THERMAL COMFORT CONDITIONS AND HEALTH RISKS TO SÃO LUÍS (MA) URBAN POPULATION

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Received: Aug. 25, 2017 - Accepted: Sep. 26, 2017
DOI XXXX

ABSTRACT: The objective of this research was to analyze how the climate, associated with the types of constructive materials in areas of socio-spatial vulnerability compromises the health of the urban population of São Luís (MA). The research is particularized by relating the study of urban climate and thermal comfort to the socio-spatial conditions of the population, through interdisciplinary methods and by using Subsystem for Thermodynamic analysis of the urban climate proposed by Monteiro (1976) as theoretical and methodological foundation. Thermal comfort was monitored and evaluated in 9 (nine) internal environment residences with different building standards, especially in area coverage of socio-spatial vulnerability of São Luís from October to November 2012. To classify thermal comfort factors used in homes, reference indexes established by Thom and Bosen (1959) were used. In addition, to qualitatively evaluate the degree perception regarding thermal comfort of the population involved and the possible association with certain types of symptoms and diseases, 40 questionnaires were applied in each one of the three monitored areas seeking to investigate *in loco* if there was a relationship of prevalence of these symptoms due to constructive attributes of households.

Keywords: Thermodynamic system, Thermal comfort, Socio-spatial vulnerability, Health.

CONDIÇÕES DE CONFORTO TÉRMICO E RISCOS A SAÚDE DA POPULAÇÃO URBANA DE SÃO LUÍS (MA)

RESUMO: O objetivo desta pesquisa foi analisar como o clima, associada aos tipos de materiais construtivos em áreas de vulnerabilidade socioespacial compromete a saúde da população urbana do município de São Luís (MA). O trabalho se particulariza por relacionar o estudo do clima urbano e do conforto térmico às condições socioespaciais da população, pela interdisciplinaridade e pela utilização do Subsistema Termodinâmico para análise do Clima Urbano proposto por Monteiro (1976) como fundamento teórico-metodológico. Foram realizados monitoramento e avaliação do conforto térmico em ambiente interno de 9 (nove) residências com padrões construtivos diferentes, especialmente a cobertura, em áreas de vulnerabilidade socioespacial de São Luís, no período de outubro a novembro de 2012. Para classificar o fator conforto térmico nas residências utilizou-se como referência os índices estabelecidos por Thom e Bosen (1959). Além disso, para avaliar qualitativamente, o grau de percepção do conforto térmico da população envolvida e a possível associação com determinados tipos de sintomas e enfermidades recorreu-se à aplicação de 40 questionários em cada uma das 3 áreas monitoradas buscando investigar *in loco* se havia uma relação da prevalência desses sintomas em função de atributos construtivos das residências.

Palavras-chave: Sistema termodinâmico, Conforto térmico, Vulnerabilidade socioespacial, Saúde.

1. INTRODUCTION

Human health is strongly influenced by the weather. Thermal conditions involved in the dispersion (winds and pollution) and air humidity are an important influence on the manifestation of several diseases, human epidemics and endemics. A great part of these internal responses depends on human adaptability. However, under certain specific circumstances, “when certain impact thresholds are exceeded, personal reactions can occur associated to weather contrasting pathological conditions” (SETTE and RIBEIRO, 2011).

In addition, social conditions such as housing, feeding, urban infrastructure and access to health services are factors that increase the vulnerability of populations to extreme weather events, which added to the exposition to atmospheric pollutants, can present synergistic effects with aggravated clinical conditions. In areas with limited or no urban infrastructure, mainly developing countries, all these factors can harm the most vulnerable populations, increasing demand and expenses with health services.

Despite weather effects on human health being known since the beginning of the industrial revolution, only recently human bioclimatology studies have acquired a scientific character, including several morbidity and mobility studies due to extreme weather situations, particularly heat waves or heat islands formation.

The main evidence of this process is the increase in air temperature in the cities, which is being studied by urban climatology and has dragged the attention of experts and the society itself which today lives in urbanized environments. Thus, man is at the same time an author and actor of these changes – feeling the consequence of its own actions, once the external environment is becoming increasingly uncomfortable thermally.

This happens because urban areas act as poles that attract populations. Since socio-spatial segregation is a feature from general and, in particular, Brazilian capitalism, popular neighborhoods have been established in peripheral zones, in great part using inadequate construction material both from a life quality and thermal efficiency point of view. This urban territorial expansion is characterized by an increase of constructed and paved areas that generate thermal inertia and produce heat. Heat islands not only cause thermal discomfort in tropical weather climates but are also responsible for an increase in energy demand and for unhealthy urban environments which affect human health (SANT'ANNA NETO and AMORIM, 2008).

Thefore, the city generates its own climate, resulting on the interference between all factors that process under the urban threshold layer and act altering the weather on a local scale (AMORIM, 2010).

Among the elements that favor thermal variations, covers (roofs) are the most responsible for the heat produced inside and outside edifications. This heat is determined by albedo (reflectance) variables and material emissivity. Albedo represents a portion of the incident solar radiation that is reflected by the material, while emissivity determines the thermal performance, characterized by the superficial temperature.

Thus, surfaces with high albedo and emissivity tend to remain colder when exposed to solar radiation due to a smaller radiation absorption and higher emission of thermal radiation to space, transmitting less heat to its surroundings. On the contrary, the smaller the albedo and the higher the emissivity, the higher will be the heat absorption and its permanence in the surrounding environment.

In this way, certain urban space characteristics can cause particularly serious environmental problems to humans. Local climate changes in cities dramatically contribute to increase these problems, and they are expected to affect the human health somehow, which must always be considered in an integrated and multifaceted perspective (ALCOFORADO and ANDRADE, 2007).

This theme generates a series of questions that converge to reflections on urbanization (with its several specialties and distinctive socio-spatial articulations) and population's life quality, delineated by a new paradigm in which health is not only assured by the health sector, but is produced socially in relationships in social, cultural, economic and political dimensions, and must favor the creation of health-favorable environments.

In this sense, the present paper is the result of a PhD thesis which approached the relationship between urban climate, socio-spatial vulnerability and health, considering that thermal (dis)comfort caused by construction materials used in houses, associated to the production of an urban climate and socio-spatial vulnerability, which are factors that compromise São Luís city's urban population health.

2. MATERIAL AND METHODS

The present research on climate investigation was oriented by the theoretical-methodological proposal by Monteiro

(MONTEIRO, 1976), considering the Urban Climate System (UCS) approach.

In UCS, a thermodynamic subsystem stands out, which directly influences the thermal comfort levels, and might enhance the action of certain psychosocial diseases due to stress, fatigue, irritation and other causes, that can actually relate directly to the physical performance, due to the fatigue that temperature increases cause to people (ALEIXO et al., 2011).

In this research, thermal comfort studies involving temperature, humidity and air movement directly affecting people are considered. However, to study intraurban climate and the thermal comfort related to health conditions of São Luís urban population, an adaptation of the methods used in urban climatology was necessary.

Several field works were carried out in 9 (nine) selected houses (called P1, P2, P3, P4, P5, P6, P7, P8 e P9), during October, November, and December of 2012 using 4 (four) *KlimaLogger TFA* hydrometric thermal stations, with an external sensor. The smaller cloud coverage and the higher temperatures in São Luís were the reasons why the measurements were conducted during these months, thus enabling a better verification of the thermal inertia in the houses where stations were installed inside (preferentially in the living room). The stations captured and stored data on temperature and relative air humidity, and were fixed at approximately 1 (one) meter below the ceiling.

Stations were programmed to register temperature and humidity once every hour, adding up to 24 daily measurements encompassing all periods of a day (early morning, day, afternoon, and night). Field data from within the houses were compared to the daily data available from the *Instituto Nacional de Meteorologia* (INMET), used as parameters to evaluate the temperature and humidity difference between residences, and the thermal conditions of the external environment.

Based on the procedures developed by Viana (2013), temperature and humidity data obtained by the stations were organized and subsequently analyzed for effective temperature in an Excel spreadsheet developed by Tommaselli (2007).

After choosing the periods, data were re-organized in new spreadsheets and to it a color was attributed, varying from yellow to red, for the different classes or levels of thermal comfort established by the effective temperature of Thom and Bosen (1959), and applied as a method by Santos and Andrade (2008).

The methods proposed by Thom and Bosen (1959) consist on an Effective Temperature Index (TE) obtained through the first equation:

$$ET = 0.4\ (Ts + Tu) + 4.8 \qquad (01)$$

where ET = Effective Temperature; Ts = dry bulb temperature; and Tu = humid bulb temperature.

According to this index, ET's value between 18.9 ºC and 25.6 ºC comprise the comfort zone; ET values lower than 18.9ºC are considered cold stressful conditions; and values above 25.6 ºC are heat stressful conditions.

Another important step was the recognition of natural urban characteristics of the selected areas with the goal of elaborating a Soil Use Classification Map, highlighting the distribution of house cover (Figure 1). The methods proposed by Souza (2012), which carried out the classification of the urban soil cover using InterIMAGE, a software based on knowledge, and Carvalho (2011) and Ribeiro (2010), which treated images in WorldView-2 to classify urban soil cover using the image analysis approach based on geographical objects (GEOBIA), were used. WorldView-2 image quality and the image processing methods available allow the researcher to distinguish urban targets. However, there are situations in which tones and colors are not distinguishable. This demonstrates that there are some limitations, but those can be corrected by field observations.

In order to identify the degree of environmental perception of the investigated population regarding thermal comfort and discomfort in the area where they live, 40 (forty) questionnaires with direct and closed questions were applied in each of the selected areas without a probabilistic pretention. Hence, we assumed that the residents would be a more realistic source when compared to the data generated by thermic hydrological stations. In this sense, it is important to notice that it would be ideal to conduct the same interview several times, in order to obtain a better consistency on the data.

To select representative houses, a resemblance criterion relating to construction patterns of the 9 (nine) houses monitored for their microclimate in the 3 (three) selected areas, *Vila Cruzado*, *Salinas do Sacavém* and *Forquilha* was determined. Resemblance aspects are referred to habitation attributes in the material type of walls and ceilings.

Residence patterns are characterized in its majority by bricks and pottery or fibercement tiles, generally conjugated, without free space between one another, which hampers air flow and reduces the possibility of diminishing temperature in hot days through ventilation (Figure 2).

Figure 2. Construction patterns of brick houses P1, P2 and P3 in the *Vila Cruzado* neighborhood.

Understanding the vulnerability as a process that involves several social and environmental conditions, we see that different social groups are subject to a higher or smaller degree of problems affecting their routines. However, the city's inordinate growth causes the low income portion of the population to occupy risk areas. The socio-spatial segregation not only increases the risk of diseases, deaths, and economic losses, but also environmental problems.

Through the research "Intraurban environmental quality in São Luís-MA: indicators of sanitation and housing", Pereira (2014) used the methodology proposed by Rodrigues (2010); and conducted a comparative analysis in the inter-century period between 2000 and 2010 for two dimensions: sanitation and housing. With the multivariate analysis of the indicators and a cluster analysis of the census sectors, data obtained revealed the maintenance of intraurban inequality in São Luís for 10 years.

In the environmental quality evaluation of the researched areas the distribution conditions of sanitation services were evaluated considering the following dimensions: water supply, sewage collection network, and trash collection work. The sanitation dimension has always been used as an indicator of urban environmental quality, aiming at identifying the amount of houses attended and the quality of the service offered, which were considered as terrible in the sampled areas.

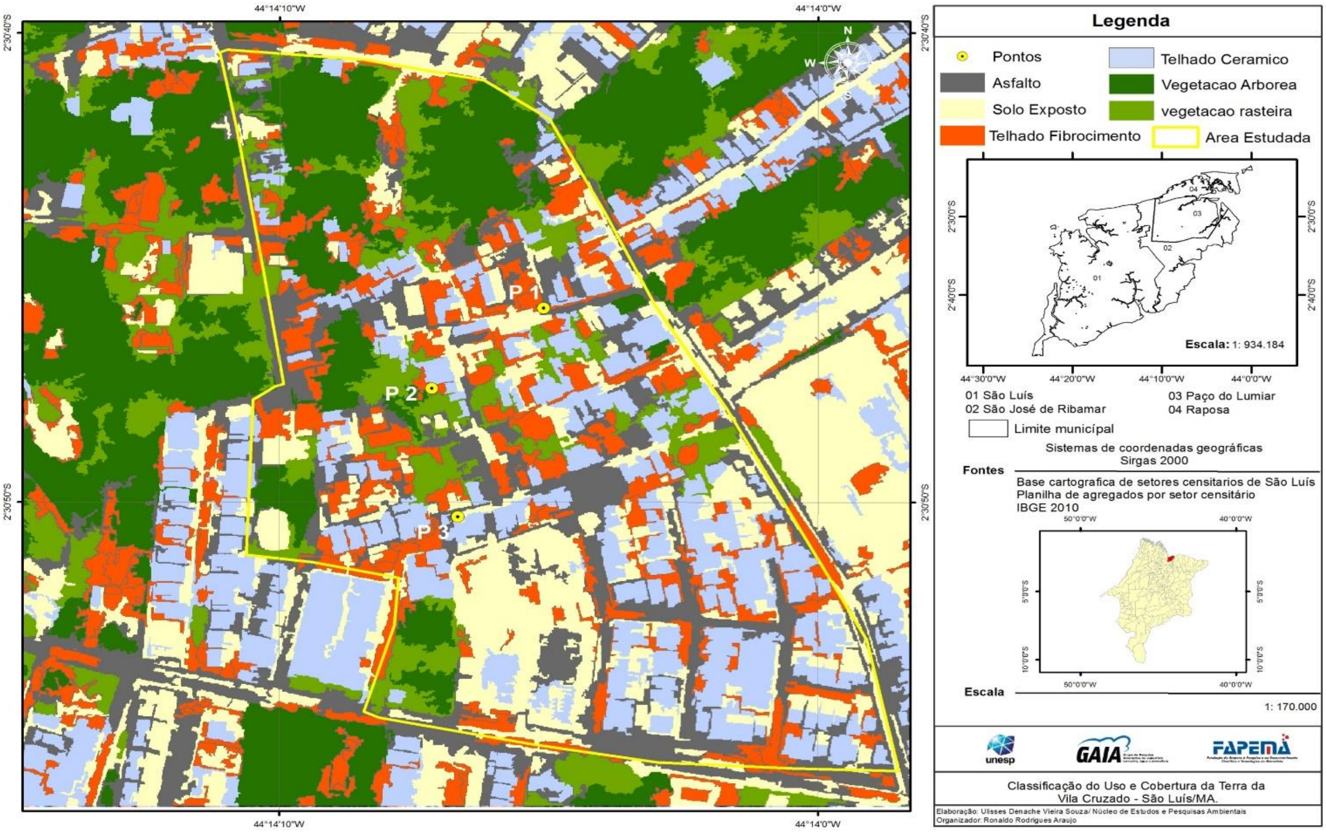

Figure 1. Soil cover and use classification of *Vila Cruzado* neighborhood with monitoring points. [Elaborated by Souza (2012) with maps of Maranhão state and Maranhão Island adapted from http://maps.google.com.br/]

3. RESULTS AND DISCUSSION

Monteiro and Mendonça (2003, p. 34) state that "thermal comfort comprises thermodynamic components which, in its relations, express through heat, ventilation and humidity in the basic references of this notion". It is a meaningful perceptive filter because it affects everybody permanently.

Constitutes, either in Medical Climatology or in housing technology, a subject of growing investigation and importance.

Thermal comfort can be analyzed in two ways: from the personal point of view, which considers individual comfort in certain environments; and from the environmental-climatic point of view, which proposes the establishment of a thermal state considering physical variables such as temperature, air humidity, radiation and wind. In this context, several authors proposed indexes to study more thoroughly the thermal comfort quantification.

Here we present a synthesis of the results obtained after analyses regarding thermal comfort in Vila Cruzado houses (P1, P2 and P3), Salinas do Sacavém (P4, P5, P6 and P7) and Forquilha (P8 and P9), without considering the differences in monitoring date to visualize, in a more general manner, the behavior in all residences (Figure 3).

A color was established for each thermal comfort class in order to perform a visual identification of the thermal comfort results presented for each house during the monitoring days. The same procedures will be used to present the results, but the analysis will be restricted only to the most expressive ones, in order to avoid repetition of frames that had strong resemblances regarding thermal comfort indexes for each residence.

Colors were also defined only for the results more similar to those of house thermal comfort. Thus, colors were used only in the 3^{rd}, 4^{th}, 5^{th}, and 6^{th} classes which had more present results, even though the residence results did not yield thermal comfort results.

Some results presented are established in 3^{rd} class (24£ TE < 29), which shows tha "half the population (in the case of residents) has a mild discomfort", confirming that none of the residences had satisfactory conditions on thermal comfort during the monitoring days and hours. This demonstrates that, from the architectural point of view, the cover types in these areas are not favorable to the thermal well-being of its residents.

Despite the already known higher thermal efficiency of pottery covers compared to fibercement, P8 building pattern "box style", which presents a low ceiling and little free passage for air circulation, compromises the household thermal quality.

It was also observed during the night and early morning that TE records in both houses represented values considered as in discomfort situation. This demonstrates a certain delay in the house internal heat dispersion caused by a high energy accumulation during the day, and the building characteristics that hinder the air exchange in its inside.

	P1	P2	P3 (1° floor)	P3 (2° floor)	P4	P5	P6	P7	P8	P9
	Ceramics	fibercement	Slab	Ceramics	Ceramics	fibercement	fibercement	Ceramics	Ceramics	fibercement
04:00	26,2	26,1	27,2	25,9	26,7	26,7	26,1	26,4	27,1	27,5
07:00	26,9	26,4	27,1	26,1	26,9	27,5	27,0	26,4	26,9	27,0
10:00	31,0	30,5	29,9	28,5	29,8	30,3	29,5	29,8	29,1	30,5
12:00	32,0	33,4	31,4	29,8	32,4	31,8	32,0	32,4	31,3	33,4
13:00	31,4	33,9	31,9	30,2	32,0	33,4	32,1	32,0	31,9	34,0
14:00	30,7	32,7	31,2	30,0	32,1	33,3	32,3	32,1	31,5	33,4
15:00	29,8	32,2	29,8	29,3	30,9	32,1	31,5	30,9	31,0	32,6
16:00	28,8	31,2	28,6	28,6	30,1	29,9	30,4	30,1	29,7	30,9
19:00	27,0	27,6	27,5	27,0	27,7	28,1	27,8	27,4	28,2	28,9
22:00	26,4	26,6	27,4	26,3	27,5	27,0	26,8	26,9	28,0	28,4
01:00	25,9	26,1	27,5	25,8	27,0	27,0	26,2	26,4	27,5	28,0
04:00	25,7	25,4	27,3	25,4	26,7	26,6	25,9	26,1	27,1	27,4
07:00	27,2	25,9	27,3	25,7	26,9	27,6	27,2	26,1	27,1	27,4
10:00	29,0	30,3	28,5	28,1	29,8	29,1	31,1	29,8	29,3	30,0
12:00	31,0	32,9	31,0	29,8	30,0	30,4	33,1	30,0	31,4	32,6
13:00	30,2	33,3	31,2	30,0	31,5	31,2	33,4	31,5	31,5	33,6
14:00	29,8	32,5	30,4	29,6	31,5	30,7	33,1	31,5	32,0	33,1
15:00	29,0	31,1	29,7	28,8	31,0	30,7	32,4	31,0	31,9	32,8
16:00	28,6	29,3	28,8	28,5	30,0	30,0	31,2	30,0	29,9	31,1
19:00	26,8	27,2	27,6	27,0	28,2	27,8	28,2	27,2	28,5	29,1
22:00	26,4	26,3	27,3	26,2	27,7	27,4	27,5	27,0	28,0	28,7
01:00	27,2	25,5	27,4	25,5	27,2	27,3	26,7	26,7	27,5	27,9

	50% of the population has a growing discomfort	24£ TE < 27
	Most has a relatively common discomfort and a meaningful deterioration of the psychophysical condition	27£ TE < 29
	All have a strong discomfort	29£ TE < 32
	Medical emergency state, a very strong discomfort	TE_32

Figure 3. Thermal comfort classes registered in the Vila Cruzado, Salinas do Sacavém and Forquilha residences.
Source: ARAUJO, R. R (2014)

According to Amorim (2010), this represents that the "higher heating in the urban environment is caused by the combination of the materials used in construction and the dark colors of the buildings and pavements which absorb and store more solar energy".

In this case, heat gains through external surfaces (walls and cover) and existing openings, as well as the insulation exposing and ventilation conditions are the main determining factors of the thermal performance in a residence. Thus, house construction has a great potential to incorporate bioclimatic strategies favoring a better exploitation of natural light and ventilation, as well as identifying the more adequate construction materials to adapt edifications to the climatic context in which they are inserted.

Evidently, when talking about low income populations from vulnerable areas, the possibility to build homes with characteristics that improve bioclimatic conditions within the house and the access to these alternatives is impaired by financial conditions, because other social needs are more important than home environmental quality for this population segment.

From the results presented above, it was possible to evaluate the existing relationships between climatic variables, building patterns of socio-spatial vulnerable areas and thermal comfort:

- Pottery covers present smaller TE values when compared to fibercement ones. The former presented the greater TE values and the larger thermal amplitude, and was also the one that registered the least adequate behavior regarding thermal comfort.

- Brick households with fibercement ceilings presented in general a higher thermal inertia when compared to brick and pottery ones. These results were mainly evidenced by P2, P6 and P9. The thermal performance differences between these households and the others are justified by fibercement tile quality, which have a smaller thermal isolation and absorbs more energy.

- During the monitoring period, TEs were classified as heat discomfort (from the moderate to the most critical health conditions) at all hours of the day. The period in which TE was highest in the houses corresponded mainly to the time between 10AM and 4PM. Even in the night period and during early mornings thermal discomfort situations were present.

- The Forquilha area and P9 were the ones that presented the greatest TE values and the largest number of classes to the strong thermal discomfort with medical emergency state. The greater impermeability associated to the intense flow in the circulatory pathway of people and vehicles in its surroundings contribute to the surface heating and the generation of anthropogenic heat irradiation in the area.

- According to the thermal comfort classification of Thom and Bosen (1959), the class that dominated the results obtained was the one in which all have a strong discomfort with TE ranging from 29º to 32ºC.

In the perspective of the perceptive studies comes the Environmental Perception study, which is being done by several authors with the concern of verifying, through man recognition, what is occurring in its surroundings, if one really has a conscience of reality. Once perception is known, the attention comes to environmental questions where Environmental Perception is found, and Sartori (2000, p. 35) says that it "must be understood as an answer of man as a whole to the stimuli present in the area one lives".

It is also known that urban structure influences certain personal behaviors; edification, gatherings, social disparities in urban space organization, lack of trees and other aspects affect men directly (since its participation in this organization), causing good or bad things and influencing in the way each individual lives. All this conditions the urban climate and affects the climatic perception of each individual.

The climatic perception has two focuses: one regarding time perception, observing knowledge about more rhythmic questions such as to how weather evolves through chronological time; the other concerning the psychophysiological perception, that is, each individual reacts in a different way to weather and climate changes. Thus, "men lives within two concentric spheres: the physical environment and internal world, which encompasses the immense psyche space" (SARTORI, 2000).

Real climate can also be different from the perceived climate or, in many cases, perception and reality differ, since Sartori (2000) highlights the fact that the perceived climate not always corresponds to the real, because several elder people declare that the currently more mild climate when compared to the past and, at the same time, it is normal for people to give their opinion about the weather.

In this way, with the goal of comparing results obtained in the field through thermal hydrological monitoring of the residences, 40 questionnaires were applied in each of the researched areas. The application was carried out in residences that were not monitored, but which presented the same constructive patterns of the monitored ones, especially if they presented a pottery and fibercement cover.

One of the questions aimed at understanding the thermal comfort perception, was about how one felt in the residence in the moment the questionnaire was applied. Its application in the residences occurred between 9 and 11 AM, when temperatures varied between 29 and 31 ºC.

The answer *too hot* appeared in all three areas, but the largest number of these answers were given in houses of fibercement cover, with more answers in Forquilha (4), followed by Vila Cruzado (3) and Salinas do Sacavém (2).

The second most common answer to the questionnaires was *hot*, which predominated also for the fibercement houses in Vila Cruzado (9) and Salinas do Sacavém (16). In this case, Forquilha was an exception in which this answer predominated in houses with pottery ceilings (13) when compared to fibercement (6). In the Salinas do Sacavém area this number was also representative, with 12 residents answering to be feeling hot when the questionnaire was applied.

Answers of *not too hot* were the less frequent, not going above 4. Forquilha was another exception in this case, where 8 residents with pottery ceilings gave this answer.

In the residences in which the ceiling has a pottery cover with lining (in this case with concrete slab), answers to these options were not common, and did not overcome 4 answers for the option *hot* (Forquilha) being the only type of cover that presented the answer *neutral* (Vila Cruzado) among all residences studied.

This result can be associated to the thermal inertia produced by this type of cover. The cover is the house portion that receives the greatest amount of sun radiation. This surface is subject to luminous radiation during almost the whole day. If the house has a slab, it acts as thermal insulation. At first, the greater the material mass, the more efficient the isolation is. Thus, a wall or a thicker cover will cause the heat to take longer to reach the house interior. Thin walls or covers have low thermal inertial and thus the heat quickly enters the construction.

As one can realize, there is a variation in perception of people regarding the given answers, although it was possible to notice that there is a small discomfort sensation that can be perceived in the residences with fibercement since the answers *too hot* and *hot* were more common in this kind of house.

When the residents were asked what was their thermal condition per type of cover , the answers that prevailed were *uncomfortable* and *very uncomfortable*, in all residences. The answer *comfortable* was given only twice, in

Vila Cruzado, in a pottery ceiling house with slab (1) and in a fibercement ceiling house (1).

The fact that a combination of *uncomfortable* and *very uncomfortable* was higher in fibercement residences of Vila Cruzado (with 10 answers) and in Salinas do Sacavém (with 15 answers) draws the attention. On the other hand, in Forquilha, this answer combination was more frequent for pottery cover houses (with 19 answers) than for fibercement covered houses, with no more than 8 answers.

Thermal discomfort perception was slightly more expressive in the fibercement residences, but the more expressive results in the pottery ceiling residences in Forquilha reinforce the anterior comments about the amount of houses built with this type of cover material and by its more evident capacity of generating anthropogenic heat due to the dimension of its constructed mass.

In this perspective, looking to know a little more about the health framework of the Vila Cruzado, Salinas do Sacavém and Forquilha residents, they were asked about which diseases are present among the interviewees, seeking to discover through their answers any kind of relationship between constructive patterns, thermal comfort and health.

The results obtained indicate that in all three areas cardiovascular (cardiac, hypertension, and pulmonary) diseases are present in all residence cover types.

Among those, we highlight hypertension which, combined with cardiac disease, was the most present group among the answers. Hypertension was present in Vila Cruzado (7), Forquilha (7), and Salinas do Sacavém (6), in the latter the condition was present only in residences with pottery ceilings. In the other areas there was no significant difference in the relationship between disease occurrence and residence type of cover.

Another case of disease present in the answers among all areas and age classes was allergy, linked to respiratory diseases. This result was expected, especially considering São Luís' climatic region, since it is characterized by a hot and humid climate during most of the year. In addition, being an island increases the air relative humidity always above 65% even in the dry season.

Lastly, residents were asked about what the types of symptoms were more often felt during the thermal discomfort periods in their houses. That is because these houses have several problems, such as structural, due to its reduced constructed area with extremely small rooms for the number of residents, as well as related to thermal comfort, in which their occupants are put in physiologically uncomfortable situations, generating health problems that directly impact their life quality. In these environments, during the intense insolation days, a great heat absorption occurs, accumulating in the houses and thus creating a thermal zone with temperatures that can go beyond 40ºC.

The more commonly cited symptom by the participants was *Irritation*, which combined with other symptoms (fatigue, headache, shortness of breath, dizziness, breathing with difficulty and high blood pressure) was always present among the answers given. It was more common in Salinas do Sacavém and Vila Cruzado houses with fibercement ceiling, in a total of 23 and 13 answers, respectively. Regarding pottery cover residences this combined answer was greater in Forquilha with 16 residents while only 9 answered positively in the fibercement homes. In houses with pottery ceiling and slab, no more than 5 positive answers for irritation were given.

This thermal stress situation easily occurs in tropical environments and is intensified by heat islands. People subjected to this situation for long periods, especially those who are part of a risk group such as elders, children, pregnant women, cardiac sensitive and asthma patients, can have problems, ranging from the simplest to the most serious. These include irritability, lack of focus, inappetence, dehydration, cramps, faints, heat exhaustion and even death (AMORIM, 2010, p. 74).

Questionnaire results here presented confirm what Oliver and Sant'Anna Neto (2010) identified while analyzing the relationship between thermal comfort and the direct impacts on population health. The authors used daily temperature and humidity data and correlated them with the cases of respiratory (respiratory morbidity) and coronary derivative diseases, stating that people exposed to low thermal comfort environmental conditions with great thermal amplitude and low air humidity were more subjected to health problems.

4. CONCLUSION

It is understood that climate and atmospheric weather implications on human health are still not well understood. In this sense, a considerable quantity of studies that evidence cyclical climatic changes influence on the biological rhythms, which in turn interfere in all human activities and functions, since humans show a dramatic individual variation in adaptability. This interferes in its greater or smaller sensitivity to the climate and weather, and thus, its comfort and health.

Therefore, the perceived approach adopted in this study demonstrated to be efficient to achieve the goals, because answers regarding the researched subject, represented by the interview questionnaire, revealed the participant's individual sensations and perceptions about thermal comfort conditions and human reactions to the temperature conditions that lead to well-being and/or thermal discomfort, considering the climatic factor's influences.

Without the intention of giving the reader a false idea that a determined vision about this relationship is being defined, factors influencing health are, in fact, diverse and varied, being able to develop in an individual scale or influencing an entire community. Some of the social factors that influence health states developed in an individual level, while others were established in a social level and so many others in both the individual and social levels, such as the environmental factors.

Even in an individual scale, factors influencing the health state are widely diverse ranging from everyday life, such as access to social services, or more structural aspects such as as family income. Factors related to income, employment, habitation conditions, access to basic services, like education and infrastructure supply for goods are determinant for health in the sense that they influence the well-being or the perceptive health conditions of the individuals or communities.

In this sense, health determinants are a result, at the same time, of individual and family characteristics (sex, age, income, and school degree), its life style and behaviors, and country's conditions (social, health, and education policies), which is tightly bound to place conditions (environmental quality, air, water, housing, work place, service and goods offers).

Furthermore, it was verified that São Luís' urban social stratification, strongly marked by dramatically uneven income, intensely characterizes the increase in vulnerability regarding thermal comfort of the economically less favored portion of the population. This segment is generally induced to establish residence in the least protected spaces and to use construction materials that do not favor any form of climate protection, mainly elevated areas, aggravating its already low life quality indices.

There is thus a relationship between social stratification in the urban space and thermal comfort conditions of the residents of socio-spatial vulnerable areas in the second semester climate conditions in São Luís. This period demonstrated to be the most critical considering the relationship between local climate and house construction materials, mainly the type of cover used. Hence, concerning the intraurban climate, the less favored classes effectively live in places and residences with more rigorous climate conditions, and have less resources to protect themselves of the climate variables.

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