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Occurrence of sporotrichosis in Belém, Pará, Brazil: a metaphor for unsustainable socioeconomic development

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ABSTRACT

Sporotrichosis is a fungal anthroponosis that has become a major public health problem in tropical countries. With that in mind, this study analyzed the relationship between this disease and demographic, socioeconomic and public health issues in Belém, State of Pará, Brazil, from 2020 to 2022. This ecological and cross-sectional study used data from the Belém Zoonosis Control Center, the Brazilian Institute of Geography and Statistics and the Health Ministry. Descriptive and spatial analyses were performed employing significance statistical, kernel, buffer and Moran techniques. One hundred sporotrichosis cases in cats and 49 in humans were analyzed. The results showed that the individuals most affected were women (61.22 %), adults (87.76 %), with the cutaneous form (95.92 %), diagnosed histopathologically (38.78 %), still undergoing treatment (46.94 %) and that the form of contagion was through cat scratches or bites (73.47 %). The profile also showed quantitative significance of ignored data related to treatment (65.31 %) and cat presence at home (63.27 %). The disease had a non-homogeneous distribution with very high densities in Campina de Icoaraci, Águas Negras and Parque Guajará. Those neighborhoods presented a very low Living Conditions Index and precarious services and health centers. The spatial dependence between the environmental and socioeconomic studied variables evidenced the establishment of an active transmission circuit for sporotrichosis in peripheral areas of the city, related to health inequalities with an underlying possible epidemiological silence,

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suggesting the need for expanding One Health public policies, aiming the sustainable development.

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1 Introduction

2 Lutz and Splendore¹ carried out the first Brazilian studies
3 focusing on the infection of animals by fungi of the genus
4 *Sporothrix*. Sporotrichosis is the mycotic disease that results
5 from this infection and can affect several animal species
6 whose interaction with human populations can lead to their
7 illness, making this disease an anthroponosis. The main
8 risk factors are principally related to injuries caused by biting
9 and scratching by domiciled or abandoned infected cats,
10 which are the main hosts.^{2,3} The disease has several clinical
11 forms, ranging from a single lesion to systemic and disseminated
12 forms that can affect the lungs, mucous membranes,
13 meninges, bones and joints.⁴

14 The occurrence of this anthroponosis in both humans
15 and cats, has a worldwide distribution with higher prevalence
16 in temperate and tropical regions, where the fungus finds the
17 most desirable conditions for development and is endemic in
18 South Africa, India, China, Japan, and Latin America.^{5,6} In Bra-
19 zil, sporotrichosis is considered emerging with a significant
20 number of cases in the metropolitan state capital areas of the
21 south and southeast and a tendency to expand to the rest of
22 the country during the last two decades.^{5,6} Because there is
23 no protocol for compulsory notification of this disease in Bra-
24 zil, which is only required in the states of Rio de Janeiro and
25 Pernambuco, its epidemiological scenario is still unknown in
26 the Brazilian territory as a whole. This poses a problem for
27 public health related to its spatial and temporal pattern of
28 occurrence, mainly because of its possible relationship with
29 demographic, socioeconomic, environmental and public
30 health variables as observed in other infectious diseases.^{5,7,8}

31 In 2018, sporotrichosis cases were identified in more than
32 eight states in the Southeast region of Brazil, mainly in the
33 states of Rio de Janeiro, Minas Gerais, and São Paulo. That
34 year, the northern Brazilian city of Belém do Pará
35 with 1.360.167 inhabitants reported the first cases of the dis-
36 ease in both humans and animals.⁹ However, in this region,
37 there are still few reports of the disease, although its risk fac-
38 tors such as favorable climatic variables and socioeconomic
39 issues are observed. The city has seven contiguous Administra-
40 tive Districts (AD): Belém (ADBEL); Outeiro (ADOUT);
41 Entroncamento (ADENT); Guamá (ADGUA); Sacramenta
42 (ADSAC); Benguí (ADBEN) and Icoaraci (ADICO). In this territo-
43 rial configuration, the ADBEL is formed by neighborhoods
44 located in the central area with the others in the peripheral
45 ones. These districts are marked by great differences in sani-
46 tation infrastructure, population distribution, and socioeco-
47 nomic level, related to the disorderly territorial expansion
48 that has occurred in the city over the last few decades.

49 The differential conjunction of the demographic, environ-
50 mental, and socioeconomic characteristics related to the dis-
51 tribution of living conditions index for the population

associated with sanitary and environmental variables in the 52
city neighborhoods and administrative districts may thus be 53
producing risk factors for the occurrence of the disease based 54
on the logic of socio-spatial segregation of the population. 55
Therefore, analyzing the distribution of sporotrichosis in this 56
territory carried out within the scope of epidemiological sur- 57
veillance is a major challenge for studies in public health, 58
since this scenario observed in Belém is recurrent in other 59
Brazilian cities as well. 60

61 Because they are able to use logical and mathematical rep-
62 resentations of geographical areas, geoprocessing techniques
63 have been widely used to analyze the spatial dependence of
64 the occurrence of various anthroponoses and their rela-
65 tionship with the living conditions of human populations and
66 the provision of health services in Brazil according to its
67 demography. This is in accordance with Law 8080 of Septem-
68 ber 1990, which created the Unified Health System in compli-
69 ance with the principle of equity.¹⁰⁻¹² The use of spatial data
70 analysis techniques in health has thus enabled the develop-
71 ment of studies based on etiological hypotheses, including
72 the identification of areas with active transmission circuits of
73 infectious diseases and their underlying conditions.

74 These techniques have recently also been used to high-
75 light the production of socio-spatial relationships in territo-
76 ries based on the hierarchical identification of access to
77 health services and its association with the occurrence of dis-
78 eases, especially those that are produced by environmental
79 and socioeconomic issues such as some anthroponoses,
80 e.g., sporotrichosis. Given the need to develop an epidemio-
81 logical scenario for this disease, this study sought to analyze
82 its relationship with demographic, socioeconomic, and public
83 health policy variables in the city of Belém, the capital of Pará
84 state, for the period from 2020 to 2022.

Materials and methods

85 This ecological and cross-sectional study analyzed the distri-
86 bution of all laboratory-confirmed sporotrichosis cases in
87 Belém, Pará, Brazilian eastern Amazon, from January 2020 to
88 December 2022, considering its contiguous neighborhoods
89 and administrative districts as spatial units for analysis. 90

91 Epidemiological data on the human cases (Gender, Age
92 Group, Evolution, Form of Contagion, Clinical Presentation,
93 Diagnosis Exam, Treatment and Cat Presence in the Home)
94 and the location of infected cats were obtained from the spo-
95 rotrichosis report produced by the Zoonosis Control Center
96 (CCZ) of the Belém Municipal Health Secretariat. Data regard-
97 ing the health centers and their services were acquired from
98 the National Registry of Health Establishments at the Ministry
99 of Health. The Living Conditions Index (LCI) and Demographic
100 data were used, based on the estimation process for 2020, and
101 from the 2010 Census carried out by the Brazilian Institute of

102 Geography and Statistics. The cartographic data and satellite
103 images were obtained from the National Space Research
104 Institute.

105 Next, the data obtained were debugged to remove incom-
106 plete or inconsistent records using Tabwin 36b software.
107 They were subsequently georeferenced in the laboratory
108 using Google Earth Pro in order to build a Geographical Data-
109 base. In the descriptive analysis, the proportion calculus and
110 the non-parametric chi-squared statistical test of expected
111 equal proportions for the individual profiles were performed
112 considering a p -value of <0.05 as significant, as well as the
113 quartile intervals of the demographic data (Low, Moderate,
114 High and Very High). Biostat 5.4 software was used for that
115 purpose.

116 In order to calculate the LCI an adaptation of the work of
117 Gonçalves¹³ and Paim¹⁴ was made, using the following socio-
118 economic indicators: income (proportion of heads of private
119 households with an average monthly income equal to or less
120 than two minimum wages); education (proportion of literate
121 people aged 10 to 14 years); cluster (proportion of houses in
122 subnormal agglomerations, such as slums and squatter set-
123 tlements in relation to the total number of households); rm/q
124 (ratio between the average number of residents per house-
125 hold and the average number of bedrooms) and sanitation
126 (percentage of households with internal plumbing connected
127 to the water supply network).

128 The LCI was calculated for each neighborhood in the city,
129 considering the average values of income, cluster and rm/q ,
130 which were arranged in ascending order and those of educa-
131 tion and sanitation in descending order. Next, each one
132 received an ascending score, relative to the value of each indi-
133 cator. In order to obtain the LCI values (lowest value of 20.33
134 and highest value of 44.32), the sum of the scores of the five
135 indicators of each neighborhood was performed and grouped
136 into quartiles so that they could be classified into strata of life
137 conditions: high (from 20.33 to 27.79), moderate
138 (from 27.80 to 34.50), low (from 34.51 to 39) and very low
139 (from 40 to 44.32). Lower LCI values corresponded to better liv-
140 ing conditions. In an effort to verify the precarious living con-
141 ditions of the resident populations in peripheral areas of the
142 city, four fieldwork activities were carried out.

143 Several techniques were used for the spatial analysis, such
144 as kernel density estimation to evaluate the distribution of
145 human sporotrichosis, considering the distance between the
146 geographic points of the occurrence of the cases, and a buffer
147 to estimate the ecological niche coverage for infected cats,
148 calculating the radius of displacement of these animals to
149 meet their physiological demands. The bivariate local Moran
150 Index (I) was also used to verify the spatial autocorrelation,
151 between areas with cases in both humans and animals. This
152 was considered direct for $I > 0$, inverse for $I < 0$, and strong
153 when indices were close to one of the defined variation limits
154 (-1 and 1).¹⁰ The analyses of the relationships between the
155 variables and their expressions in thematic maps were per-
156 formed using Arcgis 10.5 software.

157 The present study was exempted by the Research Ethics
158 Committee of the Health Science Institute at the Universidade
159 Federal do Pará (Pará Federal University) under opinion n
160 ° 1.684.124/2016 and by the Ethics Committee on the Use of
161 Animals, of the Universidade Federal Rural da Amazônia

(Federal Rural University of the Amazon) under protocol n 162
° 1464170522, both in accordance with Resolution n° 466/12 of 163
the National Health Council and with law n° 11.794, of Octo- 164
ber 8, 2008. 165

166 Results

167 Regarding the quartile calculation of the district population 167
quantitative of Belém, the following distribution was 168
observed: low in ADOUT, moderate in ADENT and ADBEL, 169
high in ADICO and ADSAC, and very high in ADGUA and 170
ADBEN. The districts that most presented cases in humans 171
and animals were ADICO and ADBEN, which are spatially con- 172
tiguous. In relation to the occurrence of the disease in felines, 173
one hundred cases in different AD and neighborhoods of the 174
city were analyzed. The epidemiological profile analysis of 175
the forty-nine cases of human sporotrichosis showed a major 176
occurrence of the disease in women (61.22 %), adults 177
(87.76 %), with cutaneous form (95.92 %), diagnosed histopath- 178
ologically (38.78 %), still undergoing treatment (46.94 %) and 179
form of contagion by cat scratches or bites (73.47 %). The pro- 180
file also showed a quantitative significance with ignored data 181
related to treatment (65.31 %) and cat presence at home 182
(63.27 %). All variables were significant except for gender and 183
the diagnosis exam (Table 1). The pathogen identified as 184
responsible for the infection was *Sporothrix schenckii*. 185

186 An overall non-homogeneous spatial distribution of sporo- 186
trichosis in both humans and animals was observed in the 187
studied area for the period. The highest numbers for the dis- 188
ease in humans were verified in the neighborhoods of Cam- 189
pina de Icoaraci (22), Águas Negras (4), Parque Guajará (4) and 190
Agulha (4). Regarding the infected cats, the highest occur- 191
rence was observed in Campina de Icoaraci (66), Águas Negras 192
(11) and Maracacuera (5). The bivariate local Moran Index (I) 193
showed a direct and strong “High-High” spatial autocorrela- 194
tion, with statistical significance between the occurrence of 195
the disease in humans and animals in the neighborhoods 196
listed above, as well as in Cruzeiro and Ponta Grossa, all 197
belonging to the ADICO, and São João do Outeiro in the 198
ADOUT. All these contiguous neighborhoods are located in 199
peripheral areas of the city (Fig. 1). 200

201 It was also observed that the provision of health services 201
and establishments related to environmental and epidemio- 202
logical surveillance presented a significant precariousness in 203
the peripheral areas of the city. This situation was principally 204
associated with the low coverage of public laboratories for the 205
diagnosis and availability of endemic combat agents, espe- 206
cially in all ADICO neighborhoods, these being Águas Negras, 207
Agulha, Campina de Icoaraci, Cruzeiro, Maracacuera, Para- 208
curi, Parque Guajará, Ponta Grossa and Tenoné (Fig. 1). 209

210 Analysis of the sporotrichosis cases in humans performed 210
with the kernel estimation technique showed densities that 211
were very high in the Cruzeiro, Campina de Icoaraci, Parque 212
Guajará, Ponta Grossa, Agulha and Águas Negras neigh- 213
borhoods, high in Maracacuera and Tapanã, and moderate in 214
Água Boa, São João do Outeiro and Bengui. It was also 215
observed that the areas covered by the ecological niche with 216
the largest number of infected cats, identified using the buffer 217

Table 1 – Epidemiological profile of human sporotrichosis, in Belém, Pará State, Brazil, from 2020 to 2022.

| Variable | Category | Frequency (n = 49) | Proportion (%) | *P-value |
|--------------------------|-------------------------------|--------------------|----------------|----------|
| Gender | Female | 30 | 61.22 | 0.2120 |
| | Male | 19 | 38.78 | |
| Age group | Adolescent | 1 | 2.04 | < 0.0001 |
| | Adult | 43 | 87.76 | |
| | Elderly | 4 | 8.16 | |
| | Ignored | 1 | 2.04 | |
| Form of Contagion | Cat Scratches/Bites | 36 | 73.47 | < 0.0001 |
| | Contact with Suspected Animal | 11 | 22.45 | |
| | Ignored | 2 | 4.08 | |
| Evolution | Discharged | 2 | 4.08 | < 0.0001 |
| | Cure | 7 | 14.29 | |
| | Undergoing Treatment | 23 | 46.94 | |
| | Ignored | 17 | 34.69 | |
| Clinical presentation | Cutaneous Form | 47 | 95.92 | < 0.0001 |
| | Ignored | 2 | 4.08 | |
| Diagnosis exam | Fungal Culture | 13 | 26.53 | 0.5647 |
| | Histopathological | 19 | 38.78 | |
| | Ignored | 17 | 34.69 | |
| Treatment | Itraconazole | 16 | 32.65 | < 0.0001 |
| | Spontaneous Healing | 1 | 2.04 | |
| | Ignored | 32 | 65.31 | |
| Cat presence in the home | Yes | 18 | 36.73 | < 0.0001 |
| | No | 1 | 2.04 | |
| | Ignored | 31 | 63.27 | |

n, Number of cases;
* Adherence chi-square, $p < 0.05$.

218 technique are spatially dependent on the high density of the
219 cases of the disease in humans (Fig. 2).

220 It was also identified that LCI in Belém presented a great
221 socioeconomic difference between its neighborhoods, with a
222 high index of living conditions identified in those located in
223 the central area of the city, such as Nazaré, Batista Campos
224 and Marco, and low or very low in peripheral ones, such as
225 Água Boa, Cruzeiro, Bengui and Parque Guajará. In the neigh-
226 borhoods that had a high LCI, there were no reports of sporo-
227 trichosis cases. However, in those where this indicator was
228 low or very low, the disease density in humans was high or
229 very high (Fig. 2).

230 The spatial dependence between the occurrence of the dis-
231 ease cases in both humans and cats observed with a non-ran-
232 dom behavior using the kernel technique pointed to a
233 geographic dependence between them, establishing a cluster
234 of the disease. This scenario was confirmed by direct and
235 strong spatial correlation between areas with high density of
236 the disease in humans and those covered by the ecological
237 niche of the infected felines, in Belém neighborhoods and AD,
238 which presented precariousness in the offer of public health
239 services and low living conditions. Thus, these observations
240 highlight a process of socio-spatial segregation of the popula-
241 tion in the studied area.

242 Discussion

243 Considering that the first confirmations of human and animal
244 sporotrichosis in Belém were only described in 2018,¹⁵ the
245 number of cases analyzed during the studied period suggests

246 the existence of an epidemiological silence possibly related to
247 the non-mandatory notification of the disease in this state, as
248 may be observed in several regions of Brazil.^{5,8} This situation
249 may be also related with the significant number of infected
250 cats in the various districts and neighborhoods of the city, as
251 well as the presence of other risk factors for this pathology
252 such as socioeconomic and environmental issues.^{16,17}

253 The fact that sporotrichosis occurred in a higher percent-
254 age of adult women who reported contagion form by cat
255 scratches or bites follows the national trend of the disease
256 profile and may be related to their more frequent permanence
257 in the home. This situation highlights that the coexistence
258 between humans and domestic animals suggests a process of
259 intra and peridomiciliary transmission of the disease due to
260 these relationship risk factors, principally in peripheral
261 areas.^{18,19} The high percentage of individuals undergoing
262 treatment may be related to the recent beginning of the spo-
263 rotichosis diagnosis in the city, in addition to the therapeutic
264 scheme adopted as a protocol, which is considered relatively
265 long and expensive, especially when the case is diagnosed
266 late. Thus, the difficulty in accessing laboratory tests and clin-
267 ical follow-up for the disease makes for an inequity in
268 health.^{16,17}

269 The fact that the disease profile showed a quantitatively
270 significant percentage of the cutaneous form as the main clin-
271 ical presentation and ignored data from the diagnostic test
272 and type of treatment indicates the need to expand the epide-
273 miological surveillance for the disease. In this context, these
274 three variables may indicate adverse consequences in rela-
275 tion to the disease cases growth, especially when the risk of a
276 sporotrichosis outbreak may be imminent in Belém, notably

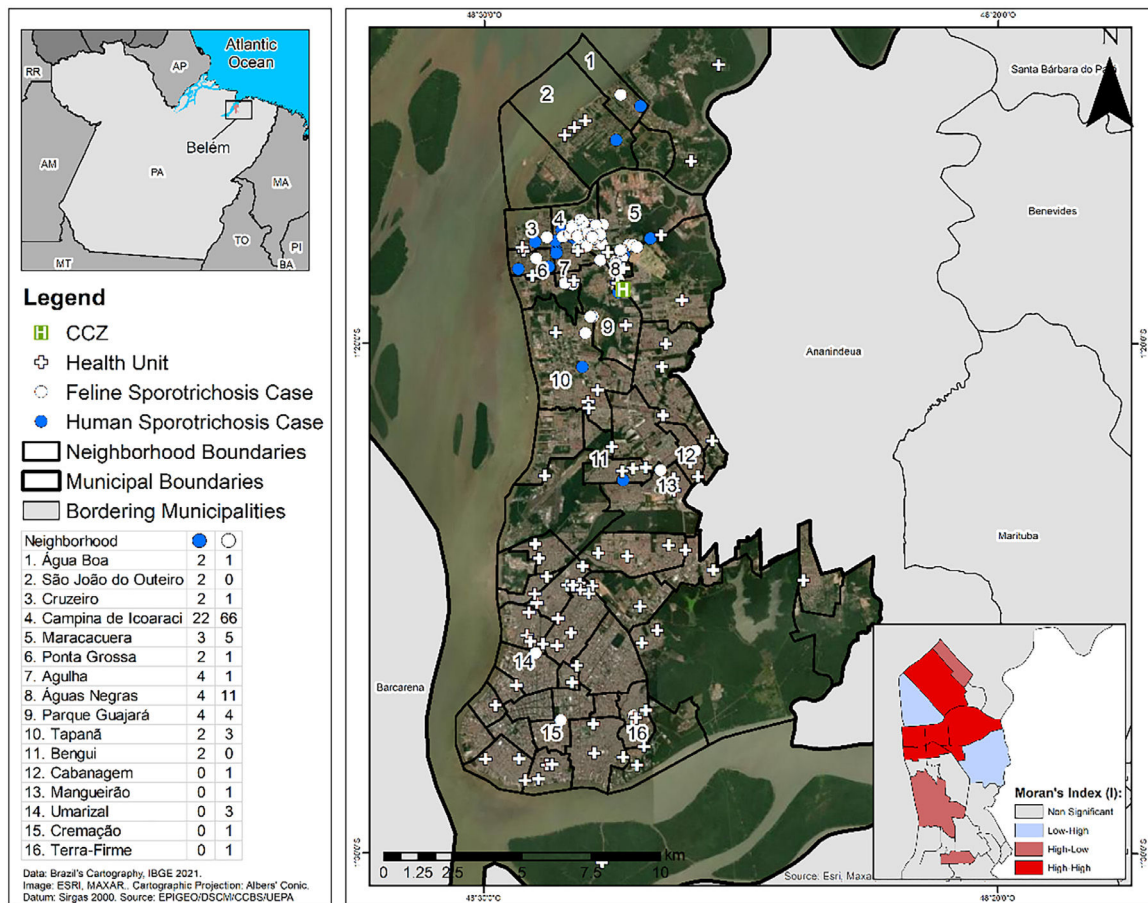


Fig. 1 – Spatial distribution of human and feline sporotrichosis and health units, in the neighborhoods of Belém, Pará State, Brazil, from 2020 to 2022.

when we consider the difficulty of access to laboratory tests and drugs such as itraconazole. The major amount of ignored data about cat presence in the home suggests the need to inform the primary health care professionals about its risk factors, as seen in others infectious processes.^{20,21}

The significant number of cats with sporotrichosis, whose epidemiological process initiated at Campina de Icoaraci at ADICO in January 2020, may be related to the lack of contraceptive actions to control the large feline population of the city, principally in peripheral areas with a large number of abandoned animals.^{17,22} Another factor possibly associated with this situation is the growth of domestic cat breeding, which was observed recently during the COVID-19 pandemic.^{1,2,23} The high density of sporotrichosis cases both humans and cats occurred in the Campina de Icoaraci, Parque Guajará and Águas Negras may be related to the socio-economic characteristics of Belém peripheral areas, given its disordered urban expansion over the last decades with unsanitary occupations with low infrastructure and precarious public services, identified in these areas during fieldwork.

The geographical dependence observed between areas with human and feline sporotrichosis and LCI based on direct and strong spatial autocorrelation of the “High-High” type using Moran’s local index technique, highlighted the social inequalities of the population resident in the ADICO neighborhoods, which was verified in the laboratory and in

fieldwork. In this context, the non-random behavior of the correlation of these variables showed the establishment of several disease clusters in the studied area. This means that these neighborhoods present major risk factors for sporotrichosis transmission, due to its precarious infrastructure such as unpaved roads with exposed soil and the accumulation of solid waste that establishes a potential epidemiological scenario for sporotrichosis, as well as other infectious processes.^{17,24,25}

The identification of the low supply of services and health centers and the low coverage of environmental surveillance in areas with quantitative significance of sporotrichosis cases points to the establishment of epidemiological silence, which limits the production of information used in the development process of public policies to mitigate the disease impacts. This situation can be also observed in several studies on the relationship between the availability of health services and the occurrence of infectious diseases, highlighting the weakness of the Brazilian Unified Health System, principally in the northern region of Brazil.^{7,26}

The spatial dependence between neighborhoods that presented low and very low LCI and high and very high density of human sporotrichosis, as opposed to those with high LCI and absence of the disease constitutes a metaphor of the socioeconomic and epidemiological segregation existing in the city, due to these relationships be limited to specific areas.

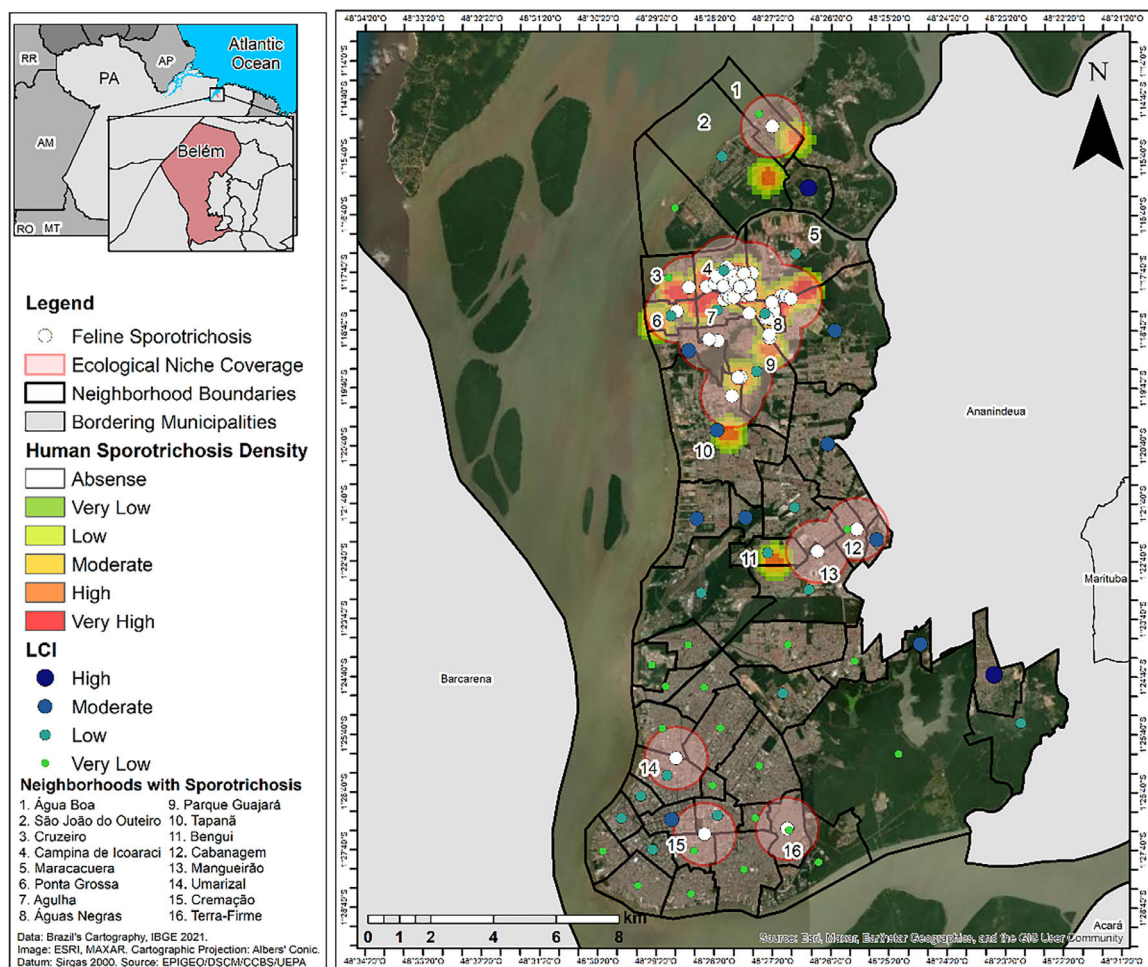


Fig. 2 – Density of human cases of sporotrichosis and living conditions index (LCI), in the neighborhoods of Belém, Pará State, Brazil, from 2020 to 2022.

329 This fact also reflects the problems of the peripheral areas
 330 residents, who need the constitutional guarantee of citizen-
 331 ship concerning their right to access sanitary public services.
 332 That is because, according to the principles of equity, the dis-
 333 tribution of health services and centers must obey a hierar-
 334 chical logic for allocation of these resources, where
 335 demographic and socioeconomic indicators should define pri-
 336 orities.²⁷ Therefore, social liabilities historically marked by
 337 non-sustainable development could be corrected.⁷

338 The fact of the spatial dependence between areas with a
 339 high density of human cases and the ecological niche of the
 340 great number of infected cats and precarious supply of health
 341 services and centers is related to the low socioeconomic con-
 342 ditions in which these populations are inserted, as observed
 343 with the use of the LCI. Thus, the geographic conjunction of
 344 these variables constitutes an active circuit for socioeconomic
 345 and environmental production of sporotrichosis, which
 346 points the health inequalities related to the concentration of
 347 primary health care for the disease in the central area of the
 348 city, where no cases were reported. This fact also indicates a
 349 socio-spatial segregation problem in Belém, based on the
 350 hierarchy of the population's access to public health services,
 351 because patients who live in peripheral neighborhoods far

352 from the center must travel great distances to find health
 353 assistance.^{7,18}

354 Thus, this situation puts a significant populational amount
 355 that lives in the city's peripheral AD in a lower social position
 356 regarding the difficulty in continuously maintaining the treat-
 357 ment prescribed for the disease, which means that many may
 358 abandon it, as observed in other infectious processes.²⁸ It is
 359 important to consider the existence of high-income condo-
 360 miniums in these areas, whose inhabitants number is very
 361 low in comparison to the population of the peripheral neigh-
 362 borhoods that surround them. This means that the need for
 363 expanding public health policies to mitigate the disease
 364 occurrence both in humans and animals among the AD is
 365 imperative given the demographic context, as advocated by
 366 World Health Organization and the Brazilian Health Ministry
 367 in the global guidelines centered on the one-health
 368 dimension.^{29,30}

369 The characteristics of the sporotrichosis risk factors in
 370 Belém point to the challenge and complexity of understand-
 371 ing its epidemiological scenario beyond the physical limits of
 372 the quantitative evidence of the land use and occupation
 373 associated with the significant spatial correlation between
 374 the environmental and socioeconomic problems, identified

375 by the geoprocessing techniques used. This situation is also
 376 aggravated by the demography of the neighborhoods and AD
 377 with great numbers of cases, where the higher number of
 378 people residing bring pressure on the few health resources
 379 offered by the government, as may be observed in other
 380 regions of Amazon.^{31,32} These facts also suggest the need to
 381 develop qualitative analyses of the social inequalities
 382 observed in these territories, as they constitute conditionings
 383 for the disease establishment.

384 Given the above, it was observed a low sporotrichosis spa-
 385 tial density in Belém central neighborhoods and very high in
 386 peripheral ones related to a socioeconomic segregation exist-
 387 ing in the city, with a significant gradient of its LCI associated
 388 to a spatial dependence between environmental and demo-
 389 graphic risk factors. In addition, a low level of public health
 390 services supply in peripheral areas was also observed. All
 391 these situations reveal the production of a socio-spatial hier-
 392 archy of the population regarding their access to better living
 393 conditions, pointing to non-sustainable development of the
 394 city.

395 Although the city is not endemic for the disease, the fact
 396 that it occurs points to the need for discussing public policies
 397 related to one health, mainly regarding epidemiological and
 398 environmental surveillance focusing on controlling anthro-
 399 zoonoses. The use of geoprocessing techniques was satisfac-
 400 tory for showing the spatial dependence between the
 401 variables analyzed in this work. Finally, we suggest the
 402 strengthening of surveillance actions for the disease to pro-
 403 mote its mitigation. Given that the risk of territorial expan-
 404 sion constitutes an imminent danger for the health of Belém
 405 population and considering the possibility for an outbreak of
 406 the disease, we can view this situation as a metaphor for
 407 non-sustainable development of the city presented here that
 408 reflects the situation of social inequalities of the Brazilian
 409 Amazon.

410 Conflicts of interest

411 The authors declare no conflicts of interest.

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