Association of Food, Water, and Sanitary Environments in Disadvantaged Communities and Measures of Mental and Physical Health

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by

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Under the Direction of Christine Stauber, PhD

ABSTRACT

This paper explores how the lack of nutritious food, clean water, and sanitary living conditions affect the mental and physical health of residents living in disadvantaged communities in Brazil. SF-12 scores which are validated instruments to measure self-reported mental and physical health were compared with residents experiencing varying degrees of insecurities regarding food, water, and sanitary conditions using ANOVA analysis. Results showed the significant associations between food insecurity and both mental and physical health. Correlations between mental health and insanitary living conditions were also observed.

There were no significant correlations detected between water insecurity and mental or physical health.

INDEX WORDS: Mental Health, Physical Health Food Insecurity, Water Insecurity, Sanitation

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Introduction

1.

Over the last century, Brazil has seen dramatic improvements in life expectancy going from 32 years of age in 1870 to 72.4 years of age now.[1] Much of this is related to improvements in control of infectious diseases through vaccines, therapeutics, and improvements in access to water, sanitation and hygiene which lead to impacts on life expectancy, infant mortality, and the spread of disease.[2] While this push towards modernization has been beneficial, other advances in technology has altered local economies in ways that leave little opportunities for residents in agrarian societies to improve their standard of living. As a result, developing countries in Latin America have seen an accelerated rise in urbanization with 80 % of residents now living in cities with Brazil being no exception.[3]

Brazil currently has over 87% of its citizens live in urban areas[3] and this percentage is expected to increase over the coming years. As people move into these new environments, they adapt to new lifestyles and often move into urban areas with insufficient resources to support their needs including housing, water, sanitation services as well as health care services.[4] As a result, additional health effects of living in these settings include increased incidence of chronic disease such as diabetes, heart disease, and obesity compared to those living in rural areas. [(5)]

Adjustments to new environments can also affect mental health, but measuring these changes are more challenging. Migration into compacted living spaces has put an enormous strain on existing infrastructure to provide clean and safe environments for residents to live. In particular,

people in these communities typically experience inadequacies in the forms of food, water, and sanitation securities. This paper will explore the association between access to these environmental resources and how they are associated with mental and physical health of people living in four communities in urban areas of Salvador, Brazil.

1.2 Purpose of study:

The purpose of this project is to examine how access to clean water, safe food, and adequate sanitation are associated the physical and mental health statuses of these residents. The research question that will be explored is: Are there statistical differences in the mean health outcomes of residents experiencing food, water, and sanitation insecurities. Mean health outcomes were derived by using SF-12 scoring algorithms. These scores were then compared across different levels of variables relating to the aforementioned insecurities using Analysis of Variance (ANOVA) test procedures.

CHAPTER II

REVIEW OF THE LITERATURE

2.1 Background:

In 1988, the constitution of Brazil was amended to declare that health care was a universal right and state responsibility.[6] In 1990, The Health Care Law was enacted to combat health inequity by providing coverage to all citizens through the Unified Health System (Sistema Único de Saúde or SUS). As a result of this law and other health care initiatives, significant improvements in many public health indicators were observed through the decades.[7] Despite these achievements however, morbidity and mortality rates in urban areas of Brazil are significantly influenced by socioeconomic disparities with the most prevalent cases of cardiovascular disease, cancers, communicable diseases, and interpersonal violence occurring in poor urban communities.[8]

These neighborhoods are often characterized by inadequate infrastructure and housing and are not formally recognized by local governments in some cases. The estimates of people living in these informal communities range from 6.9% to as high as 41.4% of Brazil's population.[9] Residents of these are areas often lack access to green spaces and quality health care which leads to higher rates of preventable diseases such as hypertension and obesity. Additional health concerns experienced by these residents are heatwaves, traffic noise, and air quality.[10]

The Gini index (a score of wealth distribution) routinely ranks Brazil in the top 10 worst countries in regard to wealth inequality.[11] This extreme income gap forces millions of urban residents to live with chronic insecurities in access to essential services that negatively impact

their physical and mental health. Food insecurity is certainly one of the major inadequacies. Access to safe and affordable food is of supreme importance in optimizing the general health of the public as it is required often and daily for biological processes and functioning. In addition to being a major determinant of physical health, there is recent evidence that food insecurity is linked to mental health conditions as well.[12]

According to the World Bank, the proportion of people in Brazil experiencing moderate to severe food insecurity in 2003 was 16.8%.[13] This percentage decreased to 7.8 % a decade later and Brazil was thought to have won the fight against hunger.[13] Unfortunately, the economic downturn due to the Covid-19 pandemic created a shift from employment labor income to free-lance income which is less resiliant.[13] As a result, the percentage of people experiencing moderate to severe food insecurity rose to 20.5% in 2020, 28.4% in 2021, and 30.7% in 2022.[13]

Of all the resources that are required for healthy living, adequate and safely managed water could certainly be the most important. The biological necessity is obvious as over half the human body is composed of water, but the versatility of its use in disease control and sanitation services are equally important. Similar to food insecurity, access to clean water has been linked to mental health conditions[14] which is unsurprising as mental processing is an emergent quality of biological processes. Despite Brazil containing approximately 12% of the worlds fresh surface water (most in the Amazon basin which is 2000 miles away from most cities), water insecurity is unfortunately a major obstacle in advancing public health due to inadequate infrastructure.[15] According to WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene (JMP), 15 million Brazilians lack access to safely managed water in urban areas.[15]

As previously mentioned, clean water plays a crucial role in fulfilling the sanitary and hygienic needs of a community which are essential to maintain good public health. In fact, inadequate water, sanitation, and hygiene (WASH) served as the basis for the 1st public health intervention conducted by John Snow in London. Poor WASH conditions have been linked to a wide variety of adverse physical and mental conditions [14,16] which underscores the importance of having proper infrastructure in congested urban areas.

Due to the close spaces in which people live, there is strong evidence that poor urban communities are especially vulnerable to communicable diseases.[17] The JMP estimates that 2.3 million Brazilians access unimproved sources of water for drinking and hygiene.[18] The same study states that over 100 million Brazilians lack access to safely managed sanitation with 21.6 million using unimproved facilities.[18] As a result of the poor condition of the sanitation facilities, 2.6 million practice defecation in open areas.[18] It is important to note that these estimates are from the start of the Covid-19 pandemic which means that the conditions more likely worsened over the course of the next few years.

There are additional health risk factors that residents living in urban environments are exposed to which may be abstract or not as easily understood but have clear adverse impacts on mental health. Studies have shown that people living in cities are at higher risk for a variety of anxiety and psychotic disorders compared to rural populations. In fact, these results have been observed in a variety of countries with different ethnic backgrounds which eliminate these factors as mediating variables. For example, studies show higher rates for anxiety disorders for urban residents in Asian countries such as China, India, and Iran as well the Latin American countries of the Dominican Republic, Peru, Venezuela, and Mexico. [19,20,21]

Higher rates for psychotic disorders such as schizophrenia were observed for city populations compared to rural residents in China, Germany, and Denmark. [22,23,24,25] The risk factors associated with urban living are more profound during formative years as the study in Denmark showed that residents who were born and raised (up to 15 years) in major cities were more than twice as likely to develop schizophrenia than those living in rural settings. Dose-response relationships were even established in some epidemiological studies which indicates a positive correlation between the amount of time spent in cities and severity of schizophrenic symptoms.[25]

In particular, one study showed that odd ratios of developing schizophrenia were always higher in city residents compared to rural populations, but increased in the order of provincial town, provincial city, capital suburb, capital city.[25] Studies regarding mood disorders were mixed however, with one study indicating a higher risk for urban cities in Germany while another showed a higher risk for rural populations in China. Likewise, addictive disorders were observed to be higher in France, but lower in China.[26]

2.2 Definition of Food Insecurity:

In 1996, the United Nations World Food Security Committee stated that people were food secure when "people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life".[27] This definition implies that food accessibility has at least 2 dimensions: (i) the actual production or existence of nutritious of foods and (ii) the ability to access it in ways that are morally acceptable (i.e. not resorting to theft). These dimensions are explicitly stated as

minimum requirements by U.S. Department of Agriculture (USDA).[28] Over the last few decades, the construct of food security has been refined into the following elements: food quantity (caloric intake), dietary quality (nutritional value), social acceptability (ethical ways of attaining food), food safety (foods free of harmful microorganisms or chemicals), Suitability (foods that are culturally acceptable), and psycho-emotional (anxiety or feelings of being deprived of food).[28]

2.3 Instruments used to detect Food Insecurity:

Food security is a measured at the household level and is a social determinant of health (SDOH). It is therefore an indirect way to measure the socio-economic status of a household. Viewed through this context, the theoretical framework used in the development of the 1st survey to detect food insecurity were based on the premise that food insecurity was a stepwise process. This sequence began with household adults being anxious of running out of food which then leads to eating cheap and innutritious foods. If the conditions worsen, then caloric intake decreases in adults followed by the children.

The population used to test this framework were poor residents in upstate New York in the early 1980s.[28] From this study, researchers were able to validate the 1st survey to be adopted by the U.S. government in 1995 called the Household Food Security Survey Module (HFSSM). This module consisted of 10 questions for households without children and 18 for those with children. Points were assigned based on each question and added up to achieve a score. The scores were then classified into three categories: Food secure, low food security, and very low

food security. The survey is currently used in the US Census Bureau Continuous Population Survey (CPS) and the National Health and Nutrition Examination Survey (NHANES).[28]

The usefulness of this survey led to other countries using HFSSM as the blueprint for measuring food insecurity. In Latin America, the Brazilian Food Insecurity Scale (EBIA) was validated in 2003 and have been used to track fluctuations in food insecurity which coincides with changes in socio-economic policy and pandemics.[28] In an effort to make the survey easier to use for researchers and participants, a short version was developed and validated in 2014. This survey consisted of 5 questions instead of 15 and was used in a joint health intervention study between researchers at Georgia State University and the Federal University of Bahia. The dataset from this intervention was used in this project.

2.4 Definition of Water Insecurity:

Since 2010, the United Nations have recognized access to safe water as a human right and a necessary component of meeting Sustainable Development Goals (SDGs) for developing countries. Recent evidence has shown that there is a strong correlation between water and food insecurity. During the Covid-19 pandemic, a study in Brazil indicated that 12% of the population were water insecure and of those experiencing water insecurity, 42% experienced severe food insecurity.[29] Much like food security, the dimensions of water security include quantity, quality, and access and can be defined as “the inability to access and benefit from affordable, adequate, reliable and safe water” for wellbeing and a healthy life.[30]

2.5 Instruments used to detect Water Insecurity:

Until recently, most measures of water insecurity focused on the availability of water at the state or regional level. While these measures have been useful in predicting or assessing water shortages for government agencies, they lack the resolution needed to understand the more granular dimensions associated with water insecurity at the household level such as affordability, accessibility, water quality, or psychological burden. The WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene (JMP) was developed to capture some of these higher resolution information at the household level.[30] The core questions on these surveys are primarily focused on the source of where residents obtain their water, treatment of their water, and accessibility.

Over the last 2 decades, other research projects to better measure water insecurity were developed at different locations and for specific demographics. For example, two studies were published focusing on the psychological distress associated with water insecurity. One developed a water insecurity scale for postmortem women in Kenya in 2018[31] and the other studied Bolivian homeless people in 2008.[32] Other examples include a study focused on residents on the US-Mexico border published in 2014[33] and another scale was validated for urban Nepalese residents in 2015.[34] While all of these studies added important results for better measuring water insecurity, the generalizability of their results were not established.

In 2019, the Household Water InSecurity Experiences (HWISE) Scale was developed and validated to address the need to measure water insecurity in a cross-culturally equivalent way. The scale was validated using randomly sampled data from over 8000 households across 28 site

locations in 23 low- and middle-income countries[30]. The original survey consisted of 34 questions about the prior month and covered a range of issues from water and food insecurity, socio-demographic, use and storage of water, and perceived stress. Statistical analysis was used to derive the 12 most relevant questions needed to measure water insecurity and is the scale which will be used in this study.

2.6 Definition of Water, Sanitation, and Hygiene (WASH) Insecurity:

A 2017 report from the JMP stated that 2.3 billion people lack access to basic sanitation services that separate human waste from human contact.[35] The majority of these people either live in areas that use unimproved waste facilities such as pits and hanging latrines (892 million) or lack any waste facilities and practice open defecation. Despite these alarming statistics, review of literature indicates that a lack of concern on sanitation insecurity particularly with respect to food or water insecurity. As of now, there is not a clear definition of sanitation insecurity which captures the multidimensionality of access, quality, affordability and distress or trauma that is typical with food and water insecurity definitions. Most current definitions simply focus on the one dimension of accessibility of sanitation facilities.

One recent study focused on defining and measuring sanitation insecurity for women in Odisha, India that accounts for the physical and social dimensions of this topic defined sanitation insecurity as “Insufficient and uncertain access to a socio-cultural and social environments that respect and respond to the sanitation needs of individuals, and to adequate physical spaces and resources for independently, comfortably, safely, hygienically, and privately urinating, defecating, and managing menses with dignity at any time of day or year as needs arise in a

manner that prevents fecal contamination of the environment and promotes health."[36] As of now, research has yet to develop a general measure of WASH insecurity that are comparable to food and water insecurity.

2.7 Water and Sanitation Insecurity Associations with Mental Health:

It is well known that poverty is one of the main social determinants of mental health (SDMH) and people who live in poverty are at an increased risk of experiencing water and sanitation insecurities. The need to understand these insecurities are important as there is an estimated 4 billion people worldwide who are affected by water insecurity[37] every year with 600 million having no access to safe drinking water.[38] The direct effects dehydration on cognitive functioning are well researched, but there are indirect ways in which water insecurity can affect mental health. These include the anxiety associated with securing safe drinking water and the frustration and shame that occurs when efforts are unsuccessful. The shame felt by people experiencing sanitation insecurity can be so overwhelming that many go without eating or drinking to limit defecation or urination.

A scoping review of the association between WASH insecurities and common mental disorders (CMDs) was released in 2017 and indicated 4 types of mental distress that were experienced. These stressors which are interrelated were identified as financial stressors, social stressors, physical stressors, and distress due to perceived inequalities.[39] This review which included 15 studies from 8 countries provided a rationale for a systemic review released in 2023. This expanded review included 25 studies in 16 low- and middle-income countries and showed significant links between water insecurities and CMDs.[40]

This review contained nine studies which reported a continuous outcome which resulted in an overall standardized mean difference (SMD) of 1.38 (95% CI = 0.88, 1.87) while review of five studies which reported binary outcomes indicated an odds ratio of 5.03 (95% CI = 2.26, 11.18). Statistically significant associations between sanitation insecurities and CMDs were also observed from this review with an overall SMD of 5.36 (95% CI = 2.51, 8.20).

2.8 Food Insecurity Associations with Mental Health:

The most recent global estimates from the United Nation (UN) states that 2.3 billion people experience moderate food insecurity while 900 million are exposed to sever food insecurity.[41] In addition, 3.1 billion people are unable to afford a healthy diet.[41] Despite the progress made in increasing food production and aid to developing nations, these statistics unfortunately indicate that food insecurity remains a major public health concern. The deleterious effects of malnutrition on physical health are well researched and indicates an increased risks for weight abnormalities, anemia, diabetes, hypertension, and cancer.[42]

Due to the subjective features of measuring mental health, understanding the association between food insecurity and mental disorders require innovative tools of measurement that are still being validated, but current research has established strong correlations. A review study released in 2017 indicated strong associations between food insecurity and mental health.[43] This study involved 149 countries and used regression analysis in modeling the association. This study also controlled for social economic status (SES), demographic differences and used 2 measuring tools for mental health. The results also indicated that food insecurity resulted in poor mental health outcomes in a dose-response fashion which may specify a causal relationship.

Correlations were established in another review study released in 2019 involving 10 middle-income to high-income countries focused on the specific disorders of depression, stress, and anxiety.[44] The results showed a positive association between food insecurity and the risk of depression and stress, but the association with anxiety was only indicated in the U.S. This review also indicated a dose-response relationship with the risk of depression increasing with exposure of food insecurity from moderate (OR=1·45; 95% CI: 1.40, 1.51) or severe (OR=1·77; 95% CI: 1·71, 1·83).

The proposed pathways on how food insecurity leads to mental disorders were similar in both studies stating that anxiety over the ability to acquire and maintain food and the shame felt for acquiring food in socially unacceptable ways were the main mechanisms. Both studies also indicated that the burden of the disorders were experienced by those over the age of 65 due to limited financial resources, social isolation, and transportation issues.

The direct correlations between general health and access to necessary environmental resources such as food and water are clearly indicated in the literature review. While these associations are evident across cultural and geographical boundaries, this study will explore how these associations are affected by the unique factors associated with living in Brazilian favelas. These communities are high density populations which lack adequate infrastructure and are low in environmental resources. The residents of these communities are often exposed to food, water, and sanitation insecurities which in theory should lead to adverse mental and physical outcomes.

3.1 Methods

The dataset for this study was obtained from a joint health intervention project conducted in 2023 between researchers at Georgia State University and the Federal University of Bahia. This joint study was conducted in four communities within the city Salvador which is the capital of Bahia. Part of this public health intervention was to collect self-reported data on a wide range of demographic, socioeconomic, and health related subjects. The goal was to examine if there were any associations between self-reported mental and physical health conditions and disparities regarding nutrition, access to safe water, and adequate sanitary environments.

3.2 Procedure

The research question that will be explored is: Are there statistical differences in the mean health outcomes of favela residents experiencing food, water, and sanitation insecurities. To accomplish the goal of this study, pertinent information regarding mental and physical health and the aforementioned insecurities will be quantized using validated measuring tools and analyzed for statistically significant associations or differences. Additional socio-economic and demographic variables will also be included in the analysis to determine how these factors affect the relationships between the statistically derived measures.

3.3 Participants

The participants for this project were obtained secondary data via survey which were completed during an existing sanitation intervention. The population-based cohort study focused on four (two sanitation intervention communities and two control communities) areas in Salvador in which participants in the study completed detailed surveys regarding access and

quality to environmental services and food. In addition, approximately 175-200 respondents per site (768 respondents in total) completed questionnaires regarding their physical and mental health.

3.4 Measures

This study utilized validated tools of measurement for food and water insecurity as well as for mental and physical health. As indicated in the literature review, there are currently no validated tools for measuring sanitation insecurity, however information regarding sanitation were derived from participants rating their experiences on a number scale and these results will be used as a substitute in the analysis. Food insecurity will be assessed using a shorter version of the Brazilian Food Insecurity Scale (EBIA) which consists of 5 questions. Water insecurity will be measured by the Household Water InSecurity Experiences (HWISE) Scale which consists of 12 questions.

Mental and physical health will be measured using the Short Form 12 (SF-12) questionnaire which has 12 questions and was originally validated from a 36-item questionnaire (SF-36) produced from the Medical Outcomes Study (MOS) in the 1980s.[45] Answers to each of these questions are rated on an intensity scale (as 0 = none, 1 = mild, 2 = moderate and 3 = severe) and are intended to be directly proportional to health status. The SF-12 covers 8 health domains which are: General health (GH), physical functioning (PF), role physical (RP), bodily pain (BP), vitality (VT), mental health (MH), role emotional (RE), and social functioning (SF).[46]

These eight domains bifurcate into 2 health scales: the physical component summary (PCS12) and the mental component summary (MCS12) scales. The domains which are used to derive the

PCS12 scales are: General health (GH), physical functioning (PF), physical function (RF), and bodily pain (BP). The domains for the MCS12 scales are: vitality (VT), mental health (MH), role emotional (RE), and social functioning (SF).[46]

The SF-12 scales were scored using norm-based methods in which the PCS12 and MCS12 scales are transformed to have a mean of 50 and a standard deviation of 10. Scoring the SF-12 summary scales involves 4 steps:

- Eliminating outlier answers for each question and reverse scoring 4 of the questions so that a higher numeric response indicates better health.
- Creating binary indicator variables (scored 1/0) for each response choice categories except the response indicating the highest level of health.
- Multiplying each indicator variable by regression weights or coefficients based on the US population and summing them (see table 4.1 of SF-12 scoring manual for regression weights).
- Standardizing the PCS12 and MCS12 scores by adding a constant (regression intercept) so that means of 50 and standard deviations of 10 are achieved based on the US population (see table 4.1 of SF-12 scoring manual for regression intercepts).[46]

To ensure the accuracy of the scores, item scale correlations were checked in accordance with the SF-12 scoring manual.[46] Domain responses which were used to derive physical health scoring (General health (GH), physical functioning (PF), physical function (RF), and bodily pain (BP) were checked for high correlation with PCS12 scores while responses used to form mental health scoring (vitality (VT), mental health (MH), role emotional (RE), and social functioning

(SF)) were checked for high correlation with MCS12 scores. In addition, correlation between PCS12 and MCS12 scores were also checked to ensure they were not correlated as they were not likely to be correlated using this tool.

3.5 Analysis

SF-12 scores were compared across different levels of variables relating to the aforementioned insecurities using Analysis of Variance (ANOVA) test procedures. The software used for all statistical procedures was Statistical Analysis Software (SAS) version 9.4. The proc ANOVA algorithm was used for test procedures and a p-value of 0.05 was used to reject the null hypothesis.

Results:

The participants for this project were obtained from an existing sanitation intervention. The population-based cohort study focused on four (two sanitation intervention communities and two control communities) neighborhoods of Salvador in which 500 subjects from each area enrolled in the study and completed detailed surveys regarding access and quality to environmental services and food. In addition, approximately 175-200 respondents per site completed questionnaires regarding their physical and mental health.

The dataset for this study contained 1131 observations from various the four neighborhoods. There were however discrepancies between this total and the number of observations for different survey results. The result of missing observations was because not all participants answered all of the survey questions. For example, only adults were asked the SF-12 questionnaire and only those considered head of household answered questions on food

insecurity. For example, there were 762 participants who answered the SF-12 health questionnaires and from this total, approximately 470 observations were obtained for the food insecurity survey. As a result, many of the analyses will be restricted to smaller numbers of observations due to the implementation the questionnaires for sections of the larger sample.

The participants in this study were residents from four neighborhoods in Salvador, Bahia. Most of these participants were people of color who mainly identified as black and tended to be young, single, and female (see Table 1). Almost 50 percent of residents were between 18-29 years of age while less than a quarter are above the age of 50. Over 50% of respondents were also single which highly correlates with a young population. Over 90% of respondents identified as black or multiracial with less than 7% identified as white or Asian. In addition, approximately 60% of respondents were female.

Participants were also economically disadvantaged as 75.9% earn less than R$ 1000 per month. For context, the average monthly gross salary in Brazil in 2023 was R$ 2,979.[47] This would indicate that three quarters of residents live in extreme poverty and as a result, 41.2% receive financial assistance through a conditional cash transfer program. People in these communities had lower levels of educational attainment as only 26.5% completed high school and only 2.1% percent completed higher education (see Table 2). Although these percentages are low, 42.3% of residents also responded that they were currently attending school indicating that these percentages may increase in the future.

Housing in these neighborhoods tend to be small and overcrowded as 44.6% of households report having 4 to 6 residents. Though most households in these areas have running water,

inadequate infrastructure leads to high occurrences of water shortages as over 30% of respondents report having at least 1 water shortage per week and only 53.7% report of having their water uninterrupted throughout the week (see Table 3). In addition, residents in these areas are impacted by environmental disasters as approximately 30% report experiencing landslides in the last 6 months.

Demographic	**N %**	**Neighborhood 1**	**Neighborhood 2**	**Neighborhood 3**	**Neighborhood 4**
Age					
18-29	47.9%	49.7%	49.2%	46.1%	46.9%
30-49	30.7%	29.4%	30.4%	33.1%	29.8%
50-64	15.7%	15.2%	15.6%	14.3%	17.8%
64+	5.7%	5.8%	4.8%	6.5%	5.5%
Total (1131)	100.0%	310	250	293	275
Gender					
Female	57.8%	43.7%	40.1%	44.0%	40.7%
Male	42.2%	56.3%	59.9%	56.0%	59.3%
Total (1122)	100.0%	309	247	291	275
Ethnicity					
White	5.2%	4.9%	4.0%	7.6%	4.0%
Black	48.9%	55.3%	47.4%	45.7%	46.5%
Asian	1.5%	0.3%	0.8%	2.4%	2.5%
Mixed Race	44.1%	39.5%	47.4%	43.6%	46.5%
Indigenous	0.4%	0.0%	0.4%	0.7%	0.4%
Total (1122)	100.0%	309	247	291	275
Marital Status					
Single	52.0%	60.7%	49.0%	46.7%	50.9%
Legally Married	19.6%	21.1%	21.4%	15.6%	20.3%
Other	28.4%	18.2%	29.7%	37.8%	28.8%
Total (888)	100%	247	192	225	222
Salary ()R$					
<1000	75.9%	72.6%	81.2%	73.4%	77.5%
1000-2000	19.6%	21.0%	15.2%	21.8%	18.5%
<2000	4.5%	5.5%	3.6%	4.8%	4.0%
Total (1131)	100%	310	250	293	275
Receiving Bolsa Família					
Yes	41.2%	30.7%	43.5%	37.5%	53.5%
No	58.8%	69.3%	56.5%	62.5%	46.5%
Total (391)	100%	101	92	96	101

Table 1: Demographic characteristics of study participants in four neighborhoods of Salvador, Bahia, Brazil 2022.

Education	N%	Neighborhood 1	Neighborhood 2	Neighborhood 3	Neighborhood 4
None	2.1%	1.5%	1.9%	2.3%	2.9%
Attended or Completed 5th Grade of Primary School	15.7%	14.9%	16.8%	15.7%	15.4%
Attended or Completed 9th Grade of Middle School	11.3%	9.1%	10.7%	11.5%	14.1%
Attended or Completed 12th Grade of High School	26.5%	30.2%	24.8%	26.8%	23.2%
Attended or Completed Higher Education	2.1%	2.2%	1.9%	1.9%	2.5%
Attending School or College	42.3%	42.2%	43.9%	41.8%	41.9%
Total (991)	100%	275	214	261	241

Table 2: Educational stratification of study participants in four neighborhoods of Salvador, Bahia, Brazil 2022**.**

Demographic	N %	Neighborhood 1	Neighborhood 2	Neighborhood 3	Neighborhood 4
Household Residents					
≥3	50.7%	49.7%	49.2%	46.1%	46.9%
4-6	44.6%	29.4%	30.4%	33.1%	29.8%
7-9	3.6%	15.2%	15.6%	14.3%	17.8%
9+	1.2%	5.8%	4.8%	6.5%	5.5%
Total (1128)	100%	310	250	293	275
Running Water					
Yes	99.2%	100%	98.8%	98.2%	99.6%
No	0.8%	0%	1.2%	1.8%	0.4%
Total (1107)	100%	302	248	285	272
Water From Service Provider Network					
Yes	97.5%	100%	94.2%	95.7%	99.6%
No	2.5%	0%	5.8%	4.3%	0.4%
Total (1091)	100%	302	240	280	269

How often does service provide have water shortages					
>3 times a week	31.7%	24.5%	35.0%	48.9%	20.1%
3-6 times a week	13.5%	4.3%	23.9%	27.7%	1.1%
No Shortages	53.7%	67.9%	40.7%	23.5%	78.4%
Don't know	1.1%	3.3%	0.4%	0.0%	0.4%
Total (1060)	100%	302	226	264	268
Landslides in the last 6 months					
Yes	28.0%	49.6%	18.4%	13.9%	27.5%
No	72.0%	50.4%	81.6%	86.1%	72.5%
Total (460)	100%	121	103	115	120

Table 3: Household characteristics of study participants in four neighborhoods of Salvador, Bahia, Brazil 2022.

Distribution of health scores from the SF-12 questionnaires skewed left and MCS12 scores tended to be higher than PCS12 scores (see Tables 4 and 5). The mean PCS12 scores was 47.7 with a range that spanned 53.4 points while the mean MCS12 scores was 51.3 and had a range of 55.9 points. The results were close to normal when examined using a histogram but failed the Shapiro-Wilk test for normality with p-values of <0.0001 for both PCS12 and MCS12 scores (see Appendix). Fortunately, the ANOVA test is robust enough to produce accurate results even when the assumption of normality is not exactly satisfied.[48] The SF-12 scores were also similarly distributed across neighborhoods (appendix) with means that were not statistically different according to ANOVA tests (see table 4 and 5). It should be noted that the p-value for differences in mean MCS12 scores was 0.0543 which is extremely close to the significance level of 0.05.

As discussed in the Methods section, PCS12 and MCS12 scores are standardized to have means of 50 with standard deviations of 10 points. This would indicate that scores above or below 50 are indicative of better or poorer than average health respectively. High correlations between item response choices in domains that determine physical and mental health results were

observed with PCS12 and MCS12 scores respectively while low correlation was observed between PCS12 and MCS12 scores (see Appendix). As mentioned in the Methods section, these correlation checks served as quality assurances of SF-12 scoring.

Younger residents reported higher levels of physical health with 18–29-year-olds reporting a mean PCS12 score of 51.2 while those above the age of 50 had means scores PCS 12 scores below 44.5. In contrast, those above the age of 50 had mean mental health score (MCS12) scores of 53.8 while 18–29-year-olds averaged a score of 47.8.(see table 6). Males reported better physical and mental health conditions than females and single residents generally had better physical health scores than married people. There were no statistically significant differences in reported physical or mental health outcomes with regards to ethnicity.

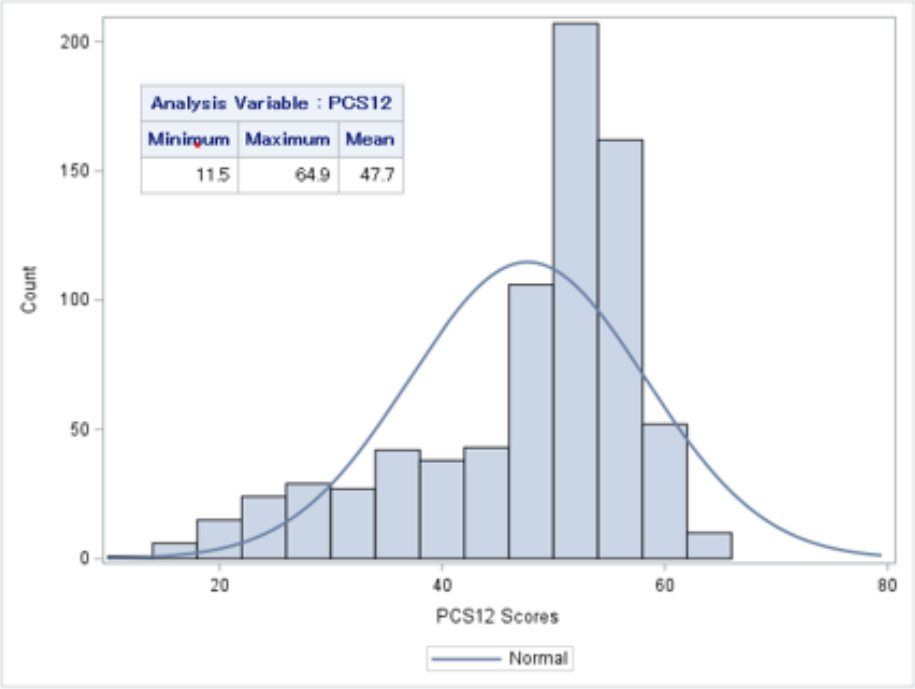

Figure 1: Distribution of PCS12 scores and their normal approximation.

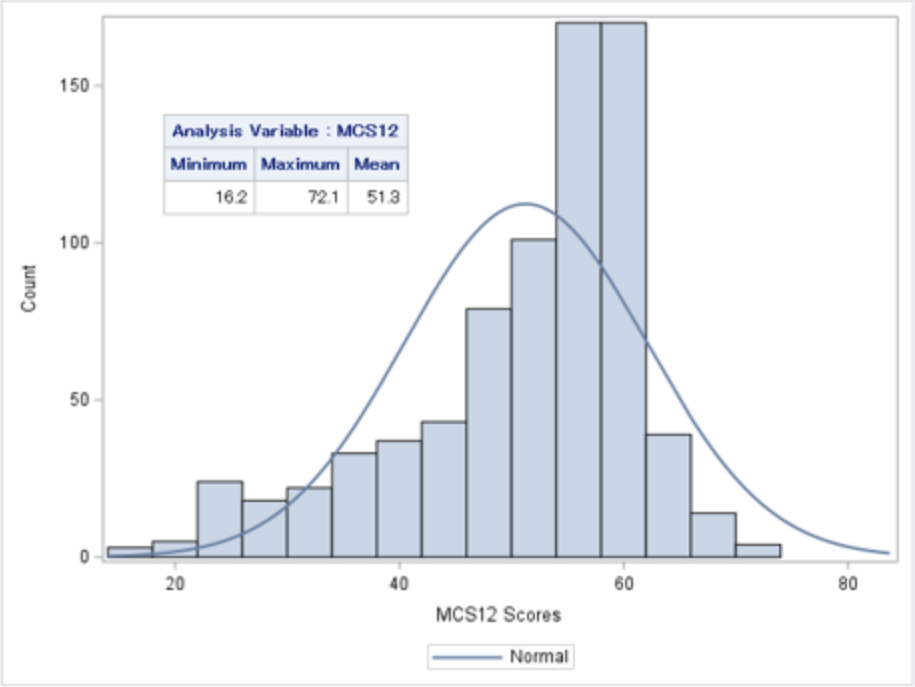

Figure 2: Distribution of MCS12 scores and their normal approximation.

Neighborhood	Mean PCS12 Score	Standard Dev.	Min. Value	Max. Value
1 (N=210)	48.9	9.5	19.0	64.2
2 (N=167)	47.5	10.8	15.7	64.9
3 (N=193)	47.6	11.6	11.5	63.9
4 (N=190)	46.7	10.5	19.9	64.6
p-value	**0.2030**			

Table 4: Descriptive statistics of PCS12 scores for each neighborhood

Neighborhood	Mean MCS12 Score	Standard Dev.	Min. Value	Max. Value
1 (N=210)	51.9	10.2	20.9	72.1
2 (N=167)	49.3	12.5	16.2	71.8
3 (N=193)	51.8	10.2	22.1	69.4
4 (N=190)	51.9	10.0	22.0	72.0
p-value	**0.0543**			

Table 5: Descriptive statistics of MCS12 scores for each neighborhood

Variable (N)	**Mean Physical Health (PCS12) Score**	**Mean Mental Health (MCS12) Score**
Age		
18-29 (183)	51.2	47.8
30-49 (340)	48.6	51.2

50-64 (177)	44.5	53.8
64+ (62)	41.6	54.5
p-value	***<.0001**	***<.0001**
Gender		
Female (481)	46.4	49.7
Male (281)	49.9	53.9
p-value	***<.0001**	***<.0001**
Ethnicity		
White (28)	47.6	49.9
Black (382)	47.8	51.6
Asian (14)	44.5	48.3
Mixed Race (335)	47.6	51.2
Indigenous (3)	56.3	45.9
p-value	**0.4902**	**0.6230**
Marital Status		
Single (343)	49.2	50.9
Legally Married (172)	47.0	51.5
Other (247)	46.0	51.6
p-value	***0.0007**	**0.6760**

Table 6: Physical and mental mean health score comparisons based on demographics of age, gender, ethnicity, and marital status.

Mean health scores significantly varied between those with different levels of education. A positive association between mean physical health scores and educational attainment was observed. Those with a high school education or greater had a mean PCS12 score of approximately 50.0 while those only primary education averaged mean PCS12 scores below 44. An inverse correlation was discovered with regards to mental health scores. While those who had completed high school reported approximately mean MCS12 scores of 50.3, participants with only primary school education reported mean scores of 52.0. Those who were attending school also showed higher physical health scores, but no differences were observed between mental health scores (see Table 7).

Mean health scores also significantly varied between those with different levels of income with positive correlations observed in physical and mental health outcomes (see Table 8). Residents receiving R$1000 per month reported mean PCS12 scores of 50.2, but those below R$1000 had a steep decline in reported physical health with a mean score of 46.3. The difference regarding MCS12 scores were less pronounced, but clear as those with $R1000 per month reporting a mean score of 52.3 while those making less having a mean score of 50.5. These effects however were not observed between those benefiting from Bolsa Família. Employed residents and those engaged in licensed (or official) work also reported better physical health outcomes, but no observable effects were reported for mental health.

Education Completed (N)	**Mean Physical Health (PCS12) Score**	**Mean Mental Health (MCS12) Score**
None*	41.2	55.3
Attended or Completed 5th Grade of Primary School (20)	43.7	52.0
Attended or Completed 9th Grade of Middle School (152)	47.4	51.8
Attended or Completed 12th Grade of High School (260)	49.6	50.3
Attended or Completed Higher Education (21)	50.6	49.6
Attending School or College (8)	50.0	41.2
p-value	***<.0001**	***0.0255**
Attending School or College		
Yes (190)	49.1	51.5
No (572)	47.2	51.2
P-value	***0.0317**	**0.6793**

Table 7: Physical and mental mean health score comparisons based on educational achievement.

Salary (N)	Mean Physical Health (PCS12) Score	Mean Mental Health (MCS12) Score
<1000 (494)	46.3	50.5
1000-2000 (218)	50.2	52.3
+2000 (50)	50.0	54.3
p-value	***<0.001**	***** **0.0129**
Receiving Bolsa Família		
Yes (157)	46.1	48.6
No (227)	45.4	50.6
p-value	**0.5694**	**0.0944**
Did you work last week?		
Yes (394)	49.3	51.8
No (367)	46.0	50.6
p-value	***<.0001**	**0.1276**
The work carried out in the last week was:		
With signed license (158)	50.6	52.8
No signed document (234)	48.3	51.2
p-value	***** **0.0129**	**0.1326**

Table 8: Physical and mental mean health score comparisons based on income and type of employment.

Residents experiencing food insecurity reported significantly lower physical and mental health scores for every question of the food insecurity survey and differences in mean mental health scores were particularly more observable compared with physical scores differences for 2 questions. (see Table 9). Mean MCS12 scores for those skipping meals was 46.7 while those not skipping meals reported a mean value of 53.4. Similar results were observed for those who reported eating less with mean MCS12 scores of 53.5 for those who did and 46.7 for those who did not.

Those experiencing sanitation insecurity reported higher levels of mental stress for most survey questions, but the same was not true in reporting to physical stress (see Table 10). The only survey item which showed a positive association for both mental and physical stress was the question posed for those experiencing sanitation insecurity related to sewage. The reported mean PCS12 scores for those experiencing sewage problems was 46.3 compared to 48.7 for

those who were not having these issues. Similar results were observed for MCS12 scores with those having sewage related sanitation problems reporting a mean value of 50.3 compared to 51.9 for those not without this concern.

	Worried food would run out? Yes: N = 216 No: N = 253	**Ran out of food?** Yes: N = 174 No: N = 295	**Limited variety in diet?** Yes: N = 211 No: N = 256	**Skipped meals?** Yes: N = 153 No: N = 315	**Eaten Less?** Yes: N = 317 No: N = 151
Mean PCS12 Score (Yes)	44.6	44.4	44.9	44.6	48.0
Mean PCS12 Score (No)	49.1	48.6	48.9	48.2	46.7
PCS12 p-value	***<.0001**	***<.0001**	***<.0001**	***0.0014**	***0.0115**
Mean MCS12 Score (Yes)	48.5	48.3	49.0	46.9	46.7
Mean MCS12 Score (No)	53.6	53.0	53.1	53.4	53.5
MCS12 p-value	***<.0001**	***<.0001**	***<.0001**	***<.0001**	***<.0001**

Table 9: Mean health score comparisons based on food scarcity.

	Is there waste accumulation near your house? Yes: N = 172 No: N = 566	**Is there a bad smell in the streets near your house?** Yes: N = 436 No: N = 307	**Experiencing problems relating to sewage?** Yes: N = 300 No: N = 446	**Does a sewar overflow near your house when it rains?** Yes: N = 270 No: N = 146	**Floods in the last 6 months?** Yes: N = 161 No: N = 301
Mean PCS12 Score (Yes)	47.0	47.1	46.3	48.0	45.3
Mean PCS12 Score (No)	47.9	48.4	48.7	46.0	47.9
PCS12 p-value	**0.3366**	**0.1184**	***0.0024**	**0.0670**	***0.0132**
Mean MCS12 Score (Yes)	49.4	50.5	50.3	50.3	50.5
Mean MCS12 Score (No)	51.8	52.3	51.9	51.9	51.6
MCS12 p-value	***0.0108**	***0.0216**	***0.0518**	***0.0517**	**0.3370**

Table 10: Mean health score comparisons based on sanitation.

Mean health score comparisons based on social connections and lifestyles showed mixed differences between physical and mental health outcomes (see Table 11 and 12). Positive correlations were observed between health scores and survey answers which indicated better social connections and healthier lifestyles. Participants who reported having trusted neighbors who were willing to help each other or have positive relationships with their community all had significantly better mean MCS12 scores and those were reported being physically active and participate in leisurely activities reported healthier mean PCS12 scores. Respondents who had better opinions of their health status and living conditions of their family members had healthier mean PCS12 and MCS12 scores.

Mean health score comparisons based on HWISE questions showed no significant differences for all survey questions except for residents who have not had enough to drink in the last 30 days (see Tables, 13, 14, and 15). Respondents who rarely or never had to worry about having enough drinking water had mean PCS12 scores of at least 51.0 while those who occasionally worried had a mean score of 45.4, but no observable differences in mean MCS12 score was observed. Overall, those experiencing water insecurity had lower mean PCS12 and MCS12 scores, but the differences were not statistically significant.

	People are willing to help each other in my community. (+): N = 438 (-) : N = 324	**How do you rate your relationship with your loved ones? Neighbors?** (+): N = 589 (-) : N = 173	**I trust most people in my community.** (+): N = 322 (-) : N = 440	**Is there a neighbor that you allow to help you when you are sick?** (+): N = 587 (-) : N = 167	**Have you helped a neighbor that was sick?** (+): N = 552 (-) : N = 201
Mean PCS12 Score (+)	47.8	47.9	47.7	47.2	47.0

Mean PCS12 Score (-)	47.5	46.8	47.6	49.4	49.5
PCS12 p-value	**0.7326**	**0.2097**	**0.8909**	***0.0176**	***0.0039**
Mean MCS12 Score (+)	52.2	52.2	52.8	51.3	51.3
Mean MCS12 Score (-)	49.9	47.9	50.1	51.3	51.2
MCS12 p-value	***0.0038**	***<.0001**	***0.0005**	**0.9642**	**0.8913**

Table 11: Mean health score comparisons based on social connections and lifestyles (part 1). (+) survey answers which indicated better social connections and healthier lifestyles than (-).

	Are you physically active? (+): N = 211 (-) : N = 551	**Do you participate in leisurely activities?** (+): N = 294 (-) : N = 467	**Would you like to stay in the neighborhood where you live?** (+): N = 518 (-) : N = 241	**In general, compared to other people in your age, how do you consider your health status?** (+): N = 533 (-) : N = 229	**In your opinion, your family's living conditions are:** (+): N = 238 (-) : N = 524
Mean PCS12 Score (+)	49.8	49.5	48.0	50.7	48.9
Mean PCS12 Score (-)	46.9	46.5	47.3	40.6	47.1
PCS12 p-value	***0.0006**	***0.0001**	**0.4972**	***<.0001**	***0.0316**
Mean MCS12 Score (+)	52.1	50.4	52.0	52.5	52.8
Mean MCS12 Score (-)	50.9	51.8	49.8	48.4	50.6
MCS12 p-value	**0.1618**	**0.0943**	***0.0091**	***<.0001**	***0.0082**

Table 12: Mean health score comparisons based on social connections and lifestyles (part 2). (+) survey answers which indicated better social connections and healthier lifestyles than (-).

	How often has water been stopped?	**How often have you worried**	**Has there been trouble**	**Have you changed plans?** Never: N = 103	**Have you had to change what you ate?**	**Have you gone without**

	Never: N = 47 Rarely: N = 136 Sometimes: N = 100 Often: N = 41	**about water accessibility?** Never: N = 61 Rarely: N = 91 Sometimes: N = 77 Often: N = 48	**washing clothes?** Never: N = 76 Rarely: N = 81 Sometimes: N = 77 Often: N = 43	Rarely: N = 83 Sometimes: N = 56 Often: N = 35	Never: N = 127 Rarely: N = 71 Sometimes: N = 55 Often: N = 24	**washing hands?** Never: N = 162 Rarely: N = 50 Sometimes: N = 44 Often: N = 21
Never	47.5	46.9	45.2	45.3	46.8	47.6
Rarely	47.8	47.6	48.7	48.8	48.7	47.4
Sometimes	46.6	46.5	47.3	47.8	46.8	46.0
Often	46.8	48.2	47.8	48.3	46.1	46.4
p-value	**0.8508**	**0.8415**	**0.2587**	**0.1634**	**0.6270**	**0.8299**
Never	52.4	53.1	51.4	52.1	50.8	51.0
Rarely	49.9	49.8	50.0	49.7	50.2	50.2
Sometimes	50.7	48.7	49.2	48.2	48.3	47.2
Often	50.7	50.4	51.1	50.0	52.8	52.3
p-value	**0.6599**	**0.1636**	**0.6276**	**0.1946**	**0.4002**	**0.2175**

Table 13: Mean health score comparisons based on HWISE questions (part 1). Rarely (1-2 times), Sometimes (3-10 times), Often (11-20 times. Blue = PCS12 values. Red = MCS12 values.

	Have gone without taking baths? Never: N = 152 Rarely: N = 69 Sometimes: N = 34 Often: N = 22	**Has there not been enough water to drink?** Never: N = 196 Rarely: N = 40 Sometimes: N = 28 Often: N = 13	**Have you been angry about water issues?** Never: N = 108 Rarely: N = 72 Sometimes: N = 58 Often: N = 39	**Have you gone to bed thirsty?** Never: N = 228 Rarely: N = 24 Sometimes: N = 23 Often: N = 2	**Has there not been usable water?** Never: N = 133 Rarely: N = 36 Sometimes: N = 32 Often: N = 76	**Have you felt shame because of water issues?** Never: N = 199 Rarely: N = 30 Sometimes: N = 22 Often: N = 26
Never	48.1	47.4	48.0	47.5	48.4	47.4
Rarely	45.7	44.9	47.5	43.4	45.3	44.9
Sometimes	47.0	49.2	45.3	48.5	47.4	50.3
Often	46.6	47.0	47.3	41.6	46.1	46.2
p-value	**0.5301**	**0.4299**	**0.1634**	**0.2821**	**0.3360**	**0.3570**
Never	51.4	51.1	52.1	50.5	51.5	50.6
Rarely	48.8	51.6	49.7	50.8	49.3	52.5
Sometimes	47.6	45.4	48.2	47.1	48.8	44.6
Often	52.1	46.1	50.0	65.0	49.5	50.7
p-value	**0.1725**	*** 0.0423**	**0.1946**	**0.1697**	**0.4465**	**0.0887**

Table 14: Mean health score comparisons based on HWISE questions (part 2). Rarely (1-2 times), Sometimes (3-10 times), Often (11-20 times. Blue = PCS12 values. Red = MCS12 values.

Based on the HWISE score, is the resident experiencing water insecurity?	**p-value: 0.5232 (PCS12)**	**p-value 0.2307 (MCS12)**

Yes (113)	46.7	49.3
No (164)	47.6	51.0

Table 15: Mean health score comparisons between those experiencing and not experiencing water insecurity.

The most substantial result from this study indicates that access to safe and affordable foods impacts the mental and physical wellbeing of the study participants. Results also indicate a similar correlation with access to sanitary living conditions, but the association are not as direct. This study has also shown far less association with access to usable water and general health.

In particular, there was no association between water insecurity and physical health detected and only a marginal correlation found to mental health. In addition, there were other associations between mental and physical health regarding other demographical factors such as education, income, and gender. Finally, lifestyle activities and social connections were also found to impact physical and mental health.

Discussion

The purpose of this study was to determine how access to clean water, safe and affordable food, and adequate sanitation correlated with mental and physical health in disadvantaged communities. This study revealed these associations by examining differences in mean physical and mental health scores from residents in 4 communities experiencing socio-economic and environmental challenges in Salvador Bahia. The associations observed in this study between overall health and environmental factors were mixed as some associations were conclusive while others were nonexistent.

The most significant observation from this study was how access to affordable foods impacted the health of residents living in these communities. Mean physical and mental health score

differences were statistically verified for every survey question and those who were more food insecure scored lower than those who weren't. Participants who ate less or skipped meals differed in their mean MCS12 scores by over 6 points to those who were eating regularly. This difference was the widest in comparison to the other survey questions and was among the starkest observed throughout the study. Though the impact of food insecurity on physical health was also shown to be significant, it's influence on mental health was statistically more noticeable.

The effects of unsanitary living conditions on mental health were also prominent with respondents indicating adverse reactions to bad smells and garbage accumulation around their homes. In addition, experiences related to sewage malfunctions were also shown to cause mental as well as physical stress on residents. Residents whose homes experienced recent flooding were not as emotionally affected, however the consequences were more discernable regarding their physical health.

The most surprising observation from this study was the lack of association between mean health scores and water insecurity. As mentioned in the literature review, the link between food and water insecurity is well established. One of the Hwise survey questions specifically asked residents if they had to alter what they ate due to water accessibility, yet there still were no significant associations detected. Residents who were experiencing water insecurity had lower mean physical and mental health scores, but the difference was not statistically significant indicating that refining the survey questions may produce clearer results.

This study also revealed how other social determinants of health (such as income and education) impacted the participants health. The results indicated a threshold of R$1000 per month in determining a 4-point difference in physical health scores. Similar improvements were not noticed for those making over R$2000 compared with residents earning R$1000 per month. Being employed and performing licensed or officially recognized work resulted in a positive association with physical wellbeing, but the same was not true regarding mental health.

It was expected that educational attainment would show similar correlations to health status as income because salary is a function of education, however the results were mixed. Those with higher education achievement showed a positive association in physical wellbeing, but an inverse relationship was observed regarding mental wellbeing. This inverse correlation may be the result of incorrect data recording or response bias, however more research needs to be done to obtain a conclusive explanation.

Other demographic factors were observed to be associated with differences in mean health score outcomes. In regard to gender, men tended to have better physical and mental health scores with an average of 3-to-4-point differences in both categories. Younger residents reported better physical health while older respondents scored higher on mental wellbeing. Single residents were observed to have better physical health but no discernable differences in mental health. There were no associations in mean health scores regarding ethnicity but this probably due to the homogeneity of population.

Over 90% residents identified themselves as black or mixed meaning they would experience the same social disadvantages from the dominant class. In addition, residents who have good social

networks scored higher on MCS12 scores and those who were physically active scored better on PCS12 scores. Also as expected, those who believed they had better general health scored better on both PCS12 and MCS12 scores along with those who felt their family members had good living conditions.

This study has added to the growing body of evidence linking food insecurity to mental and physical health and should serve as a resource for guiding policy interventions in similar communities. A 2022 review of intervention studies to reduce food insecurity in poor communities indicated suggests that residents in these communities would benefit from public health policy which focuses on expanding affordable food retail stores, investing in urban agriculture such as community gardens, and increasing nutrition education.[49] Subsidizing grocery stores and farmers markets may encourage businesses to open in food deserts which lack fresh produce and reduce pricing.[50] In addition, expanding eligibility and funding for food assistance programs would makes nutritious food more accessible.[51]

This study has also highlighted the need for investments in improving the sanitary conditions of which these residents experience. Primary attention should be given to improving housing and infrastructure by renovating plumbing and waste systems. Developing affordable housing should also be prioritized to reduce overcrowding. In addition, building public toilets and handwashing stations should also expand access to clean water and sanitation.

The study is not without limitations. Health scores were obtained from self-reported surveys in which results are susceptible to recall and social desirability bias. Sampling issues regarding selection bias may also contribute to an inaccurate understanding of the results. Question

design problems or language barriers may have also contributed to misunderstandings particularly regarding the Hwise questionnaire. This measurement tool was recently validated and may have not been translated correctly. In addition, the Bonferroni method for comparing and ranking mean differences of SF-12 scores was not used in the analysis. Lastly, the regression coefficients and normalizing constants used to calculate the SF-12 health scores were based on the US population and may not accurately depict the Brazilian community.

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Appendix

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.88275	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.158892	Pr > D	<0.0100
Cramer-von Mises	W-Sq	6.138457	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	33.62441	Pr > A-Sq	<0.0050

Table 16: PCS12 test for normality performed by SAS showing the p-value of the Shapiro-Wilk test

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.908214	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.130747	Pr > D	<0.0100
Cramer-von Mises	W-Sq	4.334564	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	24.75996	Pr > A-Sq	<0.0050

Table 17: MCS12 test for normality performed by SAS showing the p-value of the Shapiro-Wilk test

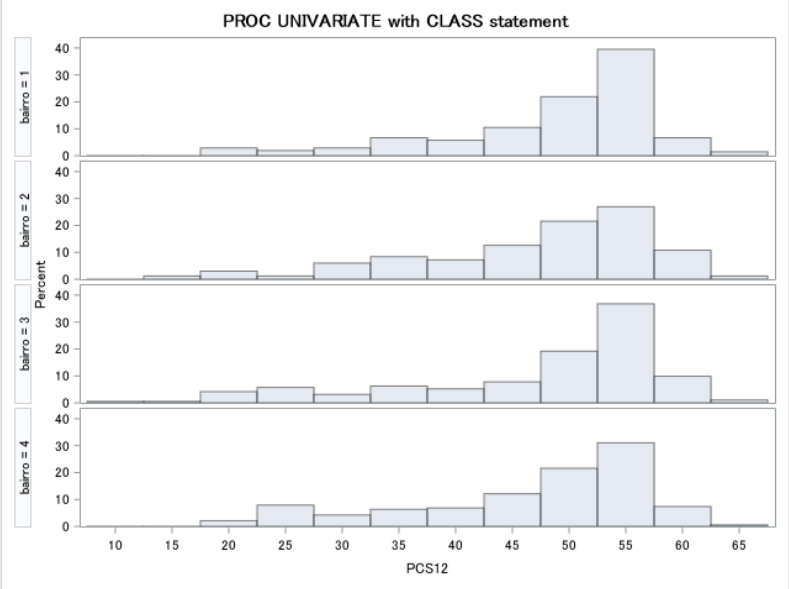

Figure 3: Distribution of PCS12 scores by neighborhood

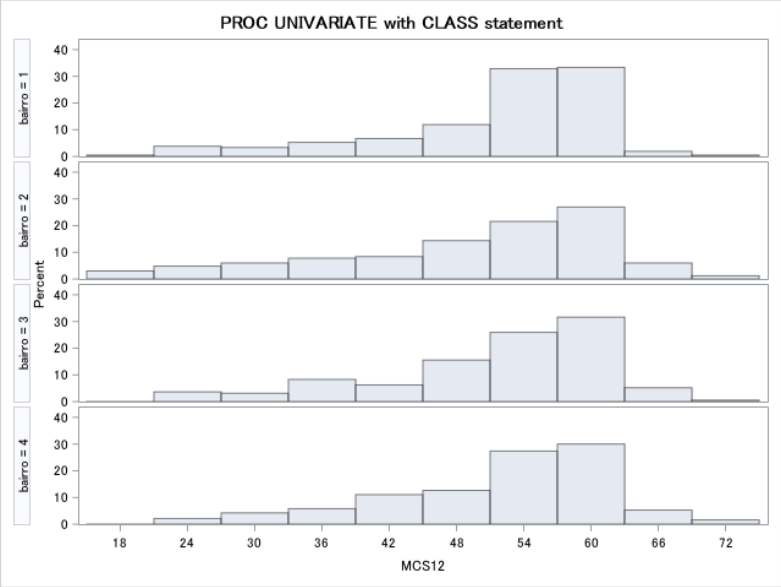

Figure 4: Distribution of MCS12 scores by neighborhood