tracts were grouped in distinct clusters by means of main component analysis. To carry out this analysis, the following socioeconomic variables were selected: average income and years of education of householders; average income and years of education of female householders; proportion of illiterate women and people; and proportion of households with five or more residents.

The analysis was made by means of the STATA program and it produced several factors, of which the one responsible for the largest proportion of total variation was chosen. The factor value for each census tract was calculated, with each variable value being multiplied by the respective factorial weights obtained from the main component analysis and by the sum of results found. The value of each tract was utilized to divide the area with the 432 census tracts into four clusters, according to socioeconomic levels (quartiles).

Taking into consideration a predicted BI value equal to 15 containers with *Aedes aegypti* larvae per 100 homes surveyed, precision of 1 and alpha error of 5%, the sample size calculated for each of the four census tract

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* Fundação Instituto Brasileiro de Geografia e Estatística. Estatcart 1.1. Rio de Janeiro: IBGE; 2002.
** Superintendência de Controle de Endemias. Aedes versão 7. [software]São Paulo: SUCEN; 2005.
*** MapInfo Professional Version 7.0. New York: MapInfo Corporation; 2002.

clusters was 4,732 homes. This value was increased to 6,760 homes due to an expected proportion of closed homes of 30%. Thus, for the city's entire urban area, the sample size was 27,040 homes.

The geocoded information was initially grouped by census tracts and subsequently by the four socioeconomic tracts. For each cluster, the following indicators were calculated: average of existing containers per home, average of containers surveyed per home, BI, HI, and CI. Thematic maps of the four socioeconomic clusters and BI values referring to the cluster of the urban census tracts were designed.

Some of the information contained in the survey of infestation indices, also grouped per block and geocoded by address, was located outside the census tract's area range. The buildings located in new districts and irregular residential development projects were analyzed as another cluster, distinct from the other four socioeconomic clusters.

The city's urban census tracts were characterized according to socioeconomic levels and in relation to some environmental characteristics (water supply, sewage system and garbage collection). Socioeconomic and environmental information on the buildings located on blocks that were situated in new districts and in irregular residential development projects was not available. To obtain this information, a qualitative characterization by means of local visits was performed.

The values of larval indices (BI, HI, CI) and the average numbers of existing containers and containers surveyed are shown with the respective 95% confidence intervals. The statistical analysis of these values was made by means of a comparison of the respective confidence intervals.

The research project was approved by the Ethics and Research Committee at the *Faculdade de Medicina de São José do Rio Preto* (School of Medicine of São José do Rio Preto).

RESULTS

A total of 22,254 buildings were surveyed. The BI value obtained for the city was 7.8 containers (95%CI: 7.1 – 8.5) with *Aedes aegypti* larvae per 100 homes surveyed.

The database with the infestation indices of surveyed addresses was comprised of 1,451 blocks. Information on all blocks was georeferenced, except for one that was not found. A total of 1,380 blocks out of these 1,450 were grouped according to urban census tracts, while other 70 blocks were analyzed separately as they were outside the area range.

The analysis of main components with the variables utilized produced one factor, here denominated as socioeconomic factor, with 87% of the variation total. The factor characterized the socioeconomic level of urban census tracts, so that the higher its value, the better the socioeconomic level of the residing population. The composition of the factor was the following: 0.97 x (average years of education of householders) + 0.94 x (average years of education of female householders) + 0.85 x (average income of householders) + 0.85 x (average income of female householders) – 0.89 x (proportion of illiterate people) – 0.89 x (proportion of illiterate women) – 0.56 x (proportion of homes with five or more residents).

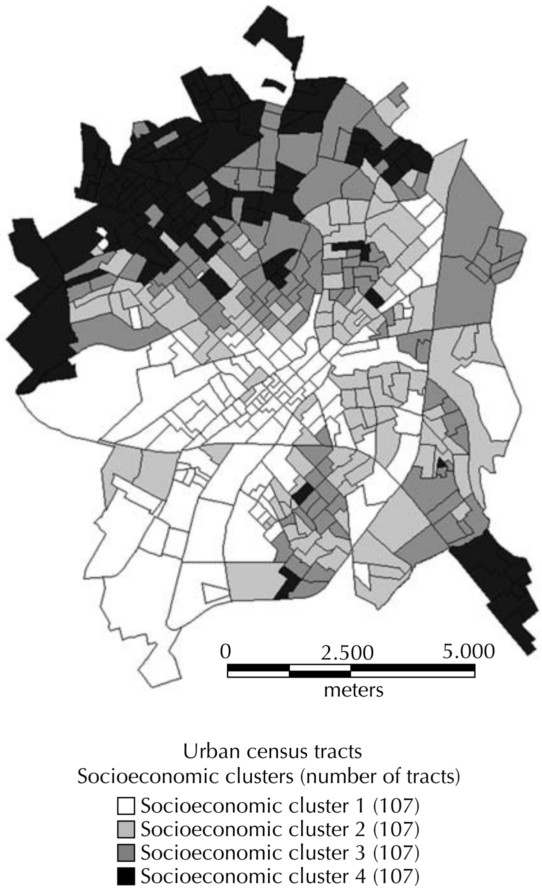

Figure 1. Urban census tracts grouped in socioeconomic clusters. São José do Rio Preto, Southeastern Brazil, 2005.

Four ranges were established for the socioeconomic factor; the grouping with the highest values was denominated Cluster 1 (best socioeconomic level), the grouping of tracts with the lowest values was denominated Cluster 4 (worst socioeconomic level), and the groupings of tracts with intermediate values were denominated Clusters 2 and 3. The grouping result generated a thematic map (Figure 1). The socioeconomic and environmental characterization of the fours clusters is shown on Table.

Table. Socioeconomic and environmental characterization of socioeconomic clusters corresponding to the urban census tracts. São José do Rio Preto, Southeastern Brazil, 2000.

Variable	Socioeconomic cluster			
	1	2	3	4
% of homes with 5 or + residents	13.7	15.5	17.2	23.5
% of people with 5 or + years, illiterate	3.2	5.8	8.1	11.3
% of women with 5 or + years, illiterate	3.6	6.6	9.2	12.4
Average number of years of education of householder	10.8	7.9	6.5	5.3
Average number of years of education of female householder	10.0	7.2	5.8	4.6
Average income of householder (in R$ for September 2000)	2,401.42	1,046.99	690.03	465.20
Average income of female householder (in R$ for September 2000)	1,510.40	687.20	453.60	298.50
% of homes without tap water	0.04	0.23	0.15	0.12
% of homes without general sewage system	0.14	0.22	0.70	0.80
% of homes without garbage collection	0.15	0.11	0.66	0.30

All the 70 blocks that were outside the area range of the urban census tracts were analyzed as a separate cluster and are shown on Figure 2. These blocks were grouped under the denomination of socioeconomic cluster 5. The visits conducted enabled to identify this area as having a socioeconomic level below cluster 4.

By comparing Figures 1 and 3, where the BI values according to census tracts are shown, it is observed

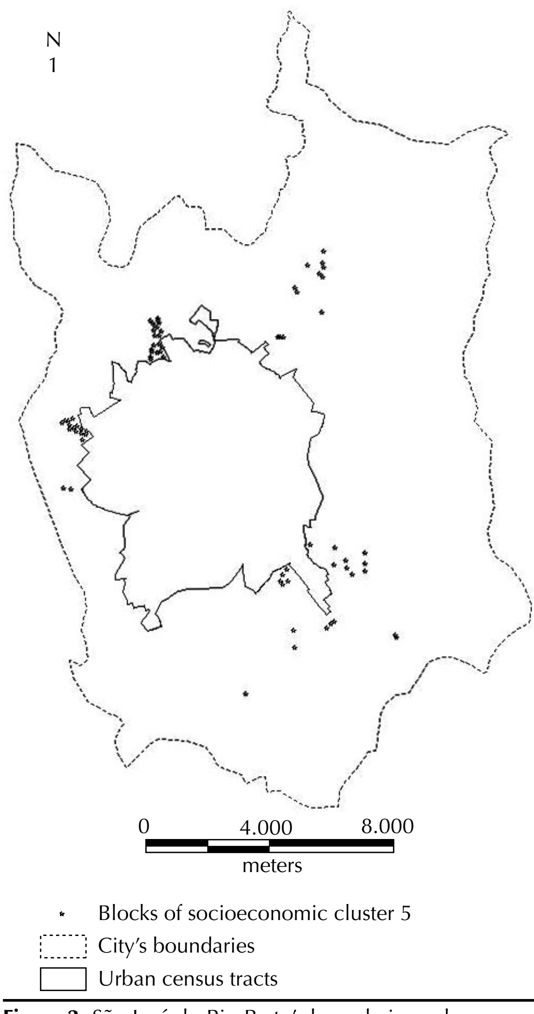

Figure 2. São José do Rio Preto's boundaries, urban census tracts and socioeconomic cluster 5. São José do Rio Preto, Southeastern Brazil, 2005.

Figure 3. Distribution of Breteau index values for the urban census tracts. São José do Rio Preto, SP, 2005.

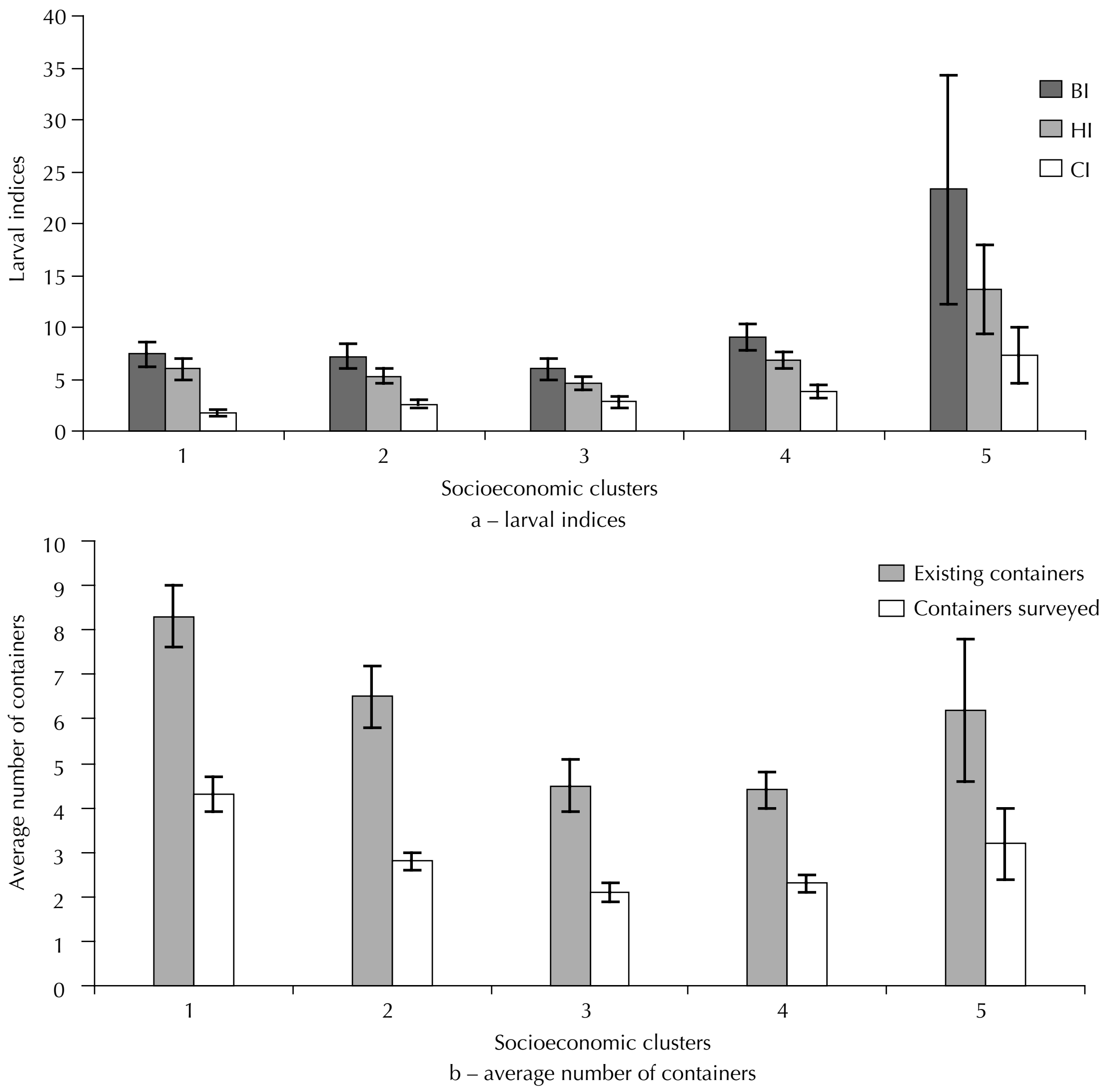

Figure 4. (a) Larval indices and (b) average number of existing containers and containers surveyed with the respective 95% confidence intervals, according to socioeconomic clusters. São José do Rio Preto, Southeastern Brazil, 2005.

that low, medium and high BI values occurred in the four socioeconomic clusters. In other words, no relation between the index values and the socioeconomic levels in the cluster corresponding to the urban census tracts was verified. This behavior is confirmed by the results shown on Figure 4 (a), where it can be observed that practically no significant differences occurred among the three indices (BI, HI and CI) in relation to socioeconomic clusters 1 to 4. The exceptions were: the BI and the HI showed differences in clusters 3 and 4; the CI showed a significant difference between clusters 1 and 3 and clusters 1 and 4. On the other hand, the values of the three indicators for socioeconomic cluster 5 were higher than the values for the other clusters.

By the comparison of the average number of existing containers and containers surveyed per home in the five clusters, the following behavioral characteristics were identified: (Figure 4 - b): cluster 1 values were significantly higher than clusters 2 to 4; cluster 2 values were significantly higher than clusters 3 and 4; clusters 3 and 4 values did not show differences between them; cluster 5 values did not show significant differences in relation to clusters 1 to 4. Except for cluster 5, and considering clusters 3 and 4 together, it is observed that the better the socioeconomic level, the higher the values of these two variables.

DISCUSSION

The main limitation of this study is the use of secondary data on *Aedes aegypti* infestation. In the case of the city of São José do Rio Preto, field workers are trained and supervised regularly, thus guaranteeing work quality and uniformity. However, one of the difficulties is related to the counting of existing containers and containers surveyed. This problem affects the RI and the average numbers of existing containers and containers surveyed, even though it does not interfere with the BI and the HI.

Focks[7] affirms that the CI is probably the poorest epidemiological indicator for dengue transmission, because it does not take into consideration the number of containers per area, home or individual, and also because the counting of containers depends on the observer's discernment. For this author, among the larval infestation indicators, the BI is the most efficient one, as it combines information about containers and homes.

Another issue related to containers is the difficult access to some of them (water tank and gutter, among others), in which case workers usually do not have the means to conduct larval survey. Nonetheless, this problem is considered to occur in a generalized form, thus affecting indicators obtained for all the city clusters uniformly.

Any proposals to modify dengue control strategies must take into consideration not only *Aedes aegypti* infestation and its determining factors, but also the disease behavior, which was not mentioned here. In this sense, Mondini & Chiaravalloti-Neto[11] (2007) carried out a study to assess the disease behavior and its relation to socioeconomic levels. The authors identified, in certain periods, a minor influence from socioeconomic factors on dengue incidence, which coincides with the results from this study, though in relation to the vector.

Lack of significant difference for the three indices (BI, HI, and CI) among the socioeconomic clusters (1 to 4) may evidence an absence of direct relation between the worst socioeconomic levels and the highest infestation levels by vector or risk of dengue occurrence. These results corroborate the findings by Costa,* in a study conducted in the city of São José do Rio Preto to verify the conditioning factors in the occurrence of *Aedes aegypti*. The associations between BI values and the three identified socioeconomic units were insufficient to point to a clear relation between socioeconomic unit and level of infestation.

Despite socioeconomic differences among the four clusters, the data presented on Table 1 show that the proportions of homes without water, sewage system and garbage collection are very small and similar. These adequate basic sanitary conditions could provide an explanation for the lack of relation between infestation and socioeconomic levels. However, cluster 5 showed significantly high values for the three larval indices. As this is a region where socioeconomic, sanitary and environmental conditions are poorer when compared to the other regions, it serves to confirm the hypothesis that has been revoked in the area range of urban census tracts.

The results found point to a relation to the socioeconomic levels, though with a preponderance of basic sanitary aspects. Poorer areas with good basic sanitary conditions can have the same infestation levels than richer areas. On the other hand, a poor area without adequate basic sanitary conditions will have higher infestation levels and risks of dengue occurrence. An example of this is presented in a study conducted by Oliveira & Valla,[14] where the relation between precariousness of basic sanitary services in slums of the city of Rio de Janeiro and the emergence of dengue epidemics is shown. Souza-Santos & Carvalho,[16] in a study conducted in the district of Ilha do Governador, in the city of Rio de Janeiro, identified the slum region as permanently positive for *Aedes aegypti* larvae and linked this problem to the water supply irregularity.

On the island of São Luís, the capital of the state of Maranhão, the high density of infested buildings is due to, among other things, the great concentration of people in clusters of homes without basic sanitary conditions on the capital's outskirts.[15] Chan et al[4] found significant differences of larval indices in areas with different socioeconomic and living standards. On the other hand, Barcelos et al[2] found distinct results in the city of Porto Alegre. Areas with high coverage of water supply services and higher number of people in the same home were the ones that showed highest vector concentration.

One of the expected consequences of the present study was that criteria permitting prioritization of dengue control and surveillance practices were defined. The fact that the highest infestation levels were found in cluster 5 shows that this region must be prioritized. Preliminary studies** point to the important role of the occurrence of dengue cases in an irregular residential development project, in the end of 2005, which led to the epidemic outbreak that happened in the city of São José do Rio Preto in 2006.

In any case, the existence of mosquito clusters and dengue cases is an issue that needs to be further investigated. Studies carried out in Thailand[13] and in Peru[7] concluded that homes infested by *Aedes aegypti* were randomly scattered in the neighborhood. Another study, carried out in Puerto Rico,[12] showed that clusters of dengue cases were identified within very short distances, most probably in the homes, as well as the fact that control measures should be adopted uniformly throughout the whole area affected by transmission to be effective.

* Costa AIP. Identificação de unidades ambientais urbanas como condicionantes da ocorrência de Aedes aegypti (Diptera: Culicidae) e de dengue na cidade de São José do Rio Preto, SP, em 1995 [dissertação de mestrado]. São Paulo: Faculdade de Saúde Pública da USP; 1995.
** Secretaria Municipal de Saúde e Higiene de São José do Rio Preto (dados não divulgados).

Even with the need to analyze data on containers more cautiously, some considerations should be made. The direct relation between a larger number of existing containers and containers surveyed and better socioeconomic levels (except for cluster 5) could be related to the greater size of plots of land and constructions in wealthier areas. Considering the point estimates of the CIs exclusively, these showed a behavior that was the opposite of the container averages. In the end, there was a compensation, a greater number of containers in the wealthiest regions that was followed by lower positivity.

New studies must be conducted to confirm and explain the differences found in the infestation levels in the area range of the urban census tracts. The first issue would be to investigate whether there is some type of structure of spatial dependence in the mosquito population or not.[7,13] Once this hypothesis is confirmed, it is suggested that the factors for the prioritization of dengue control and surveillance practices in certain urban areas be studied. Studies relating infestation levels by *Aedes aegypti* to dengue occurrence are also vitally important to better understand the relation between vector and disease.

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