Dengue risk stratification - San José del Guaviare, Guaviare- Colombia, 2022

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Abstract

Introduction: Dengue is an endemic disease in the municipality of San José del Guaviare. Epidemics were recorded in 2010, 2014, 2018 and 2022. Despite being endemic, however, it does not have a focalization that allows prioritizing actions.

Objective: To stratify the risk of dengue in the municipality of San José del Guaviare in 2022, using epidemiological, entomological, socioeconomic and environmental variables for planning prevention and control actions.

Methods: conducted. The level of risk for dengue in the municipality's neighborhoods was categorized, integrating the persistence and cumulative incidence of dengue, Aedes aegypti pupal index, socioeconomic stratum and access to drinking water. The categorization of each of the variables was done by terciles, and measures of central tendency (average, median) were calculated. For analysis, the information was processed and organized in tables and risk cartography.

Results: In the entomological variable, 43.5% (10/23) of the neighborhoods had a high index of Aedes aegypti pupae. In the epidemiological variable, 52.3% (23/44) of the neighborhoods were categorized as having high transmission. In the environmental variable, 76.2% (32/42) of the neighborhoods were categorized as medium risk. According to the socioeconomic variable, 83.3% (35/42) of the neighborhoods were categorized as high risk. When integrating the variables analyzed, the neighborhoods were catego-

rized for dengue transmission as: very high risk 23.4% (11/47), high risk 31.9% (15/47), medium risk 8.5% (4/47) and low risk 34.0% (16/47).

Conclusions: In the final risk integration, those neighborhoods that were classified as very high and high risk for dengue transmission should be focused on control, promotion and prevention actions in the municipality. Likewise, stratification should continue in seasonal periods due to changes in the ecological conditions of the vector and transmission dynamics.

Key words: Dengue. *Aedes aegypti*. Colombia. Risk. Entomology. Epidemiology.

Resumen

Introducción: el dengue es una enfermedad endémica en el municipio de San José del Guaviare. En el 2010, el 2014, el 2018 y el 2022 se registraron epidemias. Sin embargo, a pesar de ser endémico, este no cuenta con una focalización que permita priorizar acciones.

Objetivo: estratificar el riesgo de dengue en el municipio de San José del Guaviare en 2022, mediante el uso de variables epidemiológicas, entomológicas, socioeconómicas y ambientales para la planificación de acciones de prevención y control.

Métodos: se realizó un estudio descriptivo de corte transversal. Se categorizó el nivel de riesgo para dengue de los barrios del municipio, integrando la persistencia e incidencia acumulada de dengue, índice pupal de *Aedes aegypti*, estrato socioeconómico y acceso de agua potable. La categorización de cada una de las variables se realizó por terciles, se calcularon medidas de tendencia central (promedio, mediana). Para su análisis la información fue procesada y organizadas en tablas y cartografía de riesgo.

Resultados: en la variable entomológica, el 43,5% (10/23) de los barrios presentaron un alto índice de pupas *Aedes aegypti*. En la variable epidemiológica, el 52,3% (23/44) de los barrios se categorizaron en alta transmisión. En la variable ambiental, el 76,2% (32/42) de los barrios se categorizaron en nivel de riesgo medio. Según la variable socioeconómica, el 83,3% (35/42) de los barrios se categorizaron en riesgo alto. Al integrar las variables analizadas, los barrios se categorizaron para la transmisión de dengue en: riesgo muy alto 23,4% (11/47), riesgo alto 31,9% (15/47), riesgo medio 8,5% (4/47) y riesgo bajo 34,0% (16/47).

Conclusiones: en la integración final de riesgo aquellos barrios que se clasificaron en muy alto y alto riesgo para la transmisión de dengue, se deben focalizar las acciones de control, promoción y prevención del

municipio. Igualmente, se debe continuar con la estratificación en períodos estacionales por cambios en las condiciones ecológicas del vector y dinámicas de transmisión.

Palabras clave:

Dengue, *Aedes aegypti,* Colombia, riesgo, entomología, epidemiología.

Introduction

Vector-borne diseases are diseases caused by bacteria, parasites or viruses that are transmitted by vectors. Every year, more than 700,000 deaths are recorded due to diseases such as malaria, dengue, schistosomiasis, human African trypanosomiasis, leishmaniasis, Chagas disease, yellow fever, Japanese encephalitis and onchocerciasis (1), making them a public health surveillance event that requires full attention and timely intervention to counteract the consequences of their occurrence (1).

The number of dengue cases reported to WHO has increased 8-times in the last two decades, from 505,430 cases in 2000 to more than 2.4 million in 2010 and 5.2 million in 2019. Reported deaths between 2000 and 2015 increased from 960 to 4,032, affecting mostly the younger age group. The total number of cases appears to have decreased in 2020 and 2021, as well as reported deaths (2).

The distribution of these diseases is determined by a complex dynamic of environmental and social factors. Behavioral change is a crucial element concerning vector-borne diseases. In addition, our human-dominated world, where constant international travel, human behaviors combined with human-caused micro-disturbances in the ecological balance, can cause innumerable infectious agents to unexpectedly and develop resistance to sanitary measures while continually evolving in accordance with emerging infectious diseases (3)(4).

Entomological surveillance for dengue involves (potentially) systematic sampling of all stages of Aedes aegypti development: egg, larva, pupa and adult. The selection of indicators and sampling methods (including sampling effort) depends on surveillance objectives and infestation levels and, no doubt, on the capacities available to implement them. In general, pupal and adult indices are recommended as indicators of risk or success, rather than ovitrap-based indices and larval sampling, since adults (females) represent the last link in transmission and have high epidemiological value (5).

In Brazil, the ArboAlvo project aims to develop a methodological proposal for stratifying arboviruses transmission risk areas, with sociodemogra-

phic, environmental, entomological and epidemiological parameters, in four endemic cities in Brazil. The cities were chosen according to the history of endemic transmission of DENV, the quality and integrity of the data banks, and the existence of legally defined neighborhood boundaries (5).

Stratification is a set of analogies that give rise to subsets of aggregated units, called strata. This procedure is part of the integrated diagnosis-intervention-evaluation process, which, as part of the epidemiological approach to risk, is a useful strategy for obtaining an objective diagnosis according to which to plan prevention and control activities for the different diseases, and also serves as a basis for methodologically categorizing and integrating geo-ecological areas and population groups according to risk factors (6).

Currently, Colombia does not have an operational document that, on one hand, systematizes and standardizes the methodological bases for obtaining reliable and timely information to stratify the risk associated with Aedes aegypti in the variety of human settlements present in its territory and, on the other hand, updates and integrates the precepts and developments of entomological surveillance to this reconceptualization. In response to this set of needs, the protocol for risk stratification and standardization of entomological practices associated with Aedes aegypti in Colombia was developed with the leadership of the National Institute of Health and the support of the Pan American Health Organization (7).

The entomological evaluation is a tool used in vector-borne disease programs of the Health Departments of Colombia and other countries, for the detection of the degree of infestation by the Aedes mosquito in the surveillance and control of dengue, there are several studies that are conducted in territorial entities but very few are published, among those published is in 2018, risk stratification model of dengue transmission risk study conducted in Santiago de Cali (8); In the department of Guaviare, dengue is one of the endemic diseases. A permanent risk is maintained in the department and in order to describe and warn the situation in one of the departments that contributes a large number of dengue cases in the country (incidence of cases per 100. 000 inhabitants 2017: 176.0; 2018: 1345.30; 2019: 862.60; 2020: 248.4, 2021: 72.5) (9), the need arises to perform a risk stratification for dengue, although such studies have already been conducted in the department (a prioritization and targeting of dengue risk in the urban area of the municipalities of San José del Guaviare, El Retorno and Calamar, 2020-2021), they have not been published, also they do not contain all the

measurements established in this research, which managed to obtain recent epidemiological, entomological, environmental and sociodemographic variables at the local level.

Materials y methods

A descriptive cross-sectional study was conducted in the municipality of San José del Guaviare, located in the north of the department of Guaviare, bordered to the north by the department of Meta, to the west by the department of Caquetá, to the east by the department of Guainía, and to the south by the municipalities of Calamar and El Retorno (10).

The SIVIGILA databases with the epidemiological characteristics of the municipality of San José del Guaviare and the entomological characteristics found in the neighborhoods studied were analyzed using Microsoft Office Excel®. The maps for stratification (entomological, environmental, socioeconomic and environmental and integrated) were prepared with the QGIS 3.22.10 program.

Results

1. Division of the human population nucleus into neighborhoods.

For the analysis of the entomological stratification, the division of the urban area of San José del Guaviare into different sectors or zones was taken into account, grouped according to the Basic Plan of territorial organization, in this way, the neighborhoods of San José del Guaviare are listed with the information of total blocks (Mz), houses per neighborhood, sector to which it belongs and the number of inhabitants per neighborhood.

2. Stratification according to entomological stratified.

The entomological survey was conducted in the established dwellings; this activity was carried out by examining water reservoirs such as pools, low and elevated tanks, aquatic plants, leaf axils, tree hollows, small containers, tires not protected from rain, etc., sites preferred by Aedes aegypti for egg laying. The aedic survey was carried out by surveying 521 houses, according to the previously established sample determination. The estimation of absolute pupal productivity showed that ten neighborhoods had the highest values, five had a medium pupal index, seven had a low pupal index and only one neighborhood had no Aedes aegypti pupae. Based on the data obtained from the pupa/neighborhood indexes, an entomological stratification map was drawn up for each neighborhood in San José del Guaviare (Map 1).

Map 1. Entomological stratification by neighborhoods, San José del Guaviare, 2022.
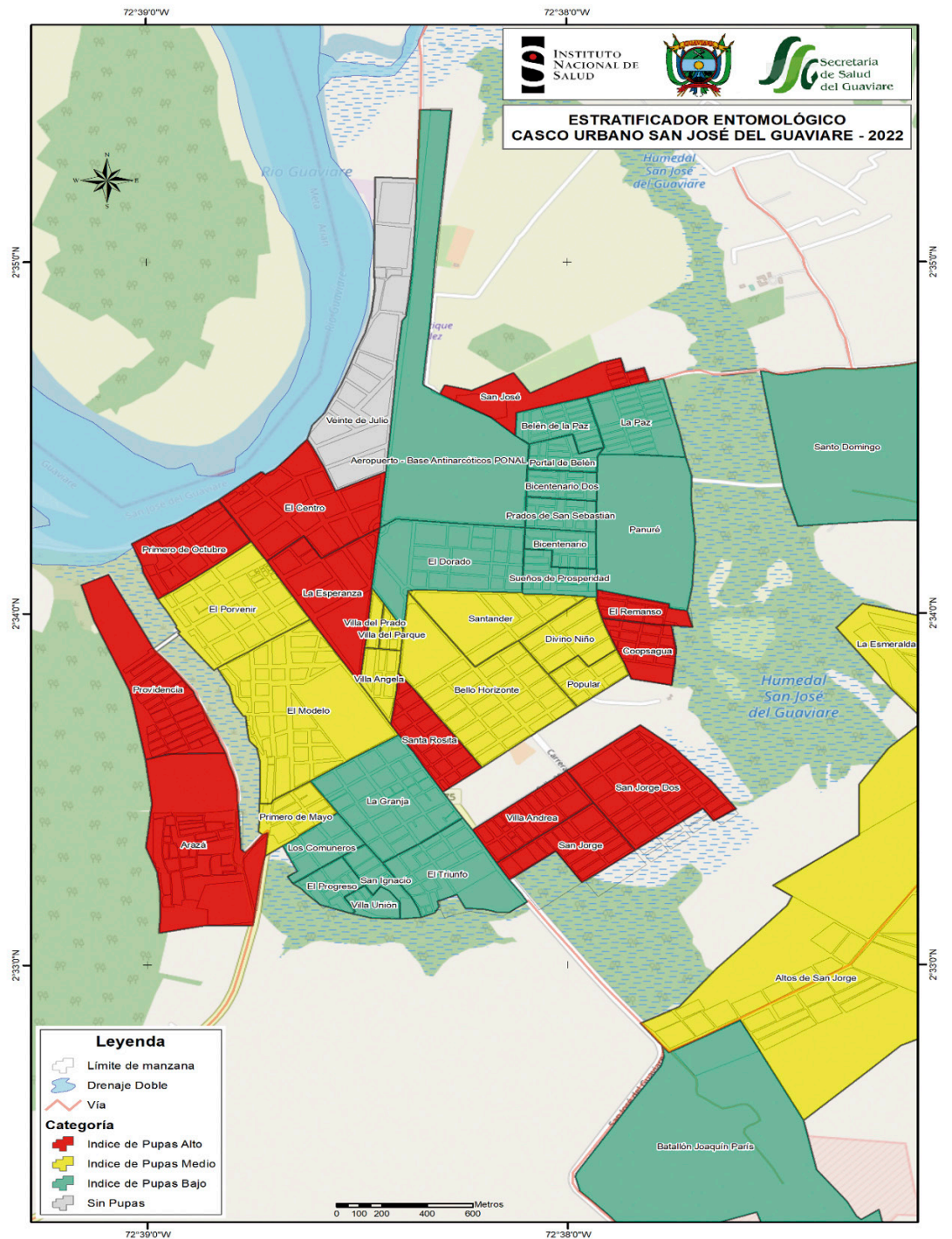
3. Stratification according to epidemiological stratified.

3.1 Persistence in the neighborhoods of San José del Guaviare.

Persistence corresponds to the number of years and epidemiological weeks in which the municipality reports the presence of cases in the period analyzed. For its measurement, the records of cases in the neighborhoods of San José del Guaviare from SIVIGILA in the period of analysis (2011-2021), with presence of the event, were reviewed, a value was assigned according to the categorization of the neighborhoods with transmission, the series was divided into terciles, The lower third corresponds to the category "low persistence" where nine neighborhoods were found, the middle third to the category "medium persistence" where 13 neighborhoods were found and the upper third to the category "high persistence" where 22 neighborhoods were found.

3.2. Accumulated incidence in the neighborhoods of San José del Guaviare.

The cumulative incidence is defined as the number of new cases of dengue fever that occurred in the urban center of the municipality of San José del Guaviare in the established period of time, which was 10 years; the calculations of population by neighborhoods were made with the average population data by neighborhoods recorded in the entomological surveys. For the classification of the results, the tercile was also calculated as a statistical measure of position, the values below the lower tercile correspond to the category "low cumulative incidence", the values between the lower tercile and the upper tercile, to the category "medium cumulative incidence" and the values located above the upper tercile, to the category "high cumulative incidence", in each of the categories the result was 14 neighborhoods respectively.

3.3 Categorization of the neighborhoods of San José del Guaviare according to transmission risk.

For the categorization of risk, the scores established in the persistence indicator and the incidence indicator by neighborhoods were added together, so that the result of the summation made it possible to establish three strata called low, medium and high transmission, determined on the basis of the final value obtained. According to this score established in each of the neighborhoods, 10 neighborhoods were found with scores between one and two, which places them in the category of "neighborhoods with low

transmission risk", 11 neighborhoods with scores between 3 and 4 in the category of "neighborhood with medium transmission" and 23 neighborhoods with scores between 5 and 6 in the category of "neighborhood with high transmission" (Map 2).

Map 2. Epidemiological stratification by neighborhoods, San José del Guaviare, 2022
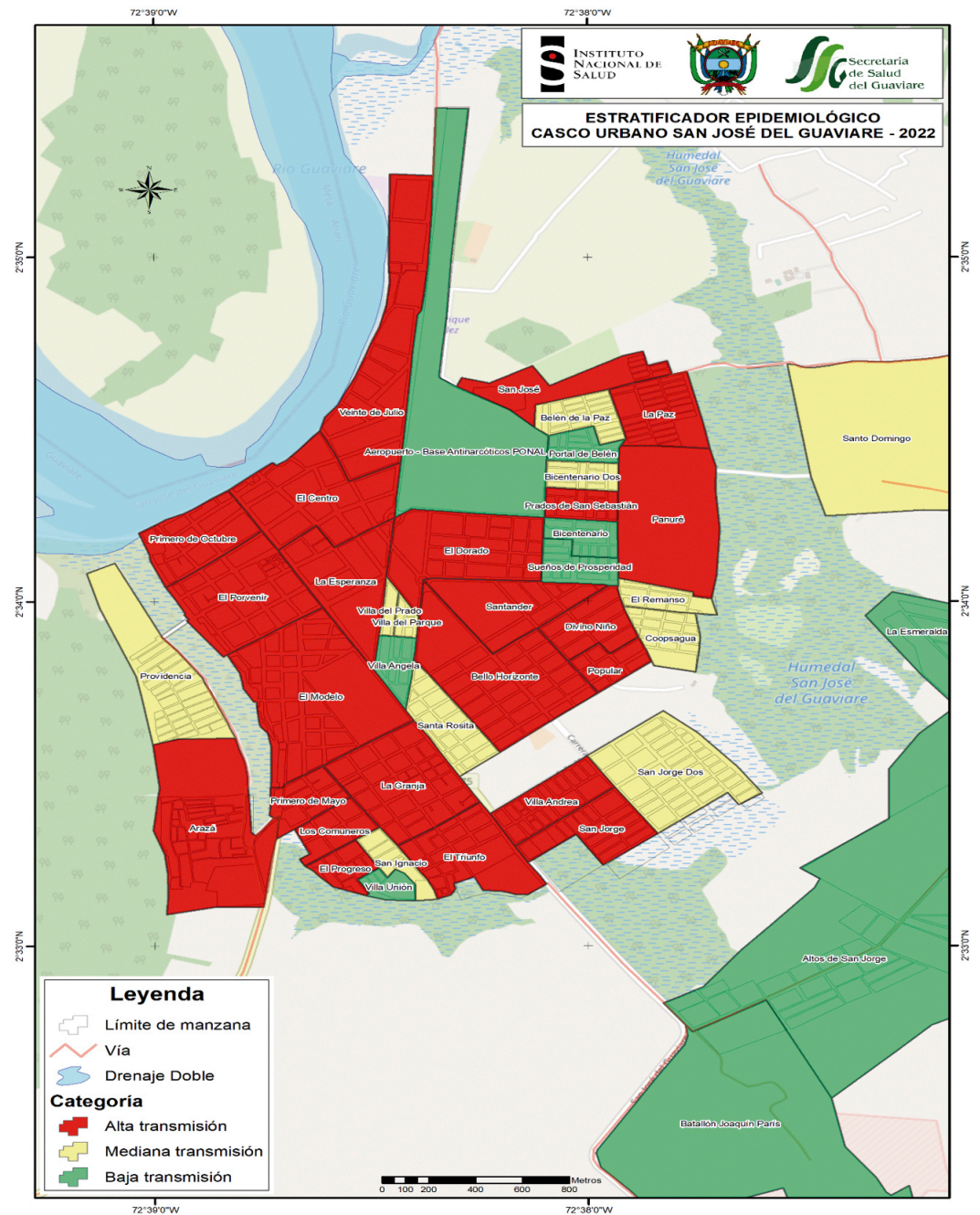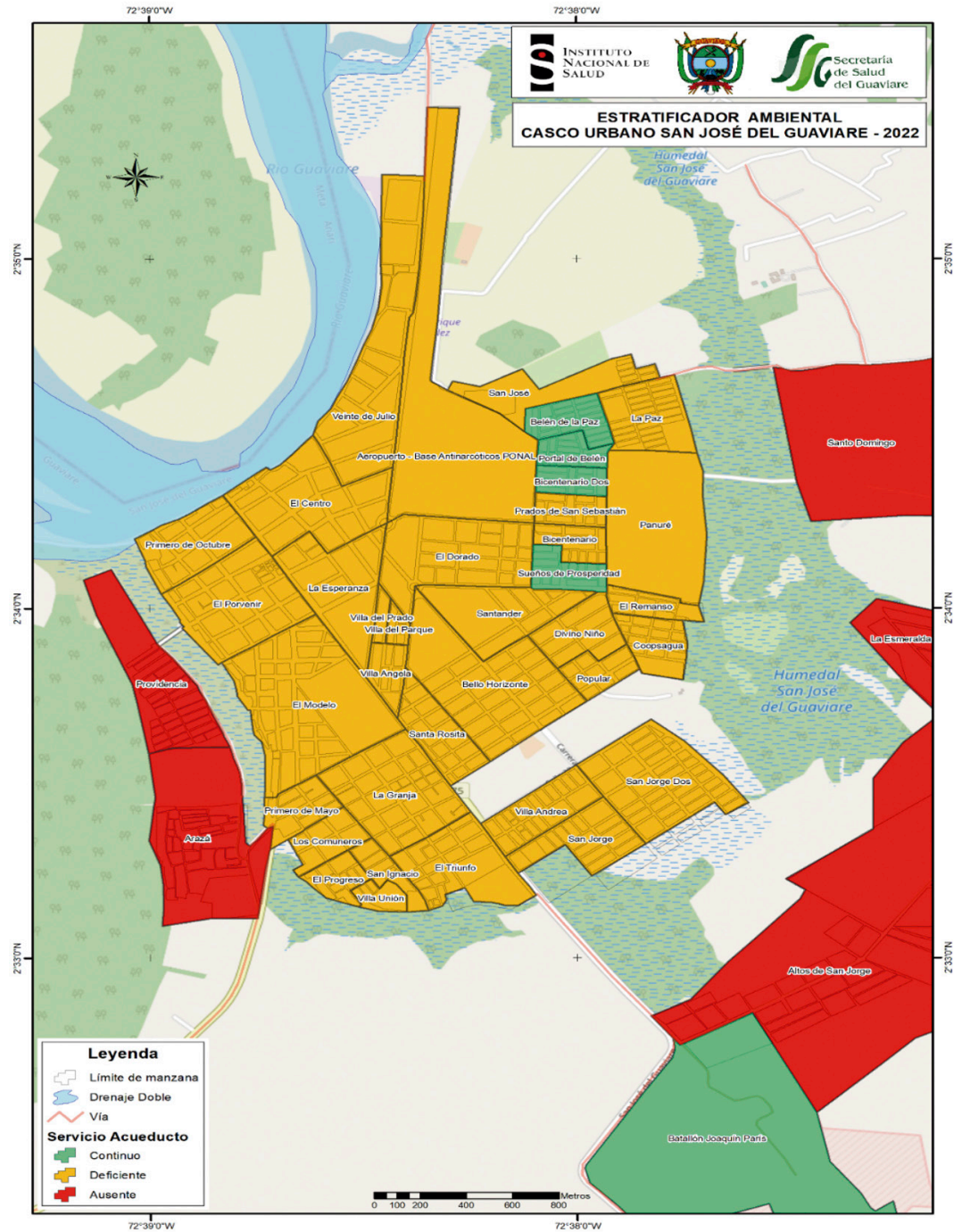
4. Environmental stratified.

In order to carry out the stratification based on this indicator, the variables established in the protocol were taken into account based on information reported by the public utilities company - Empoaguas ESP (by its acronym in Spanish) - and the considerations mentioned above. A stratification proposal was designed for the study of San José del Guaviare, taking into account that the installed aqueduct network has a high coverage of neighborhoods (greater than 90%) but at the same time, the percentage of homes effectively connected to the water supply system is lower, the percentage of homes effectively connected to the network is very low (reaching 35% in some neighborhoods), which indicates that the number of homes that store water is high because they are not connected to the network in most cases (therefore, they obtain water from drilled wells, which they store in large capacity tanks) or in other cases, although they are connected, they have water storage tanks as a cultural practice. Based on these precisions, the analysis of this component was carried out, taking into account the percentage of homes effectively connected to the network. These detailed percentages for each neighborhood were categorized based on the quartile methodology to determine the different risk levels. According to the above, 5 neighborhoods were classified as high risk (for not having any water network coverage), 32 neighborhoods at medium risk level (for having a deficient service because, although they have the aqueduct network, they have a low connection of homes to the network) and 5 neighborhoods classified with a low level of risk (for having a high percentage of homes connected to the network and continuous 24-hour service) (Map 3).

**Map 3.** Environmental stratification by neighborhoods, San José del Guaviare, 2022.

5. Socioeconomic stratified

In the methodology, the properties are categorized into different levels according to their own characteristics and those of the environment in which they are located, the information recorded was provided by the public utilities company Empresa de Energía Eléctrica del Departamento del

Guaviare S.A. E.S.P. (by its acronym in Spanish), where seven neighborhoods were located in "stratum 3" characterized as medium-low and medium risk level, 30 neighborhoods in "stratum 2" characterized as low and high risk level and five neighborhoods in "stratum 1" characterized as low-low and high risk level (Map 4).

Map 4. Stratification by socioeconomic level in the neighborhoods of San José del Guaviare, 2022.
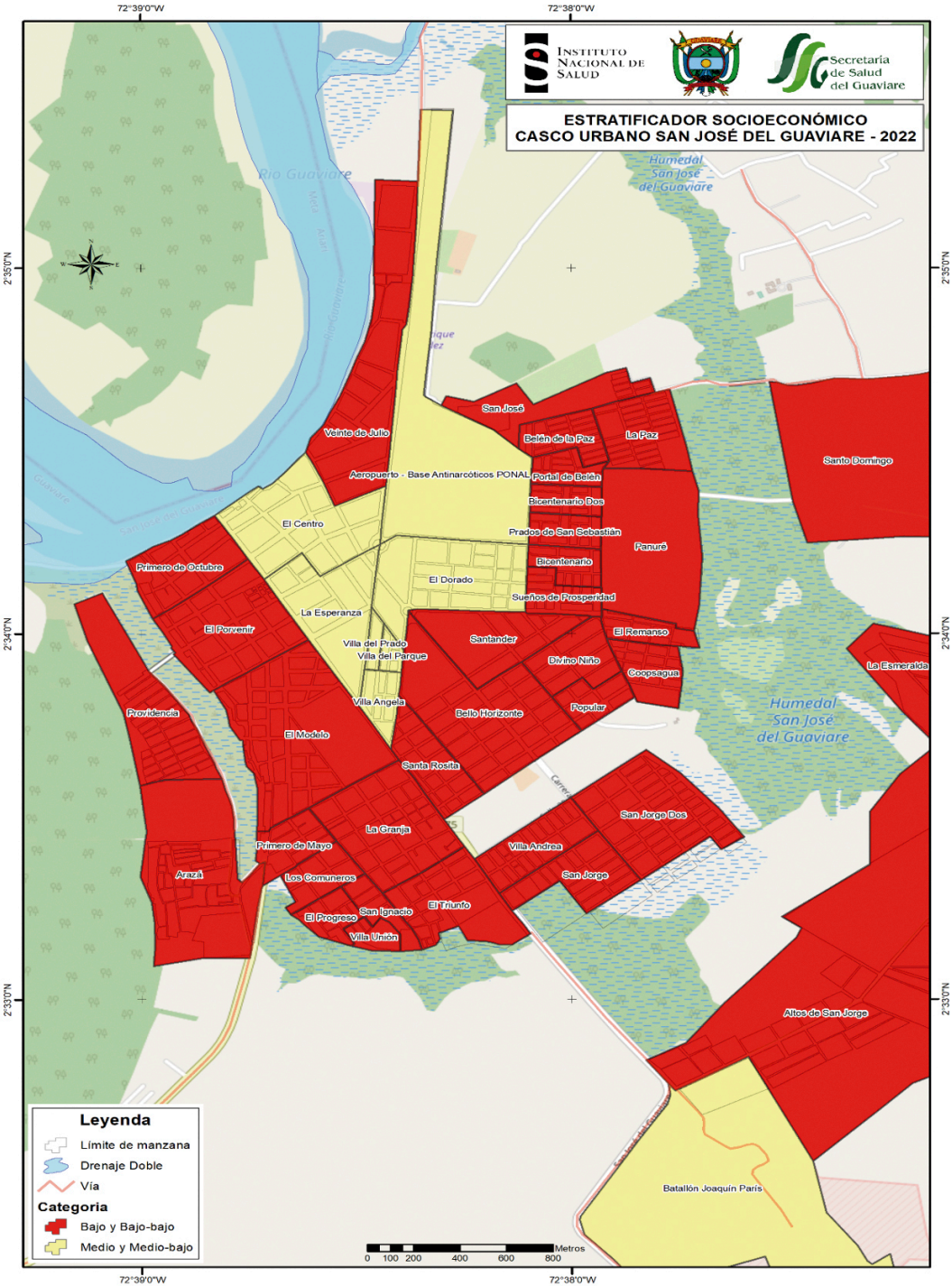
## 6. Integrated transmission risk stratification.

The categorization was based on the results of the four dimensions selected: entomological, epidemiological, environmental and socioeconomic. With these data previously identified in each of the municipality's neighborhoods, a numerical value was assigned to the variable categories for their correlation. The weighted score achieved in each of the neighborhoods was used to categorize the neighborhood in one of the four defined intervals, according to its transmission. For the low integrated risk category, the weighted scores corresponded to values between 4 and 20.5, in which 16 neighborhoods were found; for the medium integrated risk category, the weighted scores had to be between 20.6 and 32, in which 4 neighborhoods were found; For the category of high integrated risk, the weighted scores should be between 32.1 and 43.5, in which 15 neighborhoods were found, and for the category of very high integrated risk, the weighted scores should be between 43.6 and 55, in which 11 neighborhoods were found; a fifth category was assigned from the entomological stratified, which is assigned directly to neighborhoods without the presence of pupae, in which only the 20 de Julio neighborhood was found (Table 1 and Map 5).

Table 1. Integrated risk categorization, San José del Guaviare, 2022

Neighborhood	Integrated risk category	Assigned color
Arazá (Las Palmas, San Andrés, Brisas de Yurupary, La Victoria)	Very High	
San Jorge I	Very High	
Villa Andrea	Very High	
Primero de Octubre	Very High	
San José	Very High	
La Esperanza	Very High	
Bello Horizonte	Very High	
El Modelo	Very High	
El Porvenir	Very High	
Primero de Mayo	Very High	
El Divino Niño	Very High	
La Granja	High	
El Triunfo	High	
El Progreso	High	
Los Comuneros	High	
El Dorado	High	
Providencia	High	

Neighborhood	Integrated risk category	Assigned color
La Paz	High	
Popular	High	
Panuré	High	
Santander	High	
Prados de San Sebastián	High	
Santa Rosita	High	
El Remanso	High	
Coopsagua	High	
El Centro	High	
Santo Domingo	Medium	
San Ignacio	Medium	
Belén de La Paz	Medium	
Villa del Prado	Medium	
Altos de San Jorge	Low	
La Esmeralda	Low	
Villa Unión	Low	
Bicentenario I	Low	
Bicentenario II	Low	
Villa Angela	Low	
Sueños de Prosperidad	Low	
Portal de Belén	Low	
Aeropuerto	Low	
Piraquive	Low	
San Jorge II	Low	
Villa del Parque	Low	
Santa Ana	Low	
Los Rosales	Low	
Batallón Joaquín Paris	Low	
Base Antinarcóticos Policía Nacional	Low	
20 de Julio	No risk	

Map 5. Integrated risk categorization in the neighborhoods of San José del Guaviare, 2022.
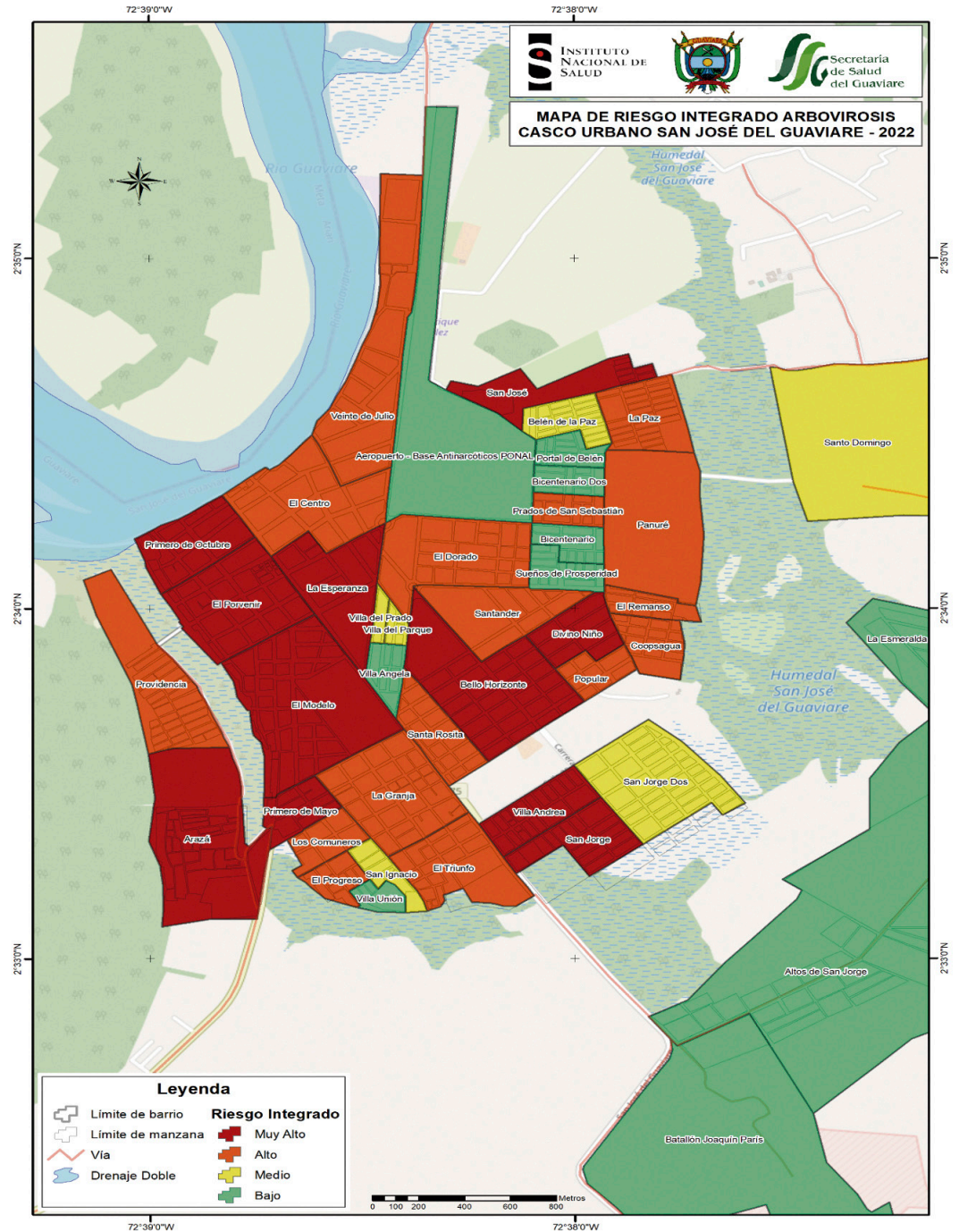
Discussion

At the municipal level, risk stratification for dengue is a public health strategy that allows resources and strategies to be adequately oriented according to the results found. This methodology established by the INS in conjunction with PAHO confirms the difficulties encountered in the territories to obtain complete and detailed information; although official sources are established for the methodological implementation of stratification, this information is not available down to the neighborhood level, much less by blocks; in addition, when correlating the different sources of information for each of the stratifies established in the methodology, there is not the same amount of data for each one of them.

In the case of the municipality of San José del Guaviare, 55% were stratified as very high and high integrated risk neighborhoods, despite the fact that there was no entomological stratification data in six neighborhoods that were in the high integrated risk category, since the methodology required randomization for sampling by neighborhood.

Among the limitations and difficulties of the study, determining the incidence has been problematic because the official source DANE (National statistical system) does not have the discrimination of the population by neighborhoods, the information was requested by the System of identification for social assistance beneficiaries SISBEN (by its acronym in Spanish) sources but the population that was registered there was different from the data that were in the records of the entomological surveys, in addition, in this source there was no record of all the neighborhoods of the municipality. Therefore, to carry out this study, the incidence analysis was performed with the population of the entomological surveys by averaging the number of houses per person; it should be noted that the documents issued by the Ministry of Health and Social Protection for epidemiological stratification do not make use of this indicator since it is always affected by the numerator.

Finally, it is important to note that the epidemiological stratification indicator already has a methodology established within the Colombian VTE functional group, a guideline that it would be important to integrate in order to work jointly with the technical concepts already established by the Ministry of Health and Social Protection and could optimize stratification results and direct actions and resources to be carried out for arboviruses prevention and mitigation in the regions.

This experience is considered a significant contribution to decision-

making in dengue vector control, since stratification is a valuable tool for decision-making.

Acknowledgements

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