



Weather Variability and Climate Change Impacts on the Mental Health of a Seaside Community

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Authors' contributions

All authors equally contributed to all phases of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To assess weather variability and climate change impacts on the mental health of a small fishing community in Sao Paulo, Brazil.

Study Design: To this study, a fishing community strongly familiarized with the region was selected. Interviews were held with the most active fishermen members among the community.

Place and Duration of Study: Interviews were held in the Association of Mussel Producers and Fishermen of Cocanha's beach (MAPEC), in the municipality of Caraguatatuba, State of Sao Paulo, Brazil, between 2009 and 2011.

Methodology: We chose 13 individuals to interview, all of them small-scale fishermen and mussel producers who were born at Cocanha beach. Their perception on the changing environment – as well as the setbacks in work activities and daily life – were codified and analyzed with NVivo 10 software. Health data were collected in a municipality level. We acquired hospital admissions for mental health and behavioral disorders from the Nacional Health System (DATASUS). We performed trend analysis (period 1998 to 2014) for rates of incidence of mental and behavioral

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disorders due to alcohol use, psychoactive substance use, Schizophrenia, schizotypal and delusional disorders. We also extracted social-economic data from the Brazilian Institute of Geography and Statistics (IBGE).

Results: The results indicated that the morbidities related to mental health problems showed a significant increase in hospital admissions, and were higher than the average rate in the state of São Paulo, Brazil, and that the interviewees were aware of ongoing environmental changes such as: marine water temperature, sea water levels, beach landscaping and intensity of precipitation.

Conclusion: Environmental changes related to climate change have a strong impact on the daily lives of the interviewees, on their mental health and on use of natural resources. The perception of the communities directly using natural resources should be considered in the assessment and monitoring of climate change.

Keywords: Climate changes; environmental changes; vulnerability; mental health; seaside communities; São Paulo; Brazil.

1. INTRODUCTION

International research has shown that global environmental changes, especially the climatic ones, affect the economy, society, politics and human health [1-9]. The impact of climate change on public physical health has already been analyzed, mainly in the context of increasing vector-borne diseases such as malaria in tropical regions [1,4-6]. Droughts, floods and heat waves are also important effects of climatic changes, particularly when they result in disasters, which create increased risks involving human and material losses [3-4,6].

It is also recognized that a clean, healthy and functional environment is integral to the enjoyment of human rights, such as the rights to life, health, food and an adequate standard of living. At the same time, adherence to human rights - such as those that ensure public access to information and participation in decision making contributes to more just decisions about the utilization and protection of environmental resources [10].

Another aspect to consider are the consequences of weather modification in urban areas due to pollution, atmospheric changes or deliberate attempts to change climate by covertly spraying micron and/or submicron size particles into the lower atmosphere, which mixes with the air we breathe. Epidemiological studies have found pollution particles with similar diameters, $\leq 2.5 \mu\text{m}$, to be associated with increased hospital admissions, morbidity and premature mortality, risk for cardiovascular disease and lung cancer, lung inflammation and diabetes, low birth weight, and reduced male fertility [11-12]. However, studies about the relationship between global environmental changes and their impact on

mental health still remain scarce in the scientific literature.

The impacts on physical health resulting from extreme climatic events are well recognized, and that the impact on mental health related to these events has become prominent, especially in Asia after the "Asia tsunami events" in 2004. Based on this consideration, authors [13] have found increasing suicide and psychosis rates in the following period after the extreme event.

The direct impacts of climate change and weather variability, e.g. extreme weather events, do not just have significant implications on the mental health, but also serious consequences for the socially, economically and environmentally vulnerable segments of the population. This urges the necessity to develop plans for these parts of the population, which aim to prevent the looming dangers at individual, communal and social level [14]. The severity of the adverse long-term effects of climate change were claimed to affect the mental health of especially those parts of the population, which were exposed to the resulting traumata [15]. The authors recommended an analysis, which considers two aspects: 1) direct effects on mental health of e.g. acute and sub-acute climatic events; 2) indirect effects, i.e. impacts from the adaptation and/or mitigation of physical health, as well as of the physical and social environment. These considerations imply that existing health systems need to be reorganized in order to deal with these problems [15].

Some studies discuss these issues on the example of rural communities in Australia, which have either fallen victim to natural disasters [16], or are disadvantaged on a regular basis, e.g. by reoccurring or prolonged events such as

droughts [17-18]. These studies help us to reflect on this complex of problems, which should also apply to coastal communities, who have a particularly close relationship with the environment.

In various parts of the world, the daily lives of inhabitants of seaside communities are subjected to socioenvironmental and cultural transformations, arising from the impact of global environmental changes [19-23]. Other issues that will influence the vulnerability are processes of urbanization and changes in land use and economic profile [24-27]. It is worth to highlight that the implications of the relationship between urbanization and human vulnerability to climate change are directly related to the risks of disorderly population growth, poverty, economic shortcomings and the lack of proper cities' infrastructure. These implications are a greater risk to adaptation and resilience of people who live and work in poor conditions and present a challenge to overcome and mitigate climate change effects [24-26].

Studies on climate change conducted in Brazil recognize the importance of the issue as one of the great challenges of the twenty-first century and the urgent need for deeper research and monitoring, particularly in coastal regions [28]. Research conducted on the effects of global warming temperatures that could cause sea levels rising show that the problems related to saline intrusion will be intensified [29]. Other diagnostics on Brazilian coastal regions consider that the study of urban sprawl and coastal management are fundamental to broaden the debate on global environmental changes in these regions [30-32].

This article presents an evaluation of the perception of vulnerabilities and risks, arising from environmental changes, for the everyday lives of inhabitants of seaside communities. There, inhabitants are currently strongly exposed to these changes, and will most likely experience even more changes in the future [9,33]. We studied a small and specific group of small-scale fishermen, mussel producers and their families, who live in Caraguatatuba, which is located on the northern coast of the federal state of São Paulo (Brazil) and considerably affected by the aforementioned socioenvironmental changes. Fisherman living on the coast have a privileged view of the coastal changes. Although the knowledge associated to their activities isn't considered technical, it is based on daily

experience and contributes to a more specific data for the region [34].

According to previous research carried out in four municipalities on the northern coast of São Paulo, two important aspects should be taken into consideration: 1) the region has experienced significant changes, requiring residents to adapt their relationships with the living environment and working conditions; 2) a significant number of adult patients of the public health service in the region were treated for depression in 2007, with an estimated prevalence of about 15% [35]. Even with respect to different methodological approaches, this percentage is well above international standards, which oscillates between 3% and 11% [36]. International studies conducted in 14 different countries indicate that the average prevalence of patients treated in primary care is around 10% [37-38].

The introduction to this article defines the scope of the study and the underlying theory. The second part contains the discussion of the study's main topics. In the third part, the interviews of the fishermen and mussel producers highlighted global and urban environmental changes and emphasized the consequences for their mental health. The article concludes with an outlook for future avenues to pursue in order to solve the presented issues.

2. METHODOLOGY

In order to continue research carried out by the authors, this article takes data previously collected into account [35-39], which are connected to recent global environmental changes studies in the area [40-41]. The methodological strategy comprised the collection and analysis of sociodemographic and health data from national and federal databases (Brazilian Institute of Geography and Statistics - IBGE; Department of Informatics of the National Health System - DATASUS; Municipality Primary Care Facilities), as well as the conduction of interviews with 13 fishermen and mussel producers from Cocanha beach. The interviews were held in the Association of Mussel Producers and Fishermen of Cocanha's beach (MAPEC), in the municipality of Caraguatatuba. During these semi-structured interviews, topics related to climate change and weather variability, alterations of natural resources and their implications for mental health were discussed. Their perception on the changing environment – as well as the setbacks in work activities and

daily life – were codified and analyzed with NVivo 10 software [42-43].

Between 2009 and 2011, we interviewed 13 individuals between 34 and 54 years of age, all of them fishermen and mussel producers, who were born and living at Cocanha beach at the time of the interviews. The average time per individual spent fishing professionally, or producing mussel respectively, was 19.5 years. The particular individuals were chosen because they had higher levels of social connectivity compared to fishermen living in other areas, enabling them to identify the region's problems more accurately, and because they were the association's most active members. Despite of being in small number, the interviewees have a long time familiarity association with the region.

Authors [34] point out that groups having historical knowledge from particular regions are extremely important in terms of environmental perception, as their long and intense relationships with space help them to easily recognize environmental alterations. Besides, as mentioned by others [44], climate changes will affect communities strongly depending on their local environment to survive. That is the case observed in the interviewed community. Thus, fishermen reveal an important knowledge about significant environmental changes that are taking place in the North Coast of São Paulo and at Cocanha beach, modifying the beach's landscape, the natural resources and their work activities. The encountered situation is not an isolated scenario and can certainly be found in other regions of the world.

The objective of the interview was for the individuals to reflect on the impact of global environmental changes on the region, as well as on their personal lives and professional activities. Interviews usually lasted one hour, were digitally recorded and subsequently transcribed and analyzed. After having been presented with the research objectives, the fishermen gave free informed consent and participated in the interviews. Once the interview was finished, further time was allocated so that each fisherman could add remarks beyond the scope of the questions, especially relevant to personal issues, which could be connected to stress situations.

The analysis of morbidities related to the mental health problems described in Chapter V of the ICD – 10 (International Classification of Diseases (ICD-10) - Chapter V - Classification of Mental

and Behavioural Disorders) [45] was performed with the rate hospital admissions per 100,000 inhabitants. This rate was calculated for each municipality of the study area and the state of São Paulo using as a numerator the number of admissions and as denominator the estimated inhabitants, times 100,000. The hospital admissions were acquired from the Department of Informatics of the National Health System (DATASUS) and the estimated inhabitants from the Brazilian Institute of Geography and Statistics (IBGE). The period availed in DATASUS for the hospital admissions were from 1998 to 2013. In the area of mental health, the conditions most sensitive to socioenvironmental and cultural issues are "mental and behavioral disorders" due to the abuse of alcohol and/or other psychoactive substances. They are known as possible causes of "mental health problems", "neurotic and humor disorders and stress", "schizophrenia, schizotypal and delusional disorders" and "other mental and behavioral disorders" [45].

An exploratory visual analysis of the line chart from each morbidities time series was performed to examine cyclic behavior and trend estimation. Also for the trend estimation, an analysis using a polynomial regression model was conducted using as dependent variable the rate of admissions and as independent variable the years, centered from the midpoint of the time series to avoid serial correlation [46]. The significance level adopted was 0,05 and the model was evaluated based on the analysis of the scatter plots, p values for the F statistic, values of the determination coefficient (R^2), constant variance (homoscedasticity) and the residual analysis (normal distribution).

2.1 The Studied Region: Caraguatatuba on the Northern Coast of the Federal State of São Paulo, Brazil

The urban areas on the northern coast of the federal state of São Paulo, including the central municipalities of São Sebastião, Caraguatatuba, Ilhabela, and Ubatuba, occupy 84 km² and host a population of ca. 282,000 inhabitants [47] (Fig. 1). Urban growth in the region started in the 1960s, when it became a tourist destination. Another inducing factor for urban growth was the construction of the highway BR-101 from Rio de Janeiro to Santos in the 1970s, which facilitated access to the region and accelerated the development of residential areas and condominiums, albeit in a disorganized way.



Fig. 1. The Atlantic coast of the federal state of São Paulo

Source: Own elaboration, 2014

Subsequently, the urban expansion gradually progressed in recent decades along the coastline. Between 1961 and 1990, the expansion advanced mostly around the four central municipal areas and in the plain areas located along the coastline, although urbanization was also already making headway towards the slopes of the “Serra do Mar” formation in Caraguatatuba. Between 1990 and 2000, the urban expansion filled the plains and intensified in the interior, predominantly on the slopes of the “Serra do Mar”. The geomorphological characteristics of the northern coast of São Paulo, i.e. a narrow coastal plain, restricted further human occupation due to the proximity of the “Serra do Mar” [48-49].

Following the regional cities’ increasing popularity as a tourist destination since the early 1960s, an extensive road network was gradually built, which now connects the coastal region with the valley of the “Paraíba do Sul” river, located in the upper northern part of the “Serra do Mar”. This stimulated economic recovery, since agriculture and fishing activities were in decline. The region is currently experiencing a new economic boom, mainly related to the exploration of deep-sea oil reserves known as “Pre-Salt”.

From 1980 to 2010, the municipalities on the north shore showed a significant population

growth. In the period between 2000 and 2010 for example, the city of Caraguatatuba exhibited an annual population growth rate of 2.49%, which is significantly higher compared to the average federal (1.08% p.a.) and national (1.17% p.a.) growth rate for the same period. In addition to this substantial increase, the city has become one of the 15 most popular tourist destinations in the state of São Paulo [35].

3. RESULTS AND DISCUSSION

3.1 Living and Working Conditions of the Fishermen and Mussel Producers

The interviews indicated that the fishermen were all aware of the changes to the ecosystem they lived in (Fig. 2).

Since the mid-1960s, starting with the opening of regional highways and the improvement of the regional infrastructure such as the expansion of the port of São Sebastião, Cocanha beach and other beaches of the region, have been facing a strong touristic influx, resulting in growing real estate prizes due to speculations [50]. Nevertheless, the region still is the biggest mussel producer (ca. 30 tons p.a.) in the state of São Paulo [51-52].

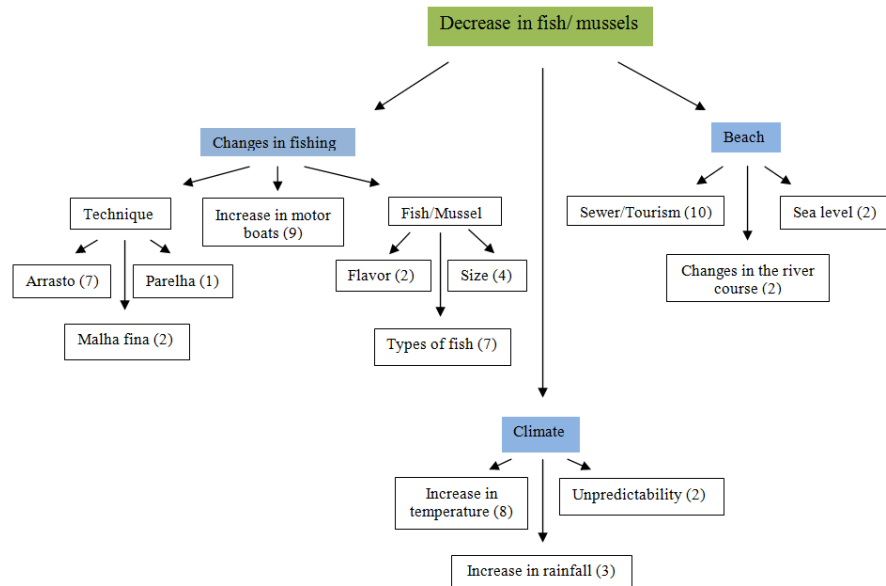


Fig. 2. Layout of categories subcategories and frequency in the speech of fishermen's and mussel producers from Cocanha beach (Caraguatatuba city)

Source: Own elaboration, 2014

The fishermen associated the presence and function of the mangrove forests (or the absence thereof, respectively) with the reproduction of several species of marine fish and also emphasized the consequences of real estate speculation in the area due to tourism. The reports furthermore identified an observed decline of fishing stock as the major changing factor in their professional activities. According to the interviewed individuals, the decline in fish production is related to the environmental and urban changes in the coastal areas, to modifications in fishing equipment and climate changes. It is worth pointing out here again that no personal questions - besides the ones related to the natural environment - that may have contributed to the fishermen's emotional concerns were asked during the interviews.

According to the fishermen, tourism and sewer, marine regression and the previous closure of the Rio Graçuí (a.k.a. Rio Cocanha) river, in order to build a residential condominium were major reasons for the substantial changes observed at Cocanha beach. The change in sea levels and tidal cycles, as well as the disappearance of forest and wetland areas in the region were also mentioned by fishermen in the interviews. For them, these landscape changes contribute to the occurrence of floods during rainy seasons (Interviews 5 and 9, 2011).

Sensitive environments are often fragmented and damaged by the construction of highways, real estate and industrial properties. The authors moreover drew attention to the pollution of fresh water reservoirs and groundwater by discharge of chemicals and pathogens into the sewer system of urban areas, causing severe adverse effects for human health [53].

In relation to the environmental sanitation, two aspects should be considered: 1) sewage production of kiosks and trading facilities near the beach; 2) sewage collection and treatment. In Caraguatatuba's 98% of the population has access to safe water supplies. On the other hand, only 56% are connected to a sewage collection and treatment system, indicating an absence of a suitable collection and treatment system for sewage on the beach [54-55].

A growing population together with being a touristic destination results in triplicating the regional population during the summer season. However, the marine water quality on the most popular beaches and close the city center has been classified as inappropriate. During most of the holiday season and especially during summer 40% of the 15 beaches analyzed showed a fecal coliform density beyond maximum acceptable levels [56-58].

This was a matter of major concern for the fishermen and mussel producers interviewed, as water contamination by fecal coliforms directly interferes with the quality of mussels, which act as biological filters. In their interviews, the fishermen mentioned kiosk sewage as one of the major problems, since it is directly dumped into the river and consequently flows through the mussel beds, causing contamination with fecal coliforms (Interview 6, 2011).

Another issue addressed by the interviewees is related to fishing techniques, e.g. motorboats and trawlers endangering the sustainability of fishing stocks by catching “fry fish” rather than adult fish. Shrimp fishing is even more destructive and less sustainable, as it is done by trawling with thin-meshed fishing nets, which retain high quantities of immature fish (Interviews 2 and 3, 2011). At the same time, the fishermen stated that the fishing stocks of the region should not have been overfished.

Besides the modifications in fishing methods, the interviewees suggested a climatic influence on the fishing productivity, both with respect to decreased availability and quality of the fish. They also discussed a rise in financial expenses, e.g. higher prices for bigger boats, which allow prolonged and therefore economically more lucrative fishing trips (Interview 2, 2011).

The interviewees furthermore perceived that the climate changes are very substantial and important for the development of their professional activities. This was affirmed during interviews with the mussel producers, who believed that water temperature had increased every year. Some of them highlighted the fact that they had allegedly lost up to two tons of tradable goods from their production in 2010, which is approximately equivalent to US\$ 9,500. Moreover, due to climate changes, it has sometimes simply been impossible to cater to the customers' demands (Interview 5, 2011). Another interviewee reported to have experienced a 90% decrease in productivity over the past 5 years (Interview 6, 2011). The same interviewee claimed that on some days of 2010 the marine water temperature reached 32°C, while the ideal water temperature for his professional activity supposedly ranges between 22 °C and 26°C.

All these observations show that the working and living conditions of these workers have been substantially modified as a result of climate changes. The impact on their mental health, i.e.

suffering and stress as well as the inability to face these difficulties beyond their routines and habits are discussed below.

3.2 The Impacts on Mental Health

The construction changes to the environment affect the ecosystem, natural resources, as well as human health and welfare [47]. Although urban areas are very attractive and offer many advantages for their residents, e.g. easy access to facilities and services, they might also affect their quality of life negatively, especially in relation to a capacity overload of resources and infrastructure. For example, the use of land is strongly affected by urban expansion, as it is usually responsible for damages to the environment by modifying the ecosystem functions, which normally results in a reduction of biodiversity [19,59-60].

Scientists have become more sensitive to the mental health of the population, now taking the importance of environmental conditions and the impact of climate changes into consideration [14].

At Cocanha beach, the change in fishing activities has caused modifications to the community's way of life. According to the fishermen and mussel producers interviewed there, the most significant change to their daily lives is the decrease of fishing stocks, resulting in a current shortage of work compared to previously abundant employment conditions (20-30 years ago). This also includes the non-commercial working environment (Interviews 3 and 8, 2011).

As a consequence of declining fishing stocks, considerable extra efforts have to be made by the fishermen in order to subsist on fishing. The difficulties experienced comprise physical efforts, e.g. the necessity for more trips to the sea, as well as the financial investments for better material to maintain fishing activities. In the interviewees' opinions this substantial human and financial investment leads to physical health hazards, and many fishermen mentioned spinal column problems, e.g. back pain or restricted mobility (Interview 5, 2011).

Climate changes will over proportionately affect already vulnerable communities (especially people in low-income brackets), or as in this study, communities strongly depending on their local environment to survive [44]. Considering the previously discussed decline in fishing

stocks, it was possible to observe an occupational shift from to a secondary activity, in order to subsidies or substitute the income from the interviewees' primary small-scale fishing profession.

In the observed region, only few fishermen can earn a living based solely on fishing nowadays. The interviewees often had secondary occupations, e.g. as housekeepers, builders or local merchants, which often became their main source of income. In some cases, the interviewees pursued an income-generating profession during the week and kept fishing for the weekend, emphasizing their need for an additional income (Interviews 2, 5 and 7, 2011).

Due to the experienced difficulties, many fishermen do not encourage their offspring to pursue a professional career in fishing. The numerical decline of fishermen can be documented by a comparison of the number of partners in the fishing communities, who actively work in the fishing business. Currently, there are 35 partners at Cocanha beach, of which 15 are mussel producers.

Unemployment and socioeconomic disadvantages have undoubtedly a negative impact on mental health. According to the literature, usually they represent a major exposure to psychosocial risk factors such as negative self-perception, stress, insecurity, loss of personal autonomy and social isolation [14,61-62]. Climate changes are likely to impact mental health and welfare through probable interferences with the economic system, the cost of living, as well as through the unequal

distribution of these disadvantages among the members of a community, i.e. mostly affecting the poor [3,14].

These aspects addressed in the interviews can be complemented by the mental health data collected in the municipally basis [63]. The Fig. 3 presents in percentage the sum of the rate of hospital admissions from 1998 to 2013 for each municipality and the State of São Paulo.

Most interestingly, in the period from 1998 to 2013, the sum of "mental and behavioral disorders due to alcohol use" and "mental behavioral disorders due to the other psychoactive substances" is surprisingly close to the federal rate of São Paulo. In contrast, the rate of "schizophrenia, schizotypal and delusional disorders" was significantly higher for the four municipalities compared to the federal rate of São Paulo (vide infra).

These findings are corroborated by entries in the national health system database (DATASUS-Brazil), which explore the mental health situation of the municipalities on the northern coast of São Paulo. As the morbidities listed in Chapter CID-10: V are most sensitive to the socioenvironmental and cultural issues and include 'diseases' linked to mental behavioral disorder due to alcohol and other psychoactive substance, they were chosen to describe the impact arising from global environmental changes on mental health. Other disorders mentioned there are related to e.g. humor (affective), neurosis, stress, schizophrenia and schizotypal delusion.

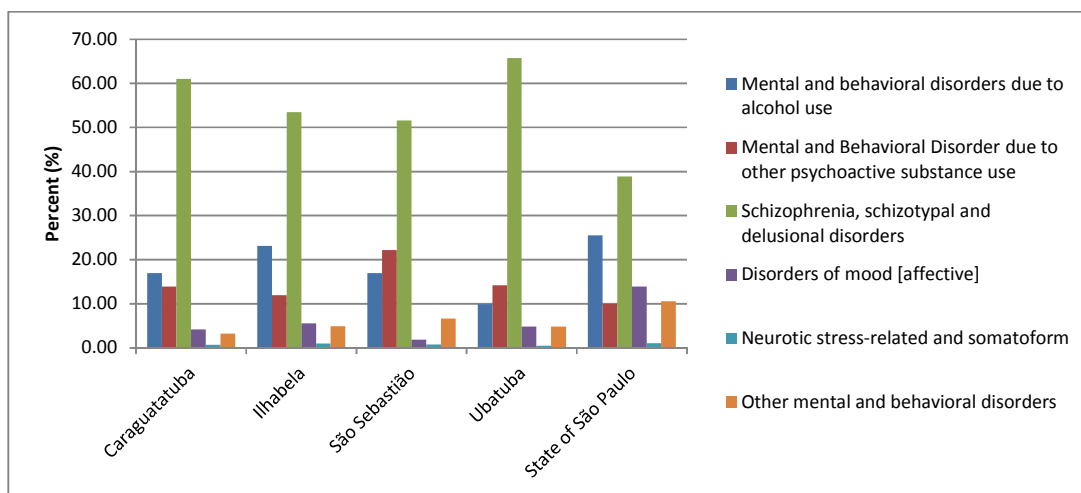


Fig. 3. Percentage distribution of the morbidities in the study area

Source: Datasus (Brasil, 2014)

What called our attention is the combined rate of “mental and behavioral disorders due to alcohol abuse” and “mental behavioral disorders due to other psychoactive substances” of 31% in Caraguatatuba, 35% in Ilhabela, 39% in São Sebastião and 24% in Ubatuba. For the period from 2000 to 2010, these numbers are surprisingly close to the federal state rate of 36%. It is important to consider the nature of these morbidities when analyzing the socioenvironmental impacts in a particular region, as they are directly related to social and cultural aspects. The abuse of alcohol and psychoactive substances often represents a compensation related to the difficulties experienced by the human individual in everyday life [64].

The section “schizophrenia, schizotypal and delusional disorders” is also interesting to consider, as the rates of Caraguatatuba (61,06%), Ilhabela (53,44%), São Sebastião

(52%) and Ubatuba (66%) are significantly increased compared to the federal rate of São Paulo state (39%). In this context, it should be highlighted that schizophrenia is a very severe disease, which predominantly affects young male adults. It is also important to remark that often, the first schizophrenic incident is triggered by heavy alcohol consumption and/or the consumption of other psychoactive substances [65-66].

Considering the time series of each morbidity from 1998 to 2013, the exploratory visual analysis of the line chart didn't present a cyclic behavior. The trend analysis for “Mental and behavioral disorders due to alcohol use” (Table 1 and Fig. 4), showed a decreasing trend for Caraguatatuba, São Sebastião and the State of São Paulo, while Ilhabela presented rates above all municipalities and even above the state rate. Ubatuba presented the lowest rates most of them under 5 hosp. per 100 thou inhabitants.

Table 1. Trend analysis for rate of mental and behavioral disorders due to alcohol use

	Model	R ²	P	Trend
Caraguatatuba	y = 17.631–2.342x	0.744	.00	Decreasing
Ilhabela	y = 36.088–1.629x	0.070	.32	Not significant
São Sebastião	y = 15.870–2.203x	0.499	.00	Decreasing
Ubatuba	y = 6.6360–0.399x	0.225	.06	Not significant
State of São Paulo	y = 51.506–3.260x	0.947	.6 ⁻¹⁰	Decreasing

Source: Datasus (Brasil, 2014)

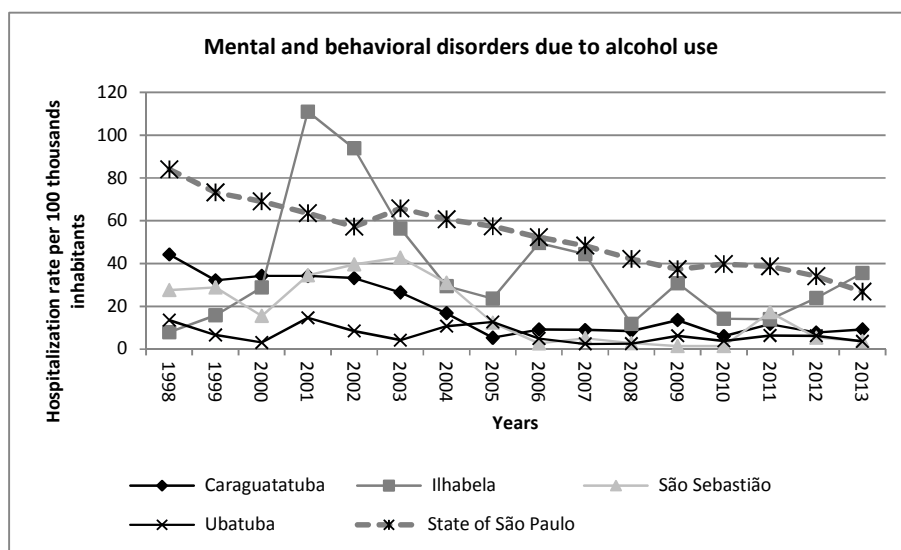


Fig. 4. Trend analysis for rate of mental and behavioral disorders due to alcohol use

Source: Datasus (Brasil, 2014)

For the Mental and behavioral disorders due to psychoactive substance use (Table 2 and Fig. 5), all regions presented an increasing pattern, following the State trend. The only exception was Ilhabela which presented most values between 5 and 20, and some very high (31,49 and 57,19) above the state rate. São Sebastião presented a rapid increase from 2007 to 2013 hitting rates above the state at the end of the series.

has showed a decreasing trend. Ilhabela presented a variation with most values near, and some above, the state rate (Table 3 and Fig. 6).

Even though “Schizophrenia, schizotypal and delusional disorders” was the most present morbidities in Fig. 4, all regions, except Ilhabela,

The State values for “Disorders of mood [affective]” presented a stationary trend between 25 and 31, with a small decreasing in the end of the series. The municipalities presented in general 0 values from 1998 – 2005, and a random pattern from 2006-2013. The only exception was Ubatuba, which presented a decreasing trend from 2008-2013 (4 and Fig. 7).

Table 2. Trend analysis for rate of mental and behavioral disorders due to psychoactive substance use

	Model	R ²	P	Trend
Caraguatatuba	$y = 16.106 + 1.642x$	0.372	.01	Increasing
Ilhabela	$y = 19.201 + 0.125x$	0.002	.86	Not significant
São Sebastião	$y = 23.547 + 2.706x$	0.508	.00	Increasing
Ubatuba	$y = 10.348 + 1.149x$	0.654	.00	Increasing

Source: Datasus (Brasil, 2014)

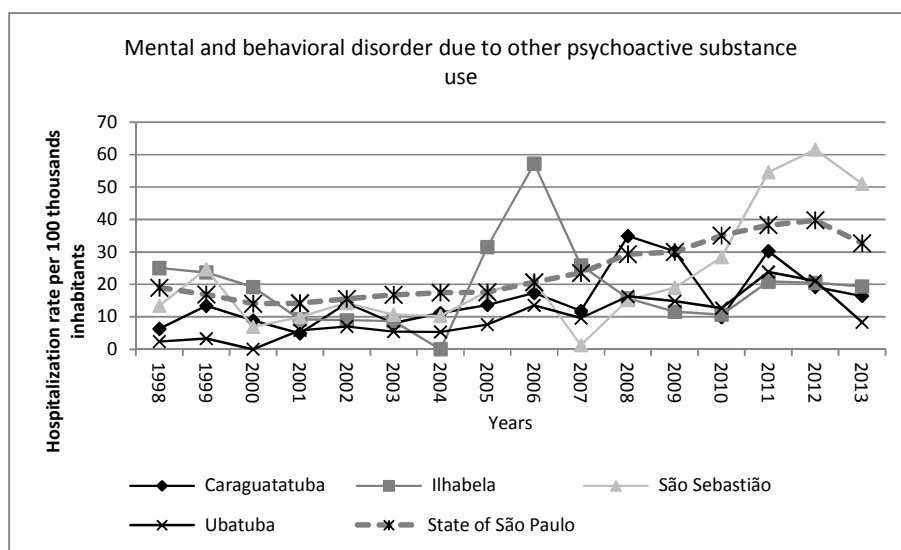


Fig. 5. Trend analysis for rate of mental and behavioral disorders due to psychoactive substance use

Source: Datasus (Brasil, 2014)

Table 3. Trend analysis for rate of schizophrenia, schizotypal and delusional disorders

	Model	R ²	P	Trend
Caraguatatuba	$y = 64.107 - 7.456x$	0.856	.00	Decreasing
Ilhabela	$y = 82.333 - 6.133x$	0.259	.04	Not significant
São Sebastião	$y = 49.158 - 4.769x$	0.772	.00	Decreasing
Ubatuba	$y = 43.929 - 2.715x$	0.732	.00	Decreasing
State of São Paulo	$y = 78.340 - 5.254x$	0.769	.00	Decreasing

Source: Datasus (Brasil, 2014)

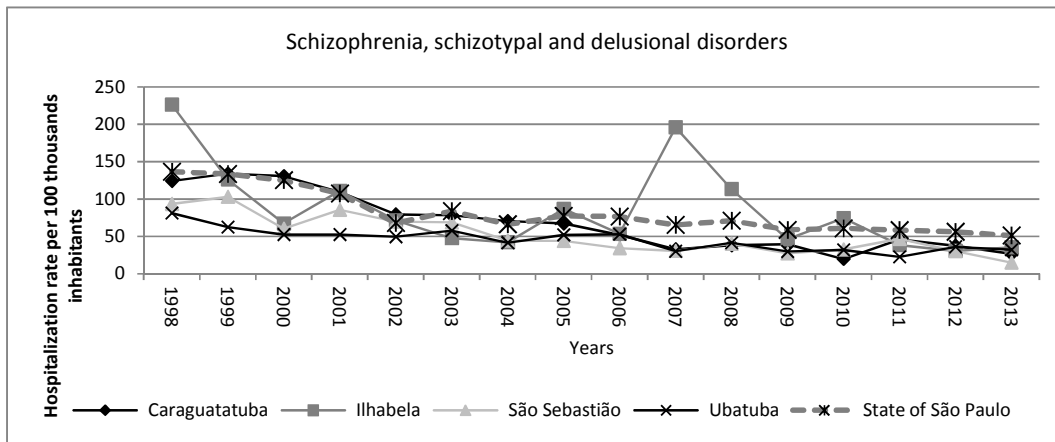


Fig. 6. Trend analysis for rate of schizophrenia, schizotypal and delusional disorders
 Source: Datasus (Brasil, 2014)

Table 4. Trend analysis for disorders of mood [affective]

	Model	R ²	P	Trend
Caraguatatuba	y = 8.286+1.5195 x	0.381	.07	Not significant
Ilhabela	y = 14.79+1.0048 x	0.205	.22	Not significant
São Sebastião	y = 3.285+0.4929 x	0.122	.36	Not significant
Ubatuba	y = 9.703-1.5606 x	0.858	.00	Decreasing
State of São Paulo	y = 28.99+0.1172 x	0.068	.33	Not significant

Source: Datasus (Brasil, 2014)

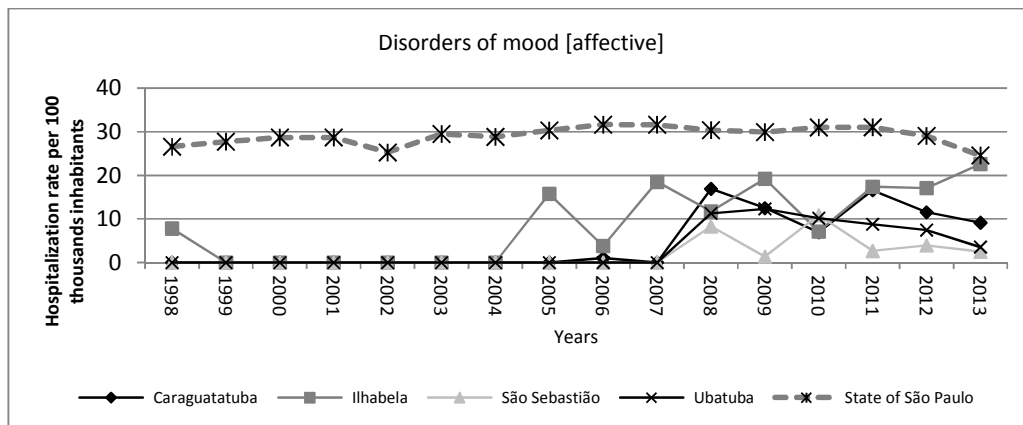


Fig. 7. Trend analysis for rate of for disorders of mood [affective]
 Source: Datasus (Brasil, 2014)

The “Neurotic stress-related and somatoform” presented the lowest values of the morbidities, with a stationary line for the State of São Paulo with values varying near 2. The municipalities presented a random pattern of small values, in general all under the state rate. Ilhabela presented some exceptions, with values above the state rate (Table 5 and Fig. 8).

For “Other mental and behavioral disorders”, the state presented a rapid decrease in the early of the series, and a smooth decrease from 2004 to 2013. São Sebastião presented a similar trend, but with values under the state rate. The other municipalities presented, in general, a random variation with values lowest than the state rate (Table 6 and Fig. 9).

Table 5. Trend analysis for neurotic stress-related and somatoform disorders

	Model	R ²	P	Tren
Caraguatatuba	y = 0.7291+0.0126 x	0.009	.72	Not significant
Ilhabela	y = 1.5207+0.2221 x	0.101	.23	Not significant
São Sebastião	y = 0.7909-0.0183 x	0.008	.74	Not significant
Ubatuba	y = 0.2926+0.0400 x	0.118	.19	Not significant
State of São Paulo	y = 2.2963-0.0500 x	0.448	.00	Decreasing

Source: Datasus (Brasil, 2014)

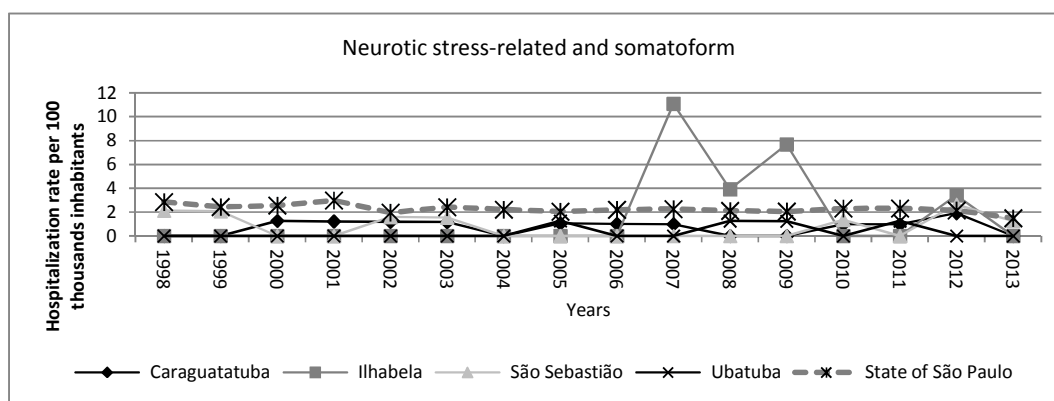


Fig. 8. Trend analysis for neurotic stress-related and somatoform disorders

Source: Datasus (Brasil, 2014)

Table 6. Trend analysis for other mental and behavioral disorders

	Model	R ²	P	Trend
Caraguatatuba	y = 3.6153-0.1358 x	0.045	.43	Not significant
Ilhabela	y = 8.0140-0.2063 x	0.033	.50	Not significant
São Sebastião	y = 7.2158-1.1860 x	0.576	.00	Decreasing
Ubatuba	y = 3.3979-0.1103 x	0.040	.45	Not significant
State of São Paulo	y = 23.1317-2.059 x	0.759	.00	Decreasing

Source: Datasus (Brasil, 2014)

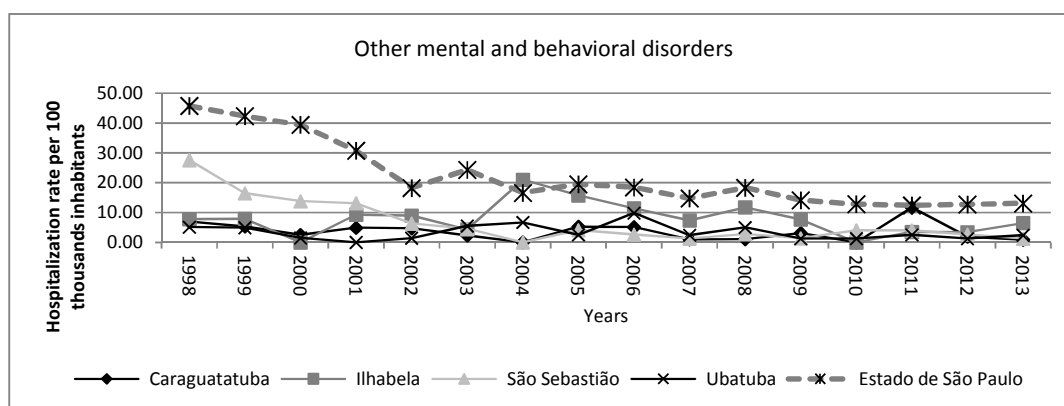


Fig. 9. Trend analysis for other mental and behavioral disorders

Source: Datasus (Brasil, 2014)

Several aspects were discussed in an attempt to correlate climate changes and mental health [15-19]. The determination of this relationship is still in its infancy and mental health can suffer from impacts of many types of climate changes, e.g. droughts, floods or other environmental

disasters and also from unplanned urban development. What we could observe in the case of our four municipalities was that the degradation and depletion of natural resources during the last decade could be considered a factor that harms the mental health of the fishermen living there, as they expressed in Cocanha beach.

We also consider that it seems difficult to establish a precise correlation between the fishermen/mussel producers, climate change and mental health problems. The 13 interviews were conducted in just one municipality – Caraguatatuba, where Cocanha Beach is located, and further studies are needed. However, the data presented show that they are facing different changes that impact and press their daily lives, and the fishermen/mussel producers mentioned that weather variability and climate change are impacts that contribute to their mental health problems.

4. CONCLUSION

The debate concerning the importance of global environmental changes, specifically the climatic ones, has recently become increasingly prominent in the scientific literature. It is also observed that climate change and its diverse aspects will have a profound effect on the exercise of human rights for many people across the world. This will occur through both direct impacts on humans and settlements, as well as through the degradation of the ecosystems and environmental resources upon which many lives and livelihoods depend and governments, organizations and citizens will need to work cooperatively to ensure the protection of human rights for all citizens across the world [10].

Another aspect to consider is vulnerability in urban areas and the related risks, like sea levels rising, coastal storms, heat stress, extreme precipitation, inland and coastal flooding, landslides, drought, increased aridity, and water scarcity which are increasing, with widespread negative impacts on people and their health and livelihoods, as well as local and national economies and ecosystems [24-27].

However, the analysis of the impact of these changes on mental health is a process, which is still in its infancy. The revision of the scientific literature highlighted a demand for more detailed studies in order to determine the key elements of this process, so that solution strategies can be devised for the future. Considering all the

examined evidence, it can be concluded that both weather modification and variability and climate change promote material and human loss resulting in stress and traumata for the affected regions.

This article outlined the climate changes on the North coast of the federal state of São Paulo over the last decades and their impact on the residents' lives and mental health. After some theoretical and methodological considerations, we presented health data and interviews with 13 fishermen and mussel producers from Cocanha beach in Caraguatatuba. From the interviews, it is evident that the fishermen have an expressive perception of the changes in their daily lives. This is evident from previous events, with which they are already more familiar, e.g. new fishing technologies and the disorganized tourism, which has been ongoing on the north coast of São Paulo for several decades. The changes that they perceive as more recent are the ones derived from weather variability, climate and urban changes, which provoke e.g. decrease of fishing stocks, the rise of marine water temperatures and social vulnerabilities, resulting in economic, social and cultural harm and also, according to them, some changes in mental health.

According to the fishermen interviewed, these losses take a heavy toll on their daily life and are associated with mental suffering and an increase in mental morbidity rates in the region. Data collected in the interviews showed that the interviewees are aware of how the climate changes affect their daily lives, the landscape, and the region's natural resources. In addition, the analyzed morbidity indicators related to mental health estimated a significant increase in cases of depression on the north coast, not to mention the hospital admissions per municipality, whose rates are significantly higher compared to the federal state rate over the period from 2000 to 2010. This situation – the increasing in the depression cases in function of alterations associated to climate changes – was also mentioned and highlighted by the interviewed fishermen. We once more point out that the environmental perception of this small social group is very significant. Considering its strong relationship with the environment, they were very sensitive to the changes in course, including the climatic ones.

The systematically analyzed data indicate that these stressful and prevalent events are difficult to measure using conventional health evaluation

instruments. The results also indicate the need for more in-depth research into this field, including a broader scope of the analysis, which could include analysis of economic aspects as a consumer market and prices among others. The observed impacts on the region are expected to continue due to global environmental changes and therefore it is necessary to reflect upon and raise questions about the future avenues to pursue with respect to the conservation of natural resources and the increase of the local population's quality of life.

Finally, we would like to suggest a potential solution, which could lie in an extension of the research in the region to include a closer dialogue with other research groups, addressing issues similar to ours. We believe that such dialogue would allow a more appropriate and profound analysis of mental health in the context of climate changes, especially since this problem seems to be more relevant than we anticipated at the beginning of this research.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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