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INDOOR AIR QUALITY AND HUMAN HEALTH

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ABSTRACT

Indoor air quality and the need for understanding the factors that contribute to its complexity, are an important area of public health. This paper presents a brief discussion on indoor air pollution as a risk factor to human health, introducing the main factors that contribute to indoor air quality and the possible agents that promote adverse effects on human health. The discussion shows that it is necessary to establish indicators that can become an effective tool in the detection, prevention and promotion of health in such environments.

Key words: Indoor air quality, Human health, Sick building syndrome, Building-related illness

INTRODUCTION

The impact of the quality of indoor air on the health and well-being of people that use or work in artificially climatized buildings has been the theme of research in the Public Health area since 1970 (WHO, 2000).

Modern, artificially climatized buildings, planned to offer the maximum comfort to their occupants, and often with bold architectural projects, may be creating an environment that is a threat to human health. Various studies have attributed the poor quality of indoor air to the high incidence of complaint reports relating to health and environmental discomfort received from the occupants of these places, as well as to the high level of absenteeism, mood changes, dissatisfaction and poor work performance (GIODA & NETO, 2003; HOJO *et al*., 2005).

Artificially climatized environments are considered to be complex environments, because of the infinite number of chemical (toxic, carcinogenic and radioactive substances) and biological (pathogenic micro-organisms) components, issued by various sources and which, depending on the physical conditions (air humidity, air temperature, inadequate ventilation) of the environment, may be interacting among themselves. Furthermore, various studies have shown that the air in closed environments may pollute more than the air outside (LEE *et al*., 2006).

Given the relevance of this subject and because there are few studies in Brazil in this important area of Public Health, the need to develop studies of indoor air quality within a multi-disciplinary context has arisen, with the aim of contributing to a better understanding of the issue and to outlining indicators that lead to an increase in the health and well-being of the occupants of such environments.

Therefore, because of the dimension and complexity of the subject, this text aims to establish the context within which indoor air pollution is a human health risk factor.

The epidemiology of artificially climatized environments

Because of the complexity of the composition of air in artificially climatized environments, the particular nature of the pollutants and the susceptibility of human beings to these pollutants, epidemiological studies have been indicated in the scientific field as an effective tool for detecting the first warning signs of poor indoor air quality.

According to the World Health Organization in 1982, the symptoms and signs reported by more that 20% of the occupants of artificially climatized environments, that may, or not, disappear when they leave the place, were classified as “sick building syndrome”. These unspecific symptoms and signs related to sick building syndrome involve, for example, headaches, dizziness, nausea, apathy, drowsiness, tiredness, weakness, difficulty in concentrating, urticaria, irritation and dryness of the skin, shortage of breath, chest noise, nasal catarrh, nose and throat irritation, a sore-throat, irritated, burning and watering eyes (WHO, 1983).

The researchers, Costa & Brickus (2000), using an epidemiological study involving an artificially climatized shopping mall, located in the Greater Rio de Janeiro Metropolitan area, showed evidence of a greater prevalence of symptoms and signs of “sick building syndrome” among those who work in the stores in this establishment, than among those working in stores that have natural ventilation. Of the 24 symptoms and signs they assessed, 17 of them (tired eyes, colds or flu, hoarseness, breathing difficulties, apathy or lack of enthusiasm, sore throats and headaches, etc) presented statistically significant differences between the two groups studied ($p<0,001$). The research also indicated that the report of complaints about environmental discomfort for the variables, lighting, relative air humidity and odors, was significantly greater among the occupants of artificially climatized environments. To understand the complexity of these artificial environments, researchers Costa & Brickus (2000) considered the different factors that may operate in the relationship between man and the environment and that interfere directly or indirectly in human health, such as those that are personal (age, gender, smoking habits); behavioral (stress, irritation, sadness, difficulty in concentrating); socio-economic (salary band); organizational (type of work); architectural (ventilation, refrigeration system) and environmental (chemical, physical and biological agents).

However, in order to associate certain closed environments with specific problems relative to the health of their occupants, in 1987, in addition to the “sick building

syndrome", a committee from the National Research Council proposed another name, i.e. "building-related illness" or "sick building" syndrome.

"Building-related illness" includes the report of symptoms and signs characteristic of exposure to certain chemical substances (for example, carbon monoxide, formaldehyde), as well as illnesses caused by the fungi, viruses and bacteria that can be identified inside buildings.

Reports of the symptoms and signs related to "building-related illness" indicate that frequently these do not disappear when the occupants leave the place and often they only affect some of its users. In this sense, in order to be successful in reducing these complaint reports it is necessary to identify and remove the source of exposure.

In 1998 the central library of the Oswaldo Cruz Foundation in Rio de Janeiro was mentioned as an example of a "sick building", where there was significant fungal contamination that spread because of the precarious nature of the maintenance of the central air-conditioning system, obliging the building to be closed for a long period of time (STRAUZ *et al*., 2001).

Given the above, we can see that poor indoor air quality plays an important role in causing damage to health. Taking into consideration this affirmation, there is no doubt that indoor air pollution is not only restricted to office buildings (ZURAIMI *et al*., 2006), but also includes non-industrial environments, as was seen in the studies carried out in residences (ALMEIDA, 2004), schools (RAMACHANDRAN *et al*., 2005), hospitals (LEUNG & CHAN, 2006), commercial centers (COSTA & BRICKUS, 2000), means of transport (LAU & CHAN, 2003) and airports (SILVEIRA *et al*., 2002).

Despite the countless pieces of research that have been done by European and North American researchers in this area, transposing data to the Brazilian reality is not an indicated course of action, because of the differences, such as those relating to climactic factors and the typical characteristics of customs and behaviors.

Due to this fact it would be interesting to carry out studies aimed at controlling the risk factors relating to indoor air pollutants and damage to health, using epidemiological studies and constructing indicators that allow for a broad vision of the health/environment relationship and that are focused entirely on the Brazilian reality.

These procedures would undoubtedly not exhaust the raft of research alternatives into these environments, although they could produce knowledge and lead to the development of new approaches to the problem, thereby contributing to the preservation of the health of the occupants of these places.

Possible sources of pollution and damage to health

In industrial environments the chemical components used as raw materials, the sub-products and the final product are known "*a priori*" and therefore their pollutants can be identified, the damage to health arising from them can be demonstrated and possible prevention measures can be indicated.

In artificially climatized, non-industrial environments, countless sources of contamination can be found that contribute to the formation of the poor indoor air quality and that may be due to inadequate ventilation, interior contamination (cigarette smoke, bodily effluents, chemical emissions from furniture, cleaning equipment and materials, curtains, carpets), exterior contamination (air quality, vehicles, industrial emissions), micro-biological contamination (bacteria, fungi) or construction material.

We need to emphasize that the probability of multiple exposure, due to the emission of these substances into the indoor air of artificially climatized environments, is very great. It is also known that, depending on the dynamic of the pollutants and the physical parameters present in these environments, different toxic effects (independent, additive, synergic, potentialized and antagonistic) on man may be witnessed. The possibility of synergic effects arising from exposure to low concentrations has been pointed out in literature (HOGUE, 2000).

On the other hand, uncertainties as to the potential for damage to health in relation to low levels of pollutants in indoor air and the exposure time to the same, principally carcinogenic and mutagenic substances, point to the relevance of studies involving the quality of indoor air (BRICKUS *et al*., 2001; COSTA & COSTA, 2002).

Therefore, damage to health arising from indoor air pollution may manifest itself in the organism immediately after exposure, or possibly years after, as in the case of carcinogens. It is worth pointing out also that a person may become susceptible to a certain pollutant after repeated exposure.

Mapping the pollutants commonly found in the air in closed environments that constitute health risk factors has revealed the presence of formaldehyde, cigarette smoke, ozone, carbon monoxide, carbon dioxide, nitrogen dioxide, ammonia, radon, volatile organic compounds (benzene, toluene, xylene, styrene, ethylbenzene, perchloroethylene??) and semi-volatile compounds, breathable particulate material, fibers, asbestos, fungi, viruses, bacteria and mites.

Among the 500 volatile organic compounds normally identified in indoor air, at least 30 of these substances are carcinogenic and mutagenic (COSTA & COSTA, 2005). In the population in general cigarette smoke, due to the presence of their more than 4,000 pollutants (of which 50 are proved to cause cancer), is considered one of the main sources of non-occupational exposure to benzene (COSTA *et al*., 2002).

Furthermore, the presence of high levels of volatile organic compounds in indoor air in comparison with outdoor air, alerts us to the fact that the issue of air quality in these artificial micro-climates is just as important as the issue of atmospheric pollution (KOTZIAS, 2005).

The health risks associated with exposure to biological contaminants, like bacteria, fungi and mites in closed environments, particularly for people who are allergic and/or have a weakened immunological system, are frequently emphasized in literature (BRICKUS *et al*., 2004), as occurred in 1977, arising from the *Legionella pneumophila* bacteria, which causes one the most serious types of pneumonia that has a high mortality rate (BRICKUS *et al*., 2001).

The lack of a preventive policy in the maintenance programs in refrigeration and ventilation systems may be a deciding factor when it comes to the occurrence of biological pollutants (pathogenic micro-organisms) in the system ducts, and may consequently constitute a threat to the health of the occupants. Biological agents may proliferate in the water in the condensation tray of air-conditioning equipment or in the refrigeration towers of ventilation systems and, are introduced into the refrigerated environment via the air.

Given this picture, environmental discomfort and the reports of complaints relative to health, arising from the poor quality of indoor air cannot be identified, minimized and controlled adequately without the appropriate use of a methodology that takes into account the complexity of all the factors involved. Therefore, assessing the issue from an inter-

disciplinary focus will undoubtedly contribute to a better understanding of the problem, leading to a reflection on the need for investigations involving health risk identification, the mapping and control of the probable sources of pollution and the gathering of information about possible pollutants.

Future prospects

In their search for alternatives for ecological and over-population problems many architects have been proposing possible solutions involving audacious projects, where mega-buildings or vertical cities would be interlinked by corridors of steel, glass and concrete. So, in the future it is estimated that a person will pass the whole of his or her life living, studying, practicing sport, shopping, working and enjoying leisure time in these artificially climatized environments.

Currently in Brazil the subject of indoor air quality is still an emerging field of study. Despite growing interest in the media, the country's scientific centers and even on the part of government we have few pieces of research involving indoor air quality or legislation on artificial micro-climates.

Additional studies are necessary, with the aim of improving the quality of life of the occupants of these environments, particularly when it comes to questioning the need for a value limit (as a point of reference) proposal for non-occupational environments for some of the pollutants present in indoor air, especially the carcinogens and mutagens. This is because industrial standards, like the Tolerance Limits introduced in the Regulatory Norms from the Occupational Health and Safety Department of the Ministry of Labor, do not apply to these non-industrial environments.

It is true that we already have Regulations published by the Ministry of Health / National Sanitary Watch Agency like Ordinance 3,523 (BRAZIL, 1998), that introduced criteria and procedures for cleaning and maintaining climate-control systems, and Resolution 9 (BRAZIL, 2003), which established the Standards of Reference for Indoor Air Quality in artificially climate-controlled environments, destined for public collective use. Despite the relevance of this resolution essential parameters in the establishment of health risk control measures, such as those relating to volatile organic compounds and formaldehydes, were not considered, only a few of the indicators (particulate material, carbon dioxide, temperature and a few others).

We must also emphasize the importance of investing more in health education, as an effective instrument in the process of making people aware and in the constant fight to try and reduce the damage to health arising from risk factors generated by exposure to pollutants in indoor air.

Issues relating to indoor air quality should not be treated in a linear fashion and solved using simple mathematical equations. The involvement of different actors in society is necessary, as is the involvement of the public health services, based on recognition of its uncertainty, given the complexity and relevance of the subject, in order for them to be able to contribute to the assessment and management of the complex interactions of man with his technology and environment in which he lives.

In this sense it is necessary to intensify the efforts for developing methodologies, relative to the deciding and conditioning factors of indoor air pollutants that interfere in human health, that can create effective Public Health tools, thereby contributing to the preparation of policies that focus on indoor air quality, as well as to the establishment of programs for controlling and preventing damage to the health of the occupants of these environments.

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