ARQUIVOS DE ASMA, ALERGIA E IMUNOLOGIA

Original Article

Environmental exposure and health risks in Brazil

Exposição ambiental e risco à saúde - Brasil

Marilyn Urrutia-Pereira[1,2], Raquel Prudente Baldaçara[2,3], Adelmir Souza Machado[2,4], Raphael Coelho Figueredo[2], Lucas Pitrez Mocelin[1], Paulo Oliveira Lima[1], Herberto Jose Chong-Neto[5,6], Dirceu Solé[2,7]

ABSTRACT

Objective: To identify potential sociodemographic, socioeconomic, health, environmental, and lifestyle factors associated with adverse health effects in residents of 3 Brazilian cities. **Methods:** This cross-sectional study with a quantitative approach was conducted in the cities of Imperatriz (Maranhão), Palmas (Tocantins), and Salvador (Bahia). A total of 975 patients aged 18 to 75 years treated at primary health care units from June 2021 to June 2022 were selected via convenience sampling. A standardized questionnaire on sociodemographic characteristics, exposure to environmental factors, and lifestyle habits was administered. The outcome measured was health status (excellent/good vs fair/bad/very poor). Multivariate analysis was performed using logistic regression, respecting each municipality individually and collectively. Data were presented as odds ratios (OR) and 95%CIs. **Results:** Women predominated in all cities: 58.3% in Imperatriz, 67.5% in Tocantins, and 65.4% in Salvador. The prevalence of smoking (present and/or past) was significantly higher in Salvador, as was the prevalence of alcohol consumption. Despite Salvador having the highest rate of comorbidities, residents of Imperatriz reported more instances of fair/poor/very poor health. Environmental factors significantly associated with poor health conditions in both analysis models included exposure to wood/coal/kerosene/other stoves during childhood, spending more than 2 hours in the kitchen with a working stove, and living close to a pollution source. Residents of Imperatriz were 1.8 times and 1.7 times more likely to have poor health compared with residents of

RESUMO

Objetivo: Identificar possíveis fatores sociodemográficos, econômicos, de saúde, ambientais e de hábitos de vida associados a efeitos adversos sobre a saúde de moradores em três cidades brasileiras. **Método:** Estudo transversal com abordagem quantitativa realizado nas cidades de Imperatriz (Maranhão), Palmas (Tocantins) e Salvador (Bahia). Participaram 975 pacientes (18 a 75 anos) atendidos em unidades básicas de saúde no período de junho de 2021 a junho de 2022. Esses indivíduos foram selecionados aleatoriamente (amostra de conveniência). Foi aplicado o questionário padronizado sobre fatores sociodemográficos e exposição a fatores ambientais, assim como o de hábitos de vida. Empregou-se a situação de saúde (excelente/boa x regular/má/péssima) como desfecho, foi realizada análise multivariada seguida por regressão logística respeitando-se cada município individualmente e o seu coletivo. Os dados foram apresentados como *odds ratio* (OR) e intervalos de confiança de 95% (IC95%). **Resultados:** Em todas as cidades houve predomínio de pacientes do sexo feminino: 58,3% em Imperatriz, 67,5% em Tocantins e 65,4% em Salvador. A prevalência de tabagismo (presente e/ou passado) foi significantemente mais elevada em Salvador, assim como a de consumo de álcool. Houve maior referência de saúde regular/má/péssima entre os moradores de Imperatriz, apesar de em Salvador haver o maior relato de comorbidades. Os fatores ambientais associados à condição precária de saúde, em ambos os modelos de análise, foram: ter sido exposto durante a infância a fogão a lenha/carvão/querosene/outro; passar mais de duas horas

1. Universidade Federal do Pampa, Faculdade de Medicina - Uruguaiana, RS, Brazil.
2. Sociedad Latinoamericana de Alergia, Asma e Inmunologia (SLAAI), Comité Científico de Polución - SLAAI, Brazil.
3. Universidade Federal do Tocantins, Faculdade de Medicina - Palmas, TO, Brazil.
4. Universidade Federal da Bahia, Instituto de Ciências da Saúde - Salvador, BA, Brazil.
5. Universidade Federal do Paraná, Department of Pediatrics - Curitiba, PR, Brazil.
6. Sociedad Latinoamericana de Alergia, Asma e Inmunologia (SLAAI), Diretor Científico - Brazil.
7. Universidade Federal de São Paulo, Department of Pediatrics - São Paulo, SP, Brazil.

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Salvador (a more developed center with more health resources) and Palmas, respectively. **Conclusions:** Health professionals should guide the population regarding socio-environmental issues affecting health indices. Demographic, environmental, and economic data can impact health conditions.

Keywords: Environmental exposure, environmental pollution, hypersensitivity.

na cozinha, com fogão em funcionamento; e residir próximo a uma fonte poluidora. Morar em Imperatriz revelou chance 1,8 vezes maior de ter saúde debilitada quando comparado aos moradores de Salvador, e de 1,7 vezes para os de Palmas. **Conclusões:** Profissionais de saúde deverão orientar a população quanto as questões socioambientais que interferem nos índices de saúde. Os dados demográficos, ambientais e econômicos podem interferir nas condições de saúde.

Descritores: Exposição ambiental, poluição ambiental, hipersensibilidade.

Introduction

Exposure to environmental pollutants has consistently been associated with adverse consequences for health, triggering a series of pathological conditions.[1,2] This phenomenon is especially evident in low-income communities and among ethnic minorities, which are subject to higher rates of exposure to these pollutants as a consequence of unfavorable social and historical structures.[1,2] One of the most worrying results of this exposure is the increased prevalence of allergic diseases in these populations, creating a worrying interface between environmental pollution and allergy.[1,2]

Emissions from fixed sources such as industrial plants release harmful substances such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate material (PM).[1,3,4] These pollutants have been extensively studied for their role in the incidence and exacerbation of respiratory diseases such as asthma, in reduced pulmonary function, and in increased mortality.[5,6] Vulnerable populations, very often living in low-income areas, are particularly susceptible to these adverse impacts. Emissions from mobile sources, such as motor vehicles, represent a significant threat to air quality.[1,7] Traffic-related air pollution is made up of gasses and particles released by combustion of fossil fuels. This type of pollution has been associated with a range of health problems, including respiratory morbidity, cancer, and heart disease. Ethnic minority and low-income communities very often live in areas with greater exposure to these pollutants, intensifying their risk of developing allergic diseases.[1,7,8]

In turn, poor quality housing plays a crucial role in exposure to pollutants and allergens. Houses with inadequate infrastructure, subject to leaks and seepage, provide the ideal conditions for growth of allergens, such as mold. Low income and ethnic minority populations are more likely to live in environments with poor housing, increasing their exposure to these agents that trigger allergies.[1,9-11]

This panorama highlights the complex interconnection between pollution and allergic diseases, emphasizing the need for immediate action. More equitable environmental policies, continuous research into the impacts of these exposures and public education are essential to mitigate the adverse effects on health and promote a healthier and fairer environment for all communities.

Against this background, the objective of this study was to identify possible sociodemographic, socioeconomic, health, environmental, and lifestyle factors associated with adverse effects on the health of residents of three Brazilian cities, with the objective of identifying risk factors that can be targeted in future prevention campaigns.

Methods

A cross-sectional study with a quantitative design was conducted in the cities Imperatriz (Maranhão) and Palmas (Tocantins), both in the North region of Brazil, and in Salvador (Bahia), in the Northeast region of Brazil. Patients (18 to 75 years of age) who were seen at primary care health centers in these three Brazilian cities, irrespective of the reason for their consultation, were invited to take part from June 2021 to June 2022. Participants were selected at random (by convenience sampling) and voluntarily and appropriately answered a standardized questionnaire on sociodemographic factors, exposure to environmental factors, and lifestyle habits, adapted from the Clinical Screening Tool for Air Pollution Risk.[12]

Individuals were asked about sex, race, educational level, marital status, employment, family income, whether they were recipients of the Bolsa Familia

welfare program, place of residence, health status, diseases, alcohol consumption, exposure to sources of pollutants at work, housing, exposure to fuel burning including biomass, fossil fuels and others, ventilation of domestic environments, cleaning products, cigarette smoking, and regular exercise, among other questions. With relation to economic level, patients were divided into those whose income was less than or equal to twice the minimum monthly wage (MMW, approximately US$ 450)[13,14] or greater than twice the MMW.[15] Participants were categorized by current health status as having regular/poor/very poor health or very good/good health.

Table 1 lists the main sociodemographic characteristics of the three cities participating in the study,[16] two of which, Palmas and Salvador, are state capitals.[15] This study is part of a larger research project also conducted in other parts of Latin America.

Analysis of the data

The data collected were input to an Excel® spreadsheet. Categorical variables were expressed as frequency distributions and proportions and comparisons between groups were performed using nonparametric tests (Chi-square or Fisher's exact test). Taking health status as the outcome (very good/good vs. regular/poor/very poor), a multivariate analysis was conducted, followed by logistic regression, taking each city individually and all three together. Data were expressed as odds ratios (OR) and 95% confidence intervals (95%CI). Two analytical models were employed. Model 1 used environmental variables only and model 2 included environmental, sociodemographic, health, and lifestyle variables, plus comorbidities (diseases included in the questionnaire) and ophthalmological comorbidities. For all analyses, the cutoff adopted for rejection of the null hypothesis was 5%.

Table 1
Some sociodemographic characteristics of the cities studied[16]

Characteristic	Imperatriz	Palmas	Salvador
Estimated population [2021], number of people	259,980	313,349	2,900,319
Area of city territory [2021], km^2	1,369.039	2,227.329	693,453
Biome [2019]	Amazônia; Cerrado	Cerrado	Atlantic Rain Forest
Per capita GDP [2019], R$	28,830.95	34,933.66	22,213.24
Mean monthly salary of registered workers [2020], MMW [a]	2.0	3.9	3.3
Percentage of 6-to-14-year-olds in school [2010], %	98.4	98	95.9
Infant mortality [2020], deaths per thousand live births	10.64	12.13	14.76
Municipal Human Development Index (HDI) [2010]	0.731	0.788	0.759
Latitude – South	5° 31' 33"	10° 11' 04"	12° 58' 16"
Longitude – West	47° 28' 33"	48° 20' 01"	38° 30' 39"
Altitude, meters	95	260	8.3

[a] Multiples of the Minimum Monthly Wage; approximately US$ 225.[4,5].

The study was approved by the Research Ethics Committee at the Universidade Federal do Pampa and all participants signed a free and informed consent form (No. 31930620.0.0000.5323).

Results

In all three cities, majorities of the patients were female: 58.3% in Imperatriz, 67.5% in Tocantins, and 65.4% in Salvador. With the exception of Palmas, majorities of the sample self-identified as of non-White races. Except for Imperatriz, high educational level predominated. The majority of patients stated they were married or in a stable relationship and were employed or self-employed. In Imperatriz, the prevalence of individuals with family income less than or equal to 2 MMW (56.1%) was significantly higher than in the other two cities and 28.1% of the sample received government benefits.

Residents of urban areas predominated in all three populations assessed. Despite the differences observed in sociodemographic characteristics, we found that all three cities had very similar HDIs (Table 1).

Table 2 presents the results of the univariate and multivariate analyses (models 1 and 2) based on the entire patient sample and the outcome of poor health. These results show that environmental factors that were significantly associated with poor health status, in both analytical models, were as follows: having been exposed to a wood/charcoal/kerosene/other stove during childhood, spending more than 2 hours in the kitchen with the stove lit, and living close to a source of pollution. When sociodemographic, health, and lifestyle variables and presence of comorbidities were also analyzed in addition to environmental variables, we found that having income of up to two MMW, living in Imperatriz or Palmas, having comorbidities, having ophthalmological comorbidities, and exercising outside were also associated with worse health status.

Table 3 shows that having been exposed to a wood/charcoal/kerosene/other stove during childhood, spending more than 2 hours in the kitchen, living close to a source of pollution, having income of up to two MMW, having comorbidities, including ophthalmological comorbidities, and exercising outside were associated with increased health risk. Living in Imperatriz was associated with a 1.8 times greater likelihood of poor health when compared to living in Salvador (a more developed city with more health care resources) and 1.7 times greater than living in Palmas.

Discussion

The present study assessed residents of three cities in Brazil: Salvador, Imperatriz, and Palmas. Although these three cities have very similar HDIs, there are differences between them in terms of *per capita* GDP (lower in Salvador); mean monthly salary of registered workers (lower in Imperatriz) and infant mortality (higher in Salvador) (Table 1).

Analysis of factors associated with worse health status identified the following as significantly associated with worse health status: early exposure to stove burning wood/charcoal/kerosene/other, spending more than 2 hours in the kitchen with the stove lit, living close to a source of pollution, having income of up to two MMW, living in Imperatriz or in Palmas, having comorbidities, having ophthalmological comorbidities, and exercising outside.

Several different studies have confirmed that populations living in extremely poor regions, without adequate refuse collection, with inadequate sanitation, and with open sewers, in areas where people are exposed to pollutants, and to biomass burning have worse health indicators, with increased morbidity and mortality, impacting on the life expectancy of these populations.[17,18]

Many pollutants are the main factors in diseases affecting humans, including particulate material (PM^{10}, $PM^{2,5}$, $PM^{0,1}$), nitric oxide, sulfur dioxide, volatile organic compounds (VOC), dioxins and polycyclic aromatic hydrocarbons (PAHs), carbon monoxide, ozone, primarily in soil, and heavy metals. The diseases caused by exposure to the substances listed primarily include respiratory problems, such as chronic obstructive pulmonary disease (COPD), asthma, lung cancer, cardiovascular events, central nervous system dysfunctions, and cutaneous and ophthalmological diseases. Additionally, climatic changes caused by environmental pollution affect the geographical distribution of many infectious diseases, in addition to natural disasters.[17,19]

Pollution is responsible for 9 million premature deaths/year worldwide, accounting for one in six deaths all over the planet. Deaths caused by pollution are an unintentional consequence of industrialization and urbanization and these mortality rates have increased 7% since 2015 and more than 66% since

Table 2
Logistic regression assessing factors associated with self-reported poor health[a]

Variables	Univariate model				Multivariate model 1 N = 895 LR = -123.91				Multivariate model 2 N = 892 LR = -445.26			
			95%CI				95%CI				95%CI	
	OR	Value p	Minimum limit	Maximum limit	OR	Value p	Minimum limit	Maximum limit	OR	Value p	Minimum limit	Maximum limit
Environmental factors												
Type of stove used												
Wood/charcoal/kerosene/solvent/other	1.28	0.276	0.82	2.00	0.79	0.376	0.48	1.32				
Natural gas/GLP	1.00				1.00							
Type of stove at home when a child												
Wood/charcoal/kerosene/other	1.88	< 0.001	1.40	2.52	1.86	< 0.001	1.32	2.63	1.54	0.028	1.05	2.25
Natural gas/GLP	1.00				1.00				1.00			
Number of hours spent in the kitchen with the stove lit												
More than 2 hours	1.66	0.004	1.18	2.34	1.48	0.026	1.05	2.08	1.51	0.034	1.03	2.20
Up to hours	1.00				1.00				1.00			
Has damp environments at home												
Yes	1.29	0.172	0.89	1.87	1.31	0.162	0.90	1.91				
No	1.00				1.00							
Lives close to a source of pollution												
Yes	1.75	< 0.001	1.32	2.33	1.73	0.002	1.23	2.43	1.55	0.010	1.11	2.16
No	1.00				1.00				1.00			
Works close to a source of pollution												
Yes	1.25	0.158	0.92	1.69	0.99	0.940	0.69	1.42				
No	1.00				1.00							
Burns any type of material inside the house												
Yes	1.63	0.044	1.01	2.62	1.45	0.204	0.82	2.55	1.61	0.121	0.88	2.92
No	1.00				1.00				1.00			
Place of residence												
Urban	0.57	0.024	0.34	0.93	0.77	0.388	0.42	1.40	1.12	0.720	0.60	2.12
Rural	1.00				1.00				1.00			
Sociodemographic factors												
Family income (MMW)												
Up to 2	1.82	< 0.001	1.36	2.42					1.85	0.008	1.17	2.91
More than 2	1.00								1.00			
Sex												
Female	1.50	0.008	1.11	2.03					1.39	0.066	0.98	1.98
Male	1.00								1.00			

[a] Regular/poor/very poor.
RV: 95%CI: 95% confidence interval, LR: likelihood ratio, OR: odds ratio, MMW: multiples of monthly minimum wage.

Table 2 *(continuation)*
Logistic regression assessing factors associated with self-reported poor health[a]

Variables	Univariate model				Multivariate model 1 N = 895 LR = -123.91				Multivariate model 2 N = 892 LR = -445.26			
			95%CI				95%CI				95%CI	
	OR	Value p	Minimum limit	Maximum limit	OR	Value p	Minimum limit	Maximum limit	OR	Value p	Minimum limit	Maximum limit
Sociodemographic factors												
Age group (years)												
60 or over	0.41	0.041	0.17	0.96					0.33	0.066	0.10	1.08
40 to 59	0.49	0.042	0.25	0.97					0.45	0.111	0.17	1.20
25 to 39	0.38	0.004	0.19	0.74					0.26	0.006	0.10	0.68
18 to 24	0.42	0.017	0.21	0.86					0.27	0.008	0.10	0.71
0 to 17	1.00								1.00			
Educational level												
Up to end of elementary	2.57	0.001	1.47	4.51					1.46	0.345	0.67	3.19
Secondary education	1.53	0.027	1.05	2.24					1.01	0.968	0.57	1.81
Started higher education	1.29	0.240	0.84	1.97					1.04	0.890	0.60	1.80
Graduated higher education	1.22	0.354	0.80	1.87					1.16	0.550	0.71	1.90
Postgraduate	1.00								1.00			
Race/Color												
Not white	1.20	0.217	0.90	1.61					1.09	0.609	0.77	1.55
White	1.00								1.00			
Region in Brazil												
Imperatriz	1.24	0.336	0.80	1.92					1.70	0.045	1.01	2.85
Palmas	1.80	0.001	1.28	2.53					1.81	0.015	1.12	2.92
Salvador	1.00								1.00			
Factor related to health												
Presence of comorbidities (except ophthalmological)												
Yes	1.69	< 0.001	1.27	2.24					2.35	< 0.001	1.63	3.40
No	1.00								1.00			
Presence of ophthalmological comorbidities												
Yes	2.10	< 0.001	1.57	2.83					2.07	< 0.001	1.44	2.98
No	1.00								1.00			
Factors related to lifestyle habits												
Exercises outside												
Yes	1.23	0.155	0.93	1.63					1.46	0.022	1.06	2.02
No	1.00								1.00			
Smokes												
Yes	1.43	0.070	0.97	2.11					1.53	0.072	0.96	2.44
No	1.00								1.00			

[a] Regular/poor/very poor.
RV: 95%CI: 95% confidence interval, LR: likelihood ratio, OR: odds ratio, MMW: multiples of monthly minimum wage.

Table 3
Logistic regression assessing factors associated with self-reported poor health status[a]

	Multivariate model N = 892 LR = -445.26			
Factors	**OR**	**Value p**	**95%CI minimum**	**95%CI maximum**
Environmental				
Type of stove used				
Wood/charcoal/kerosene/solvent/other	0.79	0.376	0.48	1.32
Natural gas/GLP	1.00			
Type of stove at home when a child				
Wood/charcoal/kerosene/other	1.54	0.028[b]	1.05	2.25
Natural gas/GLP	1.00			
Number of hours spent in the kitchen with the stove lit				
More than 2 hours	1.51	0.034[b]	1.03	2.20
Up to 2 hours	1.00			
Lives close to a source of pollution				
Yes	1.55	0.010[b]	1.11	2.16
No	1.00			
Burns any type of material inside the house				
Yes	1.61	0.121	0.88	2.92
No	1.00			
Place of residence				
Urban	1.12	0.720	0.60	2.12
Rural	1.00			
Sociodemographic				
Family income (MMW)				
Up to 2	1.85	0.008[b]	1.17	2.91
More than 2	1.00			
Sex				
Female	1.39	0.066	0.98	1.98
Male	1.00			
Age group (years)				
60 or over	0.33	0.066	0.10	1.08
40 to 59	0.45	0.111	0.17	1.20
25 to 39	0.26	0.006[b]	0.10	0.68
18 to 24	0.27	0.008[b]	0.10	0.71
0 to 17	1.00			
Educational level				
Elementary school or less	1.46	0.345	0.67	3.19
Secondary education	1.01	0.968	0.57	1.81
Started higher education	1.04	0.890	0.60	1.80
Graduated higher education	1.16	0.550	0.71	1.90
Postgraduate education	1.00			

[a] Regular/poor/very poor.
[b] Significant.
95%CI: 95% confidence interval, LR: likelihood ratio, OR: odds ratio, MMW: multiples of monthly minimum wage.

Table 3 *(continuation)*
Logistic regression assessing factors associated with self-reported poor health status[a]

	Multivariate model N = 892 LR = -445.26			
Factors	**OR**	**Value p**	**95%CI minimum**	**95%CI maximum**
Sociodemographic	1.00			
Race/color				
Not white	1.09	0.609	0.77	1.55
White	1.00			
Region in Brazil				
Imperatriz	1.70	0.045[b]	1.01	2.85
Palmas	1.81	0.015[b]	1.12	2.92
Salvador	1.00			
Related to health				
Presence of comorbidities (except ophthalmological)				
Yes	2.35	< 0.001[b]	1.63	3.40
No	1.00			
Presence of ophthalmological comorbidities				
Yes	2.07	< 0.001[b]	1.44	2.98
No	1.00			
Lifestyle habits				
Exercises outside				
Yes	1.46	0.022[b]	1.06	2.02
No	1.00			
Smokes				
Yes	1.53	0.072	0.96	2.44
No	1.00			

[a] Regular/poor/very poor.
[b] Significant.
95%CI: 95% confidence interval, LR: likelihood ratio, OR: odds ratio, MMW: multiples of monthly minimum wage.

2000. With relation to economic losses, the Global Burden of Diseases, Injuries, and Risk Factors Study 2015 (GBD) demonstrated that pollution was responsible for an economic loss of US$ 4.6 trillion (6.2% of global economic output) in 2015. Moreover, the study found that 92% of deaths related to pollution and the greater part of the burden of economic losses caused by pollution occurred in low and middle income countries. The 1.55 odds ratio observed in our study for populations that live close to a source of pollution is striking.

A study conducted in Palmas in 2014 observed that environmental factors have a causal relationship with increased admissions for respiratory diseases to a public pediatric referral hospital in the city. The study demonstrated a negative relationship between rainfall and the total number of admissions for respiratory diseases ($R = 0.606$; $p < 0.03$), especially pneumonia ($R = 0.375$; $p < 0.01$). It is known that months of extreme drought are a risk for respiratory disease exacerbation because of the increase in airborne pollutants and the reduction in the relative

humidity of the air.[20] In Tocantins state, the number of fires is particularly high during the months of the dry season, compromising the Cerrado biome, with a mean of 44 foci of fire/1,000 km^2, from 2002 to 2011.[21] The issues of airborne pollution, foci of fire, and admissions of children for respiratory diseases may be related to the factors observed in our study, such as exposure during to childhood to stoves that burn wood/charcoal/kerosene/other fuels, spending more than 2 hours in the kitchen with the stove lit, living close to a source of pollution, having comorbidities, including ophthalmological comorbidities, and exercising outside.

The social determinants of health encompass individuals' quality of life. Inequalities in social, economic, and environmental factors impact on overall health and on visual health. Williams et al. explain that factors such as income, educational level, access to health care, environmental issues, and social conditions can interfere with ophthalmological care and eye health.[22] Low socioeconomic status is associated with severe visual deficiencies or blindness (OR 2.55; 95%CI 1.36-4.79).[23]

In our study, self-reported ophthalmological comorbidities were significant (odds ratio of 2.07; $p < 0.001$). The number of people who reported having other, non-ophthalmological comorbidities was also relevant (OR 2.35 $p < 0.001$).

In China, a study that analyzed data from the 2013 Chinese General Social Survey to investigate the impact of the mechanisms of environmental problems and social inequalities on health found that, in addition to environmental pollution (both airborne pollution and contamination or pollution of food), low income, low educational level, and lack of green spaces also had negative impacts on the population's health.[24] The same was observed in our study, which documented a positive relationship between low income (up to two MMW) and poor health status (OR: 1.85, $p < 0.008$).

When we compared the residents of the three cities studied, we found that those living in Imperatriz were most exposed to environmental pollutants (passive smoking, heavy vehicle traffic, biomass burning, and exposure to paints and varnishes, and people living in the rural zone of the municipality also live near to open sewers and work close to sources of smoke and dust) and exhibited poor health status. In Salvador, there was a higher number of active smokers, a higher proportion of alcohol consumption, and a higher proportion of working close to sources of pollution and roads with heavy traffic. In Palmas, a higher proportion of individuals were aware of the harm caused by smoking and a lower proportion of people rated their health as good or very good.

It is well known that there is a direct relationship between educational level and health status, because access to information is essential for access and adhesion to disease treatment and prevention. Of the three cities, Imperatriz had the lowest educational level and the lowest income and these data may partially explain why living in Imperatriz was associated with a 1.8 times greater chance of poor health compared to living in Salvador (a more developed center with more health care resources) and 1.7 times greater than living in Palmas. If we analyze the Basic Education Development Index from 2022, Palmas was in second place in the list of state capitals in terms of performance in the first years of primary education (Year 1 to year 5), with an average of 6.1. In the second phase (years 6 to 9), Palmas was in first place of all Brazilian capitals. It should be pointed out that Palmas is a new city where a large proportion of the economically active population are public workers or service providers.[25]

In addition to studying the pathophysiology of diseases and new treatments, health professionals should also understand and teach and provide guidance to the population about socio-environmental issues, thereby intervening in health indicators within a holistic view of their patients in any given region. It is based on this knowledge that public policies are enacted with the objective of reducing morbidity and mortality, increasing life expectancy, and reducing the economic costs of public health. We have presented demographic, environmental, and economic data on the risks of harm to health in three Brazilian cities with similar HDI, located in the North and Northeast regions of Brazil.

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Corresponding author:
Herberto Jose Chong-Neto
E-mail: h.chong@uol.com.br