Dimensions and potentialities of the geographic information system on indigenous health

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Keywords
Indians, South American. Geographic information systems. Tuberculosis. Malaria. Infant mortality.

Abstract

Objective
To discuss the potentials of the Geographic Information System in the analysis of the epidemiological and socio-demographic profiles of indigenous peoples and of the organization of health services directed towards their care.
Methods
Geoprocessing analysis of tuberculosis, malaria and mortality notification of 374,123 indigenous people distributed in 36 *Distritos Sanitários Especiais Indígenas* (Special Indigenous Sanitary Districts) in Brazil was conducted. A gradient of risk intensity for tuberculosis, malaria, and infant mortality among indigenous populations was defined for the years 2000 to 2002. These coefficients were then compared with those of non-indigenous populations, during the same period.
Results
The analysis showed that the previous available data are fragmentary and do not allow for a comprehensive assessment of life conditions and health situations of these ethnic groups. The construction of gradients of risk indicated incidence of tuberculosis coefficients among the indigenous population more than 1,000 times greater than those found among the general population in Brazil. The mean malaria API among the indigenous population was up to 10 times greater than the mean values found among the non-indigenous population and the coefficient of infant mortality among the indigenous population varied from 74.7/1,000 live births in 2000 to 56.5/1,000 live births in 2001, exceeding the national average (31.8/1,000) for the same period in more than 100%.
Conclusions
The Geographic Information System is a useful administrative tool for assessing health conditions, evaluating population risks, constructing scenarios, and planning intervention strategies in several levels, shifting quickly and efficiently between macro- and micro-level realities.

INTRODUCTION

In Brazil, the Ministry of Health has been responsible for Indigenous health care by means of the implementation of *Sistemas Locais de Saúde* [Local Health Systems] denominated *Distritos Sanitários Especiais Indígenas (DSEI)*, [Special Indigenous Sanitary Districts]. Thirty-four districts are in activity and are responsible for caring for the health of an indigenous population, living within Native Brazilian villages, estimated in 374,123 people and distributed among 3,225 villages in the diverse federated units of the country.[6] These activities constitute a subsystem within the *Sistema Único de Saúde (SUS)* [Brazilian

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Paper presented at the VII *Congresso Brasileiro de Saúde Coletiva* [VIIth Brazilian Congress in Collective Health], Brasília, DF, Julho 2003.
Research was conducted at the *Centro de Pesquisas Leônidas e Maria Deane [Leônidas e Maria Deane Research Center] (Fiocruz) and the Núcleo de Estudos de Saúde Pública, Universidade Federal do Amazonas [Nucleus of Public Health Studies of the Federal University of Amazonas].*
Received on 23/3/2004. Reviewed on 22/2/2005. Approved on 17/3/2005.

Health System], which is administrated by the *Fundação Nacional de Saúde (Funasa)* [National Health Foundation] that celebrated agreements with non-governmental entities and city halls, that are executing the programmed activities according to the health districts' plans. The districts' routines cover a range of services geared towards the development of programmatic activities that seek to control the most frequent disorders such as malaria, tuberculosis, malnutrition, and vaccine-preventable diseases.[6]

Despite the advances represented by the implementation of the indigenous health subsystem, several problems still need to be addressed; among these are the precariousness of the data system, which does not supply the health teams with consistent information, congruent with the necessities and peculiarities of the population being attended.

Funasa has been implementing the *Sistema de Informação em Saúde Indígena (SIASI)* [Indigenous Health Data System] that includes modules related to the demographic composition of the population and disorders that are most prevalent in the various districts. The fact that the SIASI is not accessible for public consultation at present makes the task of evaluating its limits and potentialities more difficult. However, its structural similarity to the other morbidity and mortality data systems already in existence in Brazil suggests that it operates with a high degree of complexity. This gives rise to problems in obtaining information rapidly, impeding decision-making in the daily administration of health services.

Another difficulty is the geoprocessing of data from rural sites, since the digitization of registers depends upon a minimum standardization of addresses in order to define the unit of analysis that makes it possible to aggregate or disaggregate information in a precise way. In urban sites, the use of the Census Sectors of the *Instituto Brasileiro de Geografia e Estatística (IBGE)* [Brazilian Institute of Geography and Statistics] as a unit of analysis and geographic reference for data on health has been recommended. This procedure guarantees the homogeneity of data, making it possible to aggregate it for reliable spatial analysis in several different scales, according to the intended degree of detail, for each event being studied. This technique has been applied frequently in urban contexts,[1-3,5,8-10,12] however similar initiatives do not exist with respect to the analysis of health situations in indigenous areas. Hokerberg et al's[7] paper is an exception, for it explored spatial distribution while studying the network of health services and disorders among the Kaingang Indians in the State of Rio Grande do Sul.

Funasa has suggested the use of the *Sistema de Informações de Localidades (SISLOC)* for rural areas, which also presents problems of congruence in relation to other data banks such as the IBGE. This occurs because this Institute adopts a standardized concept of classification of the locality,* based on political and administrative criteria that are distinct from those adopted by the SISLOC.

If within the municipal scales and at the local level the lack of cartographic bases and the low degree of confidence or even the lack of data make it difficult to develop analysis base on geoprocessing,[1] an additional problem arises with respect to the DSEI. That is, the need to define a more appropriate unit of analysis that contemplates characteristics of the indigenous universe, which is not possible with the *Cadastro de Logradouros* [Census of Public Addresses] of the IBGE or of the SISLOC itself. In both cases, the official forms of geographic *reconnaissance* of the indigenous villages, communities, or areas are incompatible with the characteristics of mobility or the populations' patterns of settlement. The lack of information concerning the perimeter of the villages also makes it difficult to represent them as polygons and to appropriately express morbid events on thematic maps.

Within this context, the present article attempts to contribute towards research on the health of indigenous populations, by discussing the potentialities of geoprocessing. The latter is considered as a means for making socio-demographic analysis, as well as analysis of the organization of services and of the epidemiological profile of Brazilian ethnic groups by the indigenous health subsystem viable. Towards this end, the DSEI was considered the point of departure, being adopted as a unit of analysis, both when focusing on particular situations that express inequities within districts, and when using it as a reference while studying micro-realities such as the case of the Rio Negro DSEI in which the analysis of the distribution of deaths within a specific ethnic group according to village and clan is conducted.

METHODS

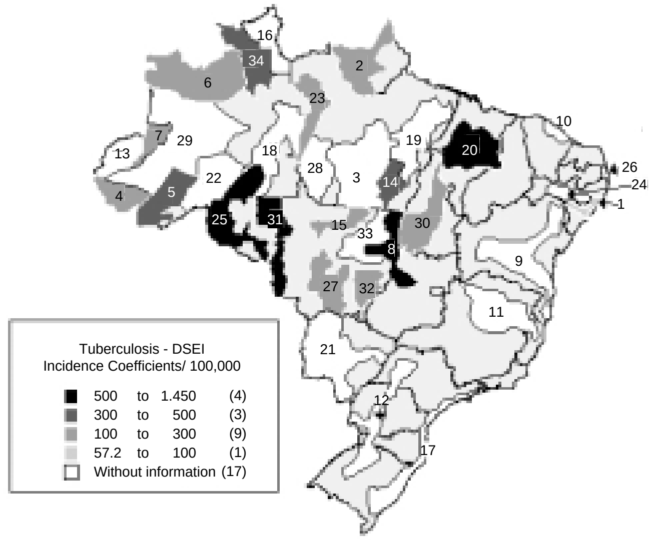
Geoprocessing of data on indigenous health required the reorganization of data from the year 2000 to 2002, made available by the *Departamento de Saúde do Índio (DESAI)* [Department of Indigenous Health], by means of the SIASI.

*According to the IBGE localities are divided hierarquically in: Federal Capitals, Capitals, Cities (Municipal seats), Villages, Urban Áreas, Isolated Urban Áreas and Rural Agglomerations. Indigenous villages are classified as an isolated Rural Agglomeration subtype. However, this type of classification is not congruent with the living arrangements found in indigenous areas.

The systematic organization of the data initiated with the geoprocessing of the "raster" figure in the *Funasa/Ministério da Saúde's* [Ministry of Health's] homepage, and with the digitization of the DSEI according to Federated Units, transforming them into digital maps. The databank was composed of notifications of disorders provided by the DESAI and organized in Excel spreadsheets.

Thematic maps were elaborated, indicating: a) risk intensity gradients for tuberculosis, malaria and infant mortality; b) comparing health indicators among the DSEI themselves as well as well as with those found among non-indigenous populations of the macro-regions and federated units in which DSEI are located.

Geoprocessing of the villages and the elaboration of thematic maps containing epidemiological data were performed, as well as information concerning the social organization of ethnic groups, expressed inequities on the local level. This data was plotted onto a pilot-map containing the set of villages within the Baniwa indigenous area, of the Rio Negro DSEI.



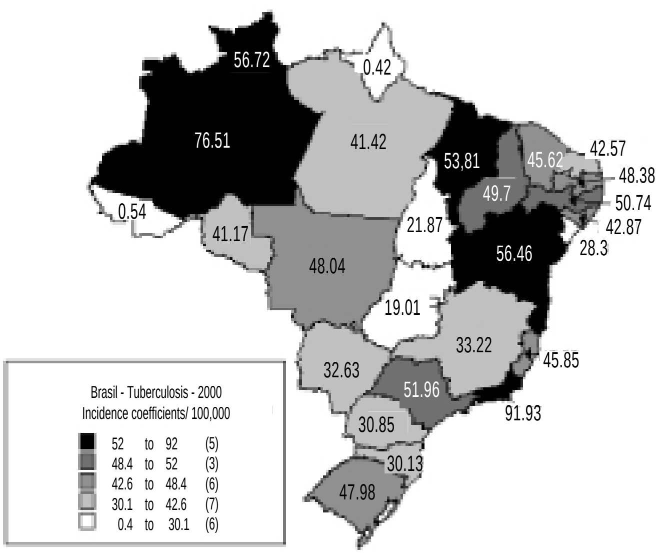
Source: *Fundação Nacional de Saúde/Departamento de Saúde Indígena*. [National Health Foundation/Department of Indigenous Health. *Relatório* [Report]. Brasília (DF); 2002

Identification of the DSEI: 1 - Alagoas and Sergipe; 2 - Amapa and Norte of Para; 3 - Altamira; 4 - Alto Rio Jurua; 5 - Alto Rio Purus; 6 - Alto Rio Negro; 7 - Alto Rio Solimoes; 8 - Araguaia; 9 - Bahia; 10 - Ceara; 11 - Minas Gerais and Espírito Santo; 12 - Interior Sul; 13 - Vale do Javari; 14 - Kayapo (PA); 15 - Kayapo (MT); 16 - East Roraima; 17 - Southern Coast; 18 - Manaus; 19 - Guama-Tocantins; 20 - Maranhao; 21 - Mato Grosso do Sul; 22 - Médio Rio Purus; 23 - Parintins; 24 - Pernambuco; 25 - Porto Velho; 26 - Potiguara; 27 - Cuiaba; 28 - Tapajos River; 29 - Medio Solimões River and Tributaries; 30 - Tocantins; 31 - Vilhena; 32 - Xavante; 33 - Xingu Indigenous Park; 34 - Yanomami

Figure 1 - Distribution of the tuberculosis incidence coefficient (per 100,000 inhabitants) according to Indigenous Special Sanitary Districts, 2000.

Geoprocessing was conducted with the aide of the software *Map Info Professional* [Professional Map Info Program] (7.0 SCP version).

Data concerning the non-indigenous population was obtained from the *Sistema Nacional de Agravos Notificáveis (SINAN)* [National System of Notifiable Disorders]. The *Índice Parasitário Anual (IPA)* [Annual Parasite Index], which represents the number of positive slides for malaria per 1,000 inhabitants/year within a specified area, was utilized to analyze the situation with respect to malaria.

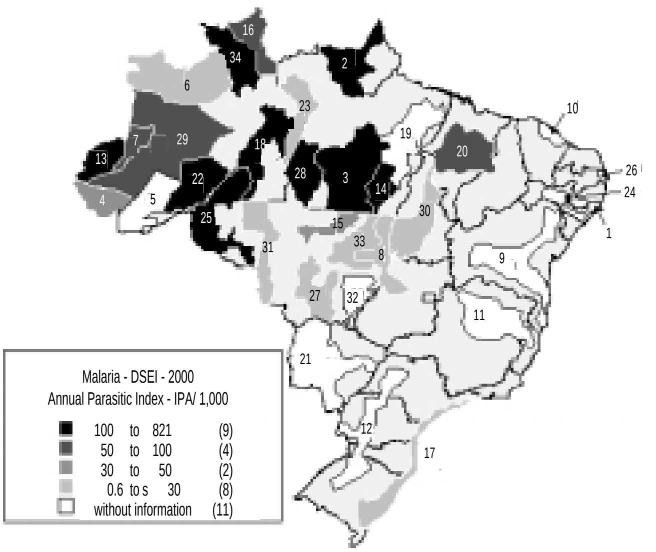


Source: Ministry of Health/ Information System of Notifiable Disorders, 2001. CD-ROM. Brasília (DF): *Fundação Nacional de Saúde* [National Health Foundation], Ministry of Health

Figure 2 - Distribuition of the incidence of tuberculosis coefficient (per 100,000 inhabitants) according to States, 2000.

RESULTS

Considering the sanitary district as the unit of analysis, it was possible to compare coefficients of the incidence of tuberculosis in 17 DSEI, for the year 2000. This data, contained in Figure 1, indicates the absence of notifications, particularly in the Southern, Southeastern and Northeastern regions in which only two of the nine existing DSEI supplied information to Funasa. The seven districts in which the greatest number of cases of tuberculosis were notified were: Araguaia, whose incidence coefficient was 1448.6/100 thousand inhabitants; Vilhena, with 540.2/100 thousand; Porto Velho, with 537.9/100 thousand; Maranhao, with 534.2/100 thousand; Kayapo/Para, with 490.3/100 thousand, Yanomami with 333.0/ 100 thousand and Alto Purus 302.1/100 thousand. All the above mentioned Districts are lo-



Source: *Fundação Nacional de Saúde/Departamento de Saúde Indígena* [National Health Foundation/Department of Indigenous Health]. *Relatório*[Report] Brasília (DF); 2002

Figure 3 - Incidence of malaria, according to the Annual Parasitic Index (per 1,000 inhabitants) in the *Distritos Sanitários Especiais Indígenas* [Indigenous Special Sanitary Districts], 2000.

cated within Legal Amazonia.

Comparing the risk gradient, expressed by the incidence of tuberculosis within the DSEI (Figure 1), with that of the general population in the federated units in which these Districts are located (Figure 2), it may be observed that the districts' coefficients, when these were informed, were all greater than those found among the general population within the Federated Units in which they were located.

Comparison of geographic macro-regions indicates that the 25 DSEI located in Legal Amazonia (including Araguaia that comprehends both Mato Grosso and Goias) had mean tuberculosis incidence coefficients of 229.83/100 thousand, whereas the mean incidence for the general population of the Northern region did not surpass 36.5/100 thousand and the Central Western region, did not surpass 30.4/100 thousand in the year 2000.

Analysis of malaria IPA for the year 2000 indicates that the districts with the greatest number of notifications were: Rio Tapajos (IPA=820.5), Yanomami (627.5), Guama/Tocantins (431.1), Amapa/North of Para (272.8), Javari(251.3), Altamira (245.0) and Kaiapo Para (242.5).

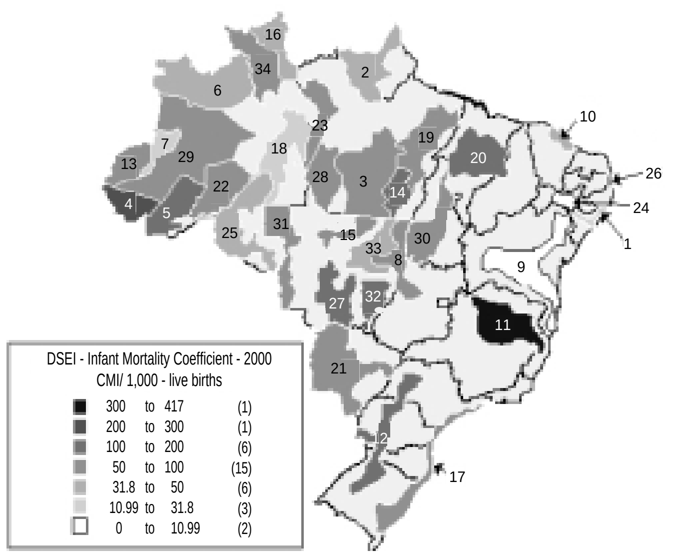
Among the 23 DSEI that notified cases of malaria during the year 2000, the IPA varied from 0.6 to 30/1,000 in eight; it varied from 30 to 50/1,000 in two; from 50 to 100/1,000 in four and from 100 to 821/1,000 in nine of these districts (Figure 3).

The indigenous population of the Altamira, Kayapo/PA, Guama/Tocantins and Rio Tapajos DSEI, located in Para, Guamá presented a mean IPA of 434.7. In the Amazons, the DSEI Alto Rio Negro (IPA=26.8), Alto Solimoes (IPA=52.4), Javari (IPA=251.3), Medio Purus (IPA=106.1), Manaus (IPA=185.5), Parintins (IPA=1.5) and Medio Solimoes (IPA=52.6) presented the mean IPA of 96.9.

In 2001 the DSEI that presented IPA above 50/1,000 were: Altamira (393.9/1,000), Rio Tapajos (264/1,000), Yanomami (208.9/1,000), Medio Purus (210/1,000), Manaus (128.6/1,000), Amapa/Norte do Para (99.6/1,000), Porto Velho (76.6/1,000), Guama/Tocantins (73.9/1,000) and Kayapo (65.8/1,000).

Analysis of the gradient of risk of death in childhood (Figure 4) indicates that 29 DSEI presented coefficients of infant mortality above the national average, estimated at 31.8/1,000 live births for the year 2000 by the IBGE.

In 2001 the notification of infant mortality indicated that only seven of the 34 DSEI registered coefficients below the national average: (Alto Solimoes: 28,7/1,000, Minas Gerais/Espírito Santo: 11.3/1,000, East Roraima:

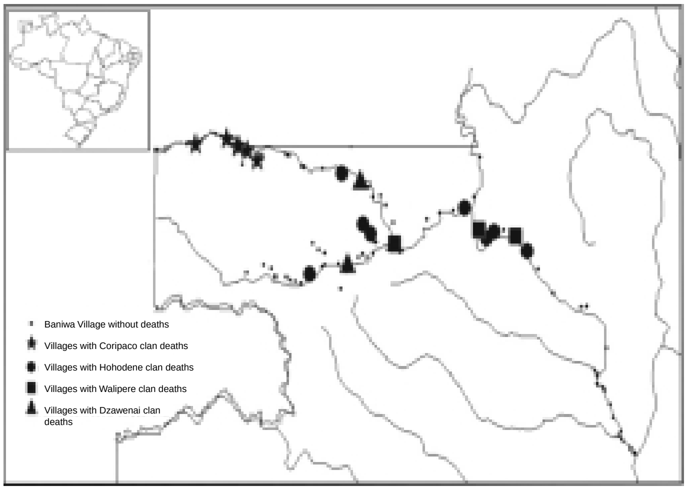


Source: *Fundação Nacional de Saúde/Departamento de Saúde Indígena* [National Health Foundation/Department of Indigenous Health]. *Relatório* [Report]. Brasília (DF); 2002. p. 12

Figure 4 - Infant Mortality Coefficient (per 1,000 live births) in the Indigenous Special Sanitary Districts, 2000.

25.93/1,000, Manaus: 25.21/1,000, Guama/ Tocantins: 28.57/1,000, Pernambuco: 21.4/ 1,000 and Potiguara: 20.6/1,000).

Shifting the focus of the study from the Sanitary District to the level of the village and utilizing the Baniwa ethnic group as an example, Figure 5 indicates the geographic location of their villages, distributed according to clan* subdivisions in various stretches of the Icana and Aiari rivers. The Baniwa population is composed of a total of 3,760 individuals that live within the territory of the Rio Negro DSEI. All the Baniwa villages are set out on this map, which indicates all of those in which deaths occurred, utilizing four symbols (star, circle, triangle and square) each of which designates one of the clans. The following results were generated after calculating the general mortality coefficients for each clan: 46.1/10,000 for the Coripaco clan, 56.3/10,000 for the Hohodene clan, 24.5/10,000 for the Walipere clan and 61.6/10,000 for the Dzawenai clan. These coefficients indicate that, even within a small and apparently homogeneous population, there are disparities that may be apprehended by a geographic information system.



Source of data on mortality: *Federação das Organizações Indígenas do Rio Negro/ Distrito Sanitário Especial Indígena do Rio Negro* [Federation of the Indigenous Organizations of the Negro River/ River Negro Indigenous Special Sanitary District]. *Relatório de Atividades* [Activities Report]. Rio Negro; 2002

Figure 5 - Distribution of deaths per clan in the Baniwa area in the Rio Negro Indigenous Special Sanitary District, 2002.

DISCUSSION

The tuberculosis notifications speak for themselves about the profound inequities in health to which the Brazilian indigenous populations are submitted. All the DSEI that notified cases, presented coefficients of the incidence of tuberculosis much greater than those registered for the general population, surpassing in more than 1,000 times the greatest coefficients found among the non-indigenous population. The precariousness of the data system suggests that the situation with respect to tuberculosis may be even worse than that which has been registered in this study, particularly because 17 of the Sanitary Districts did not notify this disorder during the period under study.[4,6]

The situation with respect to malaria is also a cause of concern. The World Health Organization considers that populations with IPAs greater than 50/1,000 are under high risk for malaria and that IPAs varying from 10-49/1,000 express a medium risk for this disease. The comparison of malaria risk gradients among the DSEI (Figure 3) indicates that approximately 30% of the DSEI that notified this disorder are in a high risk situation and all the others may be classified in a medium risk situation.

Legal Amazon is a region in which the States pertaining to it have traditionally presented much greater incidence of malaria than the rest of the country, frequently attaining coefficients 10 times higher than the national average.[12] In the States of Amazonas and Para, for example, the mean IPA for the general population in the year 2000 was 34.1/1,000 and in 2001 it was 44.9/1,000. These numbers place the region as a whole in the medium risk category. However, the mean IPA of the indigenous population in these States was 69.06 for the year 2000 and 51.58 for the year 2001, indicating that the sanitary disparities express themselves in an even more incisive form among this population group.[6]

The infant mortality notifications differ from those of tuberculosis and malaria for the latter presented high rates of non-notifying DSEI, whereas notifications of the former disorder, presented a national homogeneity, revealing a kind of equilibrium among the DSEI of the various regions of the country. However, the risk of indigenous infant mortality is very high. The mean rate of indigenous infant mortality in the year 2000 (74.7/1,000 live births) surpassed in over 100% the coefficient of infant mortality of the Brazilian population as a whole in 2000; in 2001 this value (56.5/ 1,000 live births) was approximately 78% greater than the national average. These general coefficients do not reveal the profound disparities between districts, indicated on Figure 4, in which 91% of the DSEI exhibit coefficients greater than the national average, being that, in the gravest situations, these coefficients excede the national average in up to 10 or 15 times.[11] In the seven DSEI that presented coefficients below the na-

*The Baniwa are divided in four clans or fratrias Coripaco (that have 1,084 members), Hohodene (that have 887 members), Walipere (816 members) and Dzawenai (973 members), distributed among four micro-regions (Alto Içana, Médio Içana, Aiari e Baixo Içana).

tional average, (Alto Rio Solimoes, Minas Gerais/ Espirito Santo, Leste de Roraima, Guama/Tocantins, Pernambuco, Potiguara e Manaus) the precarious nature of the sanitary data is more suggestive of sub notification than of good standards of health.[6] The plasticity of the geographic information system propitiated the production of both macro-regional and district level analysis and made it possible to study the micro-level of the village as well (Figure 5).

Within this sphere, by comparing the spatial distribution of the deaths to the demographic composition and the distribution of residential groups – data that is of interest to the district management in programming and evaluating the extension of health activities – internal disparities within the groups were brought to light. These disparities express power relations within ethnic groups that have important implications with respect to access to services and, consequently, in the morbidity profile of the population. Other data, such as rates of disorders notified by each village or availability of environmental and nutritional resources, could easily be inserted into the data banks, propitiating the elaboration of thematic maps capable of representing information according to micro-region, clans and ethnic groups. Geographic information systems do not substitute other more conventional methods being utilized by the Brazilian Unified Health System and the subsystem of indigenous health. However, management of geoprocessed data makes it possible to rapidly and efficiently build scenarios that express the disparities in the morbidity profile of the population being attended.

The use of geoprocessing propitiates the intersection of epidemiological indicators, facilitates the insertion of intersectorial data and supports analytical approaches that express the relations between living conditions and standards of health and illness.[13] It also revealed itself to be useful for research concerning small indigenous populations, aiding decision-making, promoting equity among diverse ethnic groups by contributing towards the expression of ethnic epidemiological diversity that is obscured by the totalizing approaches of conventional health information systems. However, the potential use of this instrument depends upon an appropriate standardization of the census of locations and of addresses in the information system, which makes it possible to compare data and aggregate it into units of analysis that are compatible with areas that are culturally recognized and can be represented geographically.

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