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AEDES AEGYPTI INFESTATION INDEXES BASED ON ADULT SURVEILLANCE TO MITIGATE ARBOVIRUS TRANSMISSION IN AN ENDEMIC CITY IN BRAZIL

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Abstract The development of an efficient and timely surveillance with accurate alert signals is among the bottlenecks of arboviruses epidemiology. Herein, we report the steps taken to transform an archaic and sectorized structure into a modern and timely surveillance program under the One Health approach to improve vector-borne disease practices. We also report the results of a city-wide integrated surveillance combining entomological, epidemiological and entomo-virological data gathered during within the period of 2017-2020. Five entomological indices in total were compared: House and Breteau Indexes (larval surveys), Trap Positivity Index, Adult Density Index and Mosquito per Inhabitant Index (adult trapping). Indices based on adult sampling had higher prediction than those based on larval surveys, but all indexes showed limited ability to point the hotspots of arbovirus transmission within the city.

Key words One Health, surveillance, *Aedes aegypti*, dengue, Zika, chikungunya, vector control.

INTRODUCTION

Effective public health institutions should be organized under principles of integration, personnel empowerment, community engagement and flexibility. By doing so, available resources would be optimized, health agents would be empowered to take immediate action on the ground, communities would become powerful allies to mitigate disease transmission and health managers would be able to allocate health agents accordingly to the current emerging or seasonal public health treat (Maciel-de-Freitas and Valle, 2014). However, disease surveillance of tropical diseases and vector control are often sectorized and independent from each other, i.e., there is an absence of integration among different teams at the Municipality level. Additionally, routine activities still rely on old-fashioned ineffective practices as using paper-based notification systems to store field gathered information, what endanger the adoption of timely decisions by local health managers. Herein, we summarize the steps taken in the last 25 years (1997-2022) to transform the CCZ-Foz from an archaic and sectorized structure to a modern and timely surveillance program under the One Health approach (Leandro et al., 2021). We define the One Health approach as a synergic strategy for expanding interdisciplinary collaborations of health care for humans, animals, and the environment, i.e., in the local context we embrace zoonotic diseases, venomous animal injuries, and vector-borne diseases (VBD) epidemiology. We present ongoing data regarding the use of adult *Ae. aegypti* surveillance to predict arbovirus transmission risk at Foz do Iguaçu.

MATERIALS AND METHODS

Study site. The Brazilian city of Foz do Iguaçu (25°30'58''S 54°35'07''W) is located on the Triple Border with Argentina and Paraguay. It has approximately 250,000 inhabitants and an intense daily movement across the countries' border cities. The city is divided into 73 urban areas of approximately 1500 premises each (Leandro et al., 2021). The climate is classified as a humid tropical climate characterized by hot and humid summers (mean temperature >27 °C) and cold to mild winters (mean temperature < 15 °C), with an annual rainfall above 1850mm.

Zoonotic diseases *(ZD), injuries with venomous animals (IVA), and vector-borne diseases (VBD) monitoring*. The CCZ-Foz was created in 1997 after detection of rabies virus (RABV) in 4 stray dogs and 2 domestic cats, with health agents as part of the ZD team. The VBD team was created in 1999 to enhance surveillance for malaria and dengue (no Zika and chikungunya have been detected in Foz before 2015). Finally, the IVA team was created in 2006 to improve surveillance to spiders, bees and snakes at household level.

Aedes aegypti collection and entomological indexes. From Jan/17, a total of 3476 traps originally designed to capture gravid *Ae. aegypti* females were installed in the city (Codeço et al., 2015). All traps are visited every two-month, when local health agents conduct larval surveys in the same premises to calculate House Index (HI) and Breteau Index (BI). Trap inspection produced three entomological indexes based on adult collections: The Trap Positivity Index (TPI) is the number of positive traps among the total of traps inspected and multiplied by 100 respectively; the Adult Density Index (ADI) is the total number of *Ae. aegypti* captured divided by the total number of inspected traps multiplied by 100; the Mosquito per Inhabitant Index (MII) is the total number of adult *Ae. aegypti* collected and divided by the number of householders in the houses with an Adultrap multiplied by 1000. All entomological indexes were calculated every 2 months from 2017-2020, i.e., a total of 24 observations per index.

Entomo-virological screening. Adult *Ae. aegypti* captured alive in traps were pooled according to the block level and screened for arbovirus infection by RT-qPCR.

Data analysis. To determine the spatiotemporal correlation among variables with dengue incidence, we had two different approaches. We compared the dengue incidence in the same week but also 2, 4, 6, and 8 weeks after the surveys with the 5 entomological indexes: HI, BI, TPI, ADI, and MII using generalized linear mixed models (GLMM). In these models, fixed effect was included in the explanatory variable indexes of larvae and adult mosquitoes (HI, BI, TPI, ADI and MII), and the response variable was the incidence of dengue. We chose the best scenario using Akaike's Information Criteria to rank models. Later, we develop a Bayesian model to determine if entomological indexes based on larval surveys or adult trapping are able to predict which areas have higher risk for dengue transmission. All analyses were made on R.

RESULTS AND DISCUSSION

Modernization of ZD, IVA and VBD surveillance. The adoption of the One Health approach in Foz do Iguaçu took three years and was based on 5 axes: (1) merging sectorized teams; (2) implementation of digital solutions; (3) empowered health agents by permanent capacitation; (4) community engagement; and (5) active surveys. Although annual notification averages increased between 1997 and 2013 (pre-One Health) and 2014 and 2020 (post-One Health), we believe it is a natural consequence of the presence of ~150 trained and empowered health agents gathering more robust data during their house inspection.

Entomological survey and temporal correlation with dengue incidence. An average of 4883 houses were inspected bimonthly (6.25% of Foz do Iguaçu houses). Trap positivity ranged from 3.5-17.7% with at least one *Ae. aegypti*. Indices based on larval surveys presented an expected seasonal variation with higher values during the rainy summer (~Nov-Mar), but HI and BI fluctuations were only partially in accordance with dengue notification curve (Figure 1). All entomological indices based on adult sampling (TPI, ADI and MII) presented significant relationship with dengue incidence at Foz do Iguaçu during 2017-2020, with emphasis to ADI and MII after 4 weeks. Indices based on larval surveys presented limited significant relationship with dengue incidence.

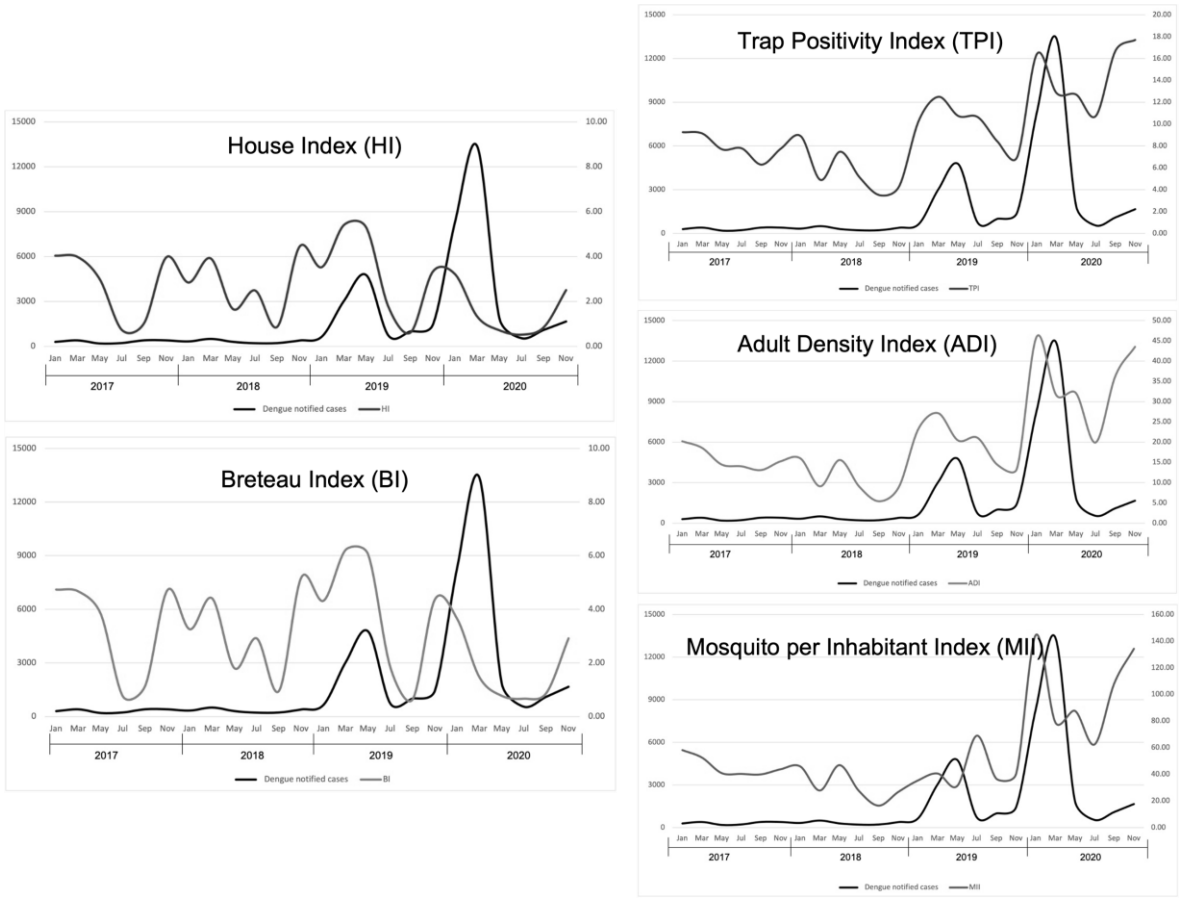

Figure 1. Bimonthly variation on infestation indices between 2017-2020. The black line in all graphs indicates the dengue notified cases in Foz do Iguaçu, whereas colored lines represent the HI and BI in the left panel and TPI, ADI, and MII on the right panel.

Entomological survey and spatial correlation with dengue incidence. From 2917-2020, a total of 11,962 adult *Ae. aegypti* were captured in the adult traps, with a massive predominance of female mosquitoes (95.4%). If entomological index based on adult trapping were able to predict dengue transmission in the subsequent 4 weeks, there was no spatial correlation between indexes and dengue incidence. Thus, indices as TPI, ADI, and MII are able to predict when a dengue outbreak might occur, but they have limited efficacy in pointing which of the 73 areas are of most concern (Figure 2).

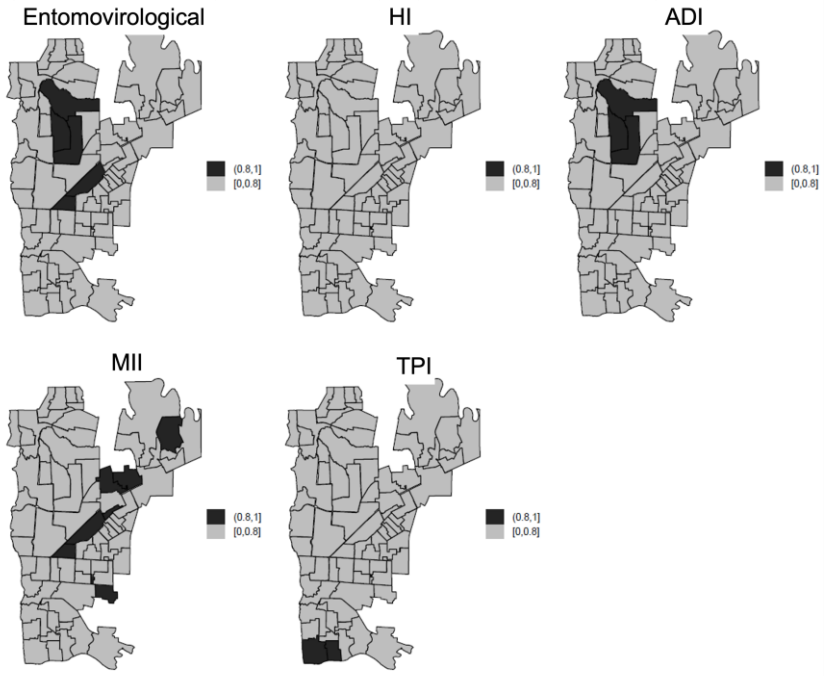

Figure 2. Lack of spatial correlation between the corresponding entomological indexes and dengue incidence for the 73 areas of Foz do Iguaçu.

CONCLUSION

The adoption of the One Health framework to improve VBD surveillance in Foz do Iguaçu transformed the CCZ-Foz from an archaic and sectorized structure to a modern and timely surveillance program dealing concomitantly with entomological, environmental, and epidemiological data. The data gathered from 2017-2020 shows that entomological indexes based on adult trapping provide more reliable predictions of dengue outbreaks than larval indexes, with emphasis to ADI and MII after 4 weeks. However, all indexes presented limited ability to point the hotspots of dengue incidence within the city.

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