Healthy housing and biosafety: strategies of analysis of the risk factors present in built environments

Habitação saudável e biossegurança: estratégias de análise dos fatores de risco em ambientes construídos

Simone Cynamon Cohen[1], Telma Abdalla de Oliveira Cardoso[1], Marli Brito Moreira de Albuquerque Navarro[1], Débora Cynamon Kligerman[1]

DOI: 10.1590/0103-1104201912317

ABSTRACT This article aims to discuss the strategies offered by reflective fields and actions proposed by the studies on healthy housing and biosafety, noting them as tools that can be applied in diagnostics of environments built for the analysis of risk factors, on aspects related to environmental quality. As a methodology, we opted for the first exploratory research to discuss the healthy housing and biosecurity as analytical brackets to point out existing risk factors in built environments, based on the field research carried out in irregular human settlements. Then, bibliographical research was used to achieve the theoretical-conceptual deepening implied in the formulations of strategies pertinent to the two fields. As results were observed between both interfaces and found to complement each other and can contribute to the realization of a checklist in built environments, identifying internal and external factors, in order to promote safety and quality. To clarify the understanding of the data analyzed, we identified which were the fundamental conditions for healthy and safe built environments. Conclusively, the relevance of transformative actions that are capable of guiding a checklist in built environments was highlighted.

KEYWORDS Housing. Environmental health. Containment of biohazards. Risk. Quality management.

RESUMO *Este artigo objetivou discutir as estratégias proporcionadas pelos campos reflexivos e das ações propostas pelos estudos sobre habitação saudável e biossegurança, observando-as enquanto ferramentas que podem ser aplicáveis em diagnósticos de ambientes construídos para análise dos fatores de risco, sobre aspectos correlatos à qualidade ambiental. Como metodologia, optou-se, inicialmente, pela pesquisa exploratória para discutir a habitação saudável e a biossegurança como suportes analíticos para apontar fatores de risco existentes em ambientes construídos, tendo como base as pesquisas de campo realizadas em assentamentos humanos irregulares. Em seguida, utilizou-se a pesquisa bibliográfica para o alcance do aprofundamento teórico-conceitual implícito nas formulações de estratégias pertinentes aos dois campos. Como resultados, observaram-se as interfaces entre ambos e verificou-se que se complementam e podem contribuir para a realização de um* checklist *em ambientes construídos, identificando fatores internos e externos, no sentido de promover, sobretudo, a segurança e a qualidade. Para tornar mais clara a compreensão dos dados analisados, identificaram-se quais eram as condições fundamentais para ambientes construídos saudáveis e seguros. Conclusivamente, destacou-se a relevância das ações transformadoras capazes de orientar um* checklist *em ambientes construídos.*

PALAVRAS-CHAVE *Habitação. Saúde ambiental. Contenção de riscos biológicos. Risco. Gestão de qualidade.*

[1] Fundação Oswaldo Cruz (Fiocruz), Escola Nacional de Saúde Pública Sergio Arouca (Ensp) – Rio de Janeiro (RJ), Brasil.
simoneccohen@gmail.com

Introduction

The article presents the strategies formulated by the fields of healthy housing and biosafety as tools that are applicable as analytical support for building projects.

Biosafety involves a set of actions in prevention, control, reduction, and elimination of risks that can impact human, animal, and environmental health.

The healthy housing strategy assesses the existing risks in the indoor and outdoor environment that can compromise human and environmental health. Both strategies thus aim to guarantee safe, healthy, quality environments.

The choice of the healthy housing and biosafety fields is due to the fact that the two share the need for a checklist to monitor indoor and outdoor risk factors in the built environment that impact human and environmental health, in order to establish the necessary short, medium, and long-term interventions according to the risks' level of severity.

The first step is to identify existing risk factors in spaces, in order to proceed to environmental upgrading for preservation and protection and make the spaces healthier and safer.

Pertinent data on the physical environment are thus collected step by step with a participatory approach, essential for planning the environment to be built, having met the definition of physical space and addressing the real needs, thereby making the project more sustainable.

The article thus aims to discuss the strategies provided by the theoretical fields and actions proposed by studies on healthy housing and biosafety as analytical support for identifying risk factors in built environments, to back professionals participating in the elaboration of the architectural project, demonstrating the importance of applicability to diagnoses of built environments for the analysis of manifest or latent risk factors (aspects related to environmental quality and safety).

The methodology began with an exploratory study to discuss healthy housing and biosafety as analytical support for identifying existing risk factors in built environments, including the environment and healthy surroundings, biosafety, risk, quality, and health. The article's configuration thus begins with the theme of built environments and healthy housing. It then addresses the field of biosafety, followed by tracing the interface between healthy housing and biosafety as a strategy for analyzing built environments.

Built environments and healthy housing

The formulation, implementation, and assessment of social-interest housing policies, programs, and projects as strategies for health promotion in informal human settlements should be based on reflection and the theoretical and conceptual debate on the healthy housing methodology and how this initiative can help attain acceptable housing standards with quality and safety. Thus, the use of real scenarios and professionals' commitment to linking and integrating with communities' and organized social movements' priorities can lead to effective health promotion in housing initiatives[1,2]. It is thus essential to reflect on the relationship between housing, health, and the environment to promote healthy public policies and supportive environments for health in order to achieve steady improvement in the population's quality of life. Understanding the relationship between housing and health is also essential for understanding housing as a social determinant of health. It is therefore crucial to achieve a more in-depth understanding of housing and health as a healthy public policy.

Healthy public policies appear in the Adelaide Recommendations[2] as instruments for equity and commitments to the impact of such policies on the population's health, by which it is possible to balance the

State's capacity to respond to the population's demands and help address situations of social exclusion.

The Sundsvall Statement[3] approaches healthy environments by incorporating the physical dimension (water, sewage disposal, household and industrial solid waste disposal, urban storm drainage, vector control, and protection of the air, soil, rivers, lakes, and oceans) and the social, political, economic, and cultural dimensions. Thus, for the built environment to be considered healthy, it is necessary to identify the interdependence with other sectors in the process of environmental conservation and protection. This requires progress in knowledge on health and its contribution to the healthy housing approach, making housing a space for maintenance of the residents' health.

Housing is considered one of the spaces in which individuals live and interact throughout life, alongside school, workplace, hospital, community, neighborhood, city, and country, among others. It is not only the physical space, but also the sociocultural, technical-sanitary, and psychological space that should have the proper quality to be inhabitable. The fundamental requirements for healthy housing with the promotion and protection of human health are a balanced relationship with the neighborhood, the functionality of each indoor space, spatial flexibility, infrastructure of basic services and equipment, rational spatial solutions, building quality and durability, safety (defined as a physical, social, and health factor), and urban inhabitability and that of the housing unit, where a dwelling's final configuration is expressed by each room's spatial form and the space's accessibility[4-6].

Biosafety

The foundations of biosafety as a field of knowledge are marked by the construction of complex meanings associated with technological and scientific processes, providing analytical support for the management of multicausal factors linked to risks in built environments. Biosafety principles have started to be incorporated, modifying spatial concepts, finishing materials, furnishings, treatment, air turnover, and pressure differentials to minimize potential environmental risks, requiring a collaborative effort by the professionals involved in order for the architectural project to establish standards and norms that ensure environmental quality and meet the necessary safety conditions[7]. However, the innovative dimension of biosafety is still limited to the building project's solutions for the physical structure devoted to workspaces. Meanwhile, the numerous variables that can reveal the cause-and-effect relationship between environmental conditions and the types of injury to the health of the occupants and the environment have been questioned in other areas such as that of housing.

A WHO report[8] on the relationship between health and housing lists six principles that express and reinforce the importance of the relationship between healthy housing and biosafety as a strategy for environmental risk analysis, combining knowledge on sanitation targeted to the prevention and control of biological, chemical, sanitary, physical, and socioenvironmental risks in the micro space of housing and the peridomicile[2,5,9]. Yet biosafety's history in Brazil has also involved social and environmental concerns focused on unveiling and controlling risks that scientific work can pose for the environment and life[10].

The first WHO principle involves protection against exposure to etiological agents and vectors of infectious-contagious diseases. This principle calls for adequate space for the number of inhabitants, adequate supply of drinking water, and access to sewage and solid waste disposal systems to reduce disease transmission, especially gastrointestinal diseases and dengue, chikungunya, and Zika, in addition to reducing the proliferation of insects and rodents[9]. The design, structural characteristics, and preservation and maintenance of housing structures can affect the protection from diseases. Packed-earth floors favor the reproduction and nidification of disease vectors. Lack of adequate ventilation (via proper placement of doors and windows) is reason for concern, because it also affects protection against transmissible diseases. Overcrowding, especially when associated with poverty and inadequate installations, is related to the transmission of tuberculosis, pneumonias, bronchitis, and gastrointestinal infections.

According to the second principle, housing units should provide protection against avoidable harms, poisoning, extreme temperatures, risks of natural disasters, noise, and other exposures that can contribute to chronic diseases[9].

Special attention should be given to structural aspects such as location in order to prevent risks from noise, extreme temperatures, pollution, flooding, and landslides. Furnishings and building and finishing materials are important items for maintaining safe, comfortable, and ventilated environments free of hazardous chemical substances, insects, and rodents.

The third principle relates to mental health, highlighting the importance of adequate housing for individuals' social and psychological development. Housing should minimize stress as much as possible. Housing must be a safe refuge, without stressful factors such as and noise and heat, equipped and furnished to provide an environment that allows establishing personal and social interaction, besides comfort, privacy, warmth, and safety for its inhabitants. Housing that serves these purposes reinforces mental health[9].

According to the fourth principle, adequate housing environments should provide access to workplaces and the necessary social services for health promotion and safety[9].

The fifth principle emphasizes the adequate use of housing for health promotion. It is necessary for the housing structure to be maintained in order defend against risks. Likewise, land-use planning cannot guarantee a neighborhood's healthy qualities if the residents are negligent with environmental preservation, failing to take measures against potential environmental damage[9].

The last principle relates to the protection of special populations. Housing units should minimize risks to the health of these groups, including women and children, refugees, immigrants, the elderly, persons with special needs, and persons with chronic illnesses[9].

Healthy housing and biosafety as strategy for the analysis of built spaces

Various risk factors are observed inside residential spaces. Physical risks in housing (radiation, ventilation, noise, vibration, lighting, insolation) are phenomena qualified by the types of energy by which they are manifested, namely mechanical, thermodynamic, sound, electrical, and nuclear. Chemical risks are categorized by the types of effects and harms from the most significant chemical products and their processes of environmental contamination. Ergonomic risks involve inadequate posture, monotony, repetitiveness, intense physical effort, and lifting and carrying weights. Psychosocial risks are intrinsically related to the social context to which the housing unit belongs and the prevailing external factors, such as violence, that cause physical or psychological stress. Biological risks involve biological agents in the environment, such as fungi, bacteria, viruses, and vectors, among others. There are also risk factors leading to accidents, such as the use of faulty tools, electric overload, fire hazards, and inadequate physical arrangements. Sanitary risks pertain to the public water supply reaching the unit's interior, the sewage drains leaving the unit and connecting to the public sewage mains, solid waste disposal, and storm drains and utility holes along the roadways close to the housing units. Socioeconomic risks are closely related to the family's purchasing power and issues of income, employment, and level of schooling, among others[2,7]. The physical space should thus ensure the compatibility of the elements related to the construction and the methods employed to maintain environmental quality, aimed at reducing or eliminating the occurrence of adverse effects from the causal agents of environmental imbalances or risks that can impact health or the environment. Environmental risk control analysis is thus crucial in the construction of housing units, targeted to planning safer and more environmentally sustainable spaces, balancing the project's requirements and biosafety aspects[11].

In the architectural planning and programming phases, building aspects such as location, typology, structure, building networks, and other systems should be related to the spatial needs of flexibility, safety, containment, maintenance, care, surveillance, environmental quality, and monitoring.

Importantly, the strategy of healthy housing and biosafety relates to the planning and project moment, survey of safety conditions pertaining to the choice of the building's location, physical size of the built environment, and the criteria for its spatial and functional organization. The elaboration of construction projects requires observance of the requirements set by federal laws and other pertinent provisions, including state health, sanitation, and environmental regulations and the respective municipal building codes. The strategy involves the following criteria[5,7,11-13]:

1. Location of the building

The choice of location should observe the terrain's geomorphology, assessing the risk of landslides, flooding, and soil erosion; sources of noise and vibration; sunlight; sources of pollution; available infrastructure such as running water, electricity, sewage disposal, etc.

Location is also heavily related to interactions with existing buildings and social integration, incorporating factors for equilibrium with the neighborhood, setting limits for each resident; accessibility, regardless of the resident's age bracket and physical condition; urban mobility where inhabitants have access to the existing means of transportation, networks of social interaction and survival, such as supermarkets, restaurants, bars, clothing stores, schools, and daycare centers, churches, areas for sports and leisure, healthcare networks, and other services.

2. Definition of the building unit's size

The construction's size is directly related to spatial needs to meet the minimum requirements for the individual's housing, that is, each room's spatial form and use. The size should consider each space's functionality with the human needs (cooking, studying, resting, etc.), considering furniture, persons, and space for circulation; besides environmental requirements of flexibility, due to the possibility of expansion and transformation to meet other future demands. It is thus a difficult task.

3. Functional organization

Housing is obviously a different environment from workplaces, requiring adequate building materials and equipment for the residents, regardless of age bracket and physical condition, and characteristics of flexibility and communication, in order to promote social interaction through pleasant environments. Each built environment (housing, schools, hospitals, factories, commerce, public squares) is incorporated by spaces according to its functions and organization.

4. Architectural characteristics

Carvalho and Tavares[14] show that the use of modular building design favors the project's process, since it defines parameters for the measures applicable to the components and to the project as a whole, meanwhile ensuring flexibility in the combination of measurements and ease of production; its allows the use of building components with few local adaptations and without the need for changes in the project for the construction work, avoiding expenses and waste of time; multiple use of designed spaces and ease in subsequent renovations, additions, maintenance, and adaptations in general.

Modular design is more common in construction projects that require a rapid and rationalized building method, as in the case of housing projects and schools.

The basic module has a preestablished length and width that can vary according to the necessary standards for the equipment, circulation, and other building areas.

The establishment of the basic module's dimensions should allow the module's divisibility into smaller units; the size of internal circulation, furniture, and equipment; the location of the building networks for electricity, water, natural gas, and other engineering systems; characteristics of the proposed or existing building and finishing materials; and other elements that can affect the housing space.

5. Building and environmental characteristics

The housing unit's building characteristics and materials should provide adequately salubrious conditions for its users, preventing the entry of insects and rodents, besides acceptable levels of particulate matter in suspension from constructions and renovations, toxic gases from intense motor vehicle traffic and other environment pollutants from outdoor environments, aerosols and dusts present in the furniture and equipment, and infectious agents, among others.

Observation of the criteria related to the housing's environmental characteristics is important to provide the unit with environmental comfort, that is, shaping the built environment according to human use, respecting both the technical conditions such as ventilation and/or sunlight as well as the acoustic and visual characteristics.

These characteristics pertain to the building and finishing model, including the foundation, slabs, beams, and pillars; doors and windows; materials used in the walls, floor, and ceiling; and circulation (stairways, corridors, ramps, and elevators).

Roofing, façades, and windows should be impenetrable to dust and aerodispersoids such that their concentration does not exceed that in the outdoor environment.

The roofing and awnings cannot have parts that come loose or shift under their own weight or from the wind and other accidental loads. Roofing with metal parts should be grounded in order to offload electric charges and dissipate electrostatic charges that can accumulate on the tiles from friction with the wind.

The walls, floors, and ceilings should be made of materials that do not favor the retention of humidity and the proliferation of biological agents such as fungi.

Floors should not have irregularities that can cause occupants to trip and fall. The joints should not exceed 4 mm, except in the case of moving joints in outdoor environments. The floors should be as flat as possible, with a smooth decline towards the drains. They should favor the accumulation of water that would facilitate the development of mosquito larvae. The decline should be a maximum of 2% in showers and outdoor flooring and 1% in the other areas. If there are irregularities greater than 5 mm, there should be a signage system to guarantee their visibility, for example changes of color and signage strips[15].

The construction should comply with the users' requirements for thermal and acoustic comfort.

a) Thermal comfort is a factor that impacts people's performance of their normal activities in the housing unit.

The feeling of thermal comfort depends greatly on the conditions of ventilation in the environments, with major influence from the position and size of the window openings, but also directly related to the building's thermal performance, in addition to impacting energy consumption via the use of electric ventilation or climatization systems.

Thermal performance depends on various characteristics: the building's location (topography, temperature, and relative humidity, sunlight, wind direction and speed, etc.) and the building itself (thermal properties of the materials in the façades and roofing, number of floors, size of rooms, ceiling height, orientation of the façades, opening and types of doors and windows, among others).

The degree of absorbance of solar radiation on the surfaces exposed to weather conditions can be determined by the choice of the color and characteristics of outer surfaces on the roof and exposed walls, as provided in the project.

The dimensions of the openings in the doors and windows should allow sunlight to reach the indoors, ventilation, and air turnover in the rooms. An appropriate distance between buildings and between the buildings and containment walls, walls, and other obstacles is essential to guarantee adequate ventilation and natural light.

The Brazilian Association of Technical Standards (ABNT)[16] has a standard, NBR 15575-1, setting a ventilation rate (in the summer) of five air turnovers per hour in the room (5.0 turnovers/hour – window completely open) with unshaded windows; or with protection on the window (Persian blinds, curtains, or the equivalent) that provide shade against at least 50% of the sunlight, for a joint air turnover rate of 1.0 turnover/hour.

b) Acoustic comfort is essential for achieving physical and psychological wellbeing for a building's users. Acoustic discomfort can decrease individuals' concentration and productivity and increase their blood pressure and irritability. Acoustic comfort or discomfort is related to external noise (neighbors, street, vehicles) and internal noise (from some rooms clashing with others). Brazilian Standard 10152 of the ABNT and Regulating Standard NR[17] of the Ministry of Labor and Employment set parameters for acoustic comfort in various types of built environments. For example, in activities that require concentration, the ideal level is less than 45 decibels (dB). The maximum acceptable noise for acoustic comfort is 65dB; levels above this may cause adverse effects and even deafness in the inhabitants[17,18].

The outdoor and indoor characteristics of the built environment are responsible for the acoustic quality of the resulting space. Factors such as shape, dimensions, volume, finishing, and sealing materials determine the sound that individuals perceive.

Initially, noise sources should be identified, since they orient the mitigation measures to be taken. There are sources of noise outside the building (vehicle traffic, factories, sports stadiums, and others) and indoor sources (appliances, equipment, recreational areas, and others).

The materials most frequently used on the outside of buildings, such as concrete, ceramic tiles, stone, and asphalt, do not have a good sound absorption coefficient. The presence of plants has a significant effect on the sound ambience in outdoor spaces, based on the absorption, diffusion, and masking of noises.

Partitioning of indoor housing spaces helps control noise. The inner walls of the façade closest to vehicle traffic are used for the least sensitive spaces (entries, hallways, stairways), with the most noise-sensitive environments (bedrooms, offices) located near the more protected façades. Service areas and kitchens should be located away from the bedrooms, and if this is not possible, the project should avoid placing water and sewage pipes in the dividing walls.

Wall thickness is also a determinant for decreasing noise. A brick and mortar wall (mean thickness of 15 cm) insulates approximately 35 dB, and a concrete slab insulates about 45dB. This can also be done with composite walls, that is, the use of a rigid panel on absorbent material (soundproofing), but this increases the project's cost.

The presence of slits in the roofing and façades substantially alters acoustic performance, and even small cracks can reduce the acoustic insulation by more than 30%.

Window and door frames are one of the façade's weak spots, since they are usually made out of light materials and almost always have elements with openings (Venetians, gratings), besides the difficulty in grouting the cracks between the masonry and the frame and sealing between the frame and the moving slats. PVC frames with double-pane glass reduce the passage of vibration.

6. Infrastructure

Housing units should be furnished with hydraulic, sanitary, electric, electronic, and natural gas distribution installations. It is essential to have technical manuals covering all the information on the installations.

a) Hydraulic and sanitary installations include the building systems for sewage disposal, supply of hot and cold water, rainwater drainage, and collection and disposal of solid waste. Each of these systems has a series of standards that regulate both the project design and specifications on materials, equipment, and executive procedures. These are defined in projects according to safety standards, complying with national technical standards to facilitate the system's safety, performance, cost-effectiveness, operation, and maintenance, as well as flexibility in future modifications. The project should include a descriptive memorial to orient and complement the specific project, to ensure a better understanding and comprehension of how the installations will be designed. The choice of materials and equipment and the marks, models, and types are related to the technical specifications and cannot be altered without prior justification of the criteria for modification, since they have building characteristics and standards, manufacturing standards, and operations and performance tests.

The hydraulic and sanitary installations must comply with the standards of the Brazilian Association of Technical Standards (ABNT): NBR-10844: 'Building installations for rainwater'; NBR-8160: 'Building systems for sewage disposal, project and execution'; NBR-5626: 'Building installations for cold water'; NBR-7198: 'Project and execution of building installations for hot water'; and NBR-6493: 'Use of colors for the identification of pipes'.

b) Electric and electronic installations. The electric system should be designed in any built environment, with details on the positioning of electric conduits and appliances in order to ensure greater safety, reliability, and quality. According to McPartland et al.[19], the system should be divided into three basic stages: (1) selection of basic concepts in electric installations and configurations that will provide the supply of electricity, with the desired characteristics for each point of use; (2) identification of the planned circuits with the conduits, appliances, and accessories, choosing the respective types, sizes, models, characteristics, nominal values, and other necessary specifications; and (3) project for the overall electric system, showing the location of the appliances, respective assembly details, electricity ducts, connections to the main feeder lines, and any other elements that require special attention. It is essential to consider aspects of flexibility, accessibility, reliability, and safety[19].

c) Natural gas installations. Natural gas is a mixture of light hydrocarbons, like methane, which remains in the gaseous state at room temperature and atmospheric pressure. Natural gas installations must comply with the standards in ABNT NBR 13933: 'Natural Gas (NG) installations: project and execution', which applies to buildings and construction projects in general, under execution or subject to renovation or reconstruction, or those submitted to minor renovations or repairs. It is used in Liquid Petroleum Gas (LPG) installations and in buildings that use fuel gas for industrial purposes, which in turn have other specific standards according to each installation's peculiarities.

Final considerations

The link between biosafety and healthy housing showed that they are complementary and joint strategies that contribute to a more holistic view of the built space and help increase the quality and safety of a building's inhabitability, as factors for healthiness, minimizing internal and external risks.

Therefore, the environment, housing, and health should not be treated as independent, since they require transdisciplinary visions, considering not only the physical, health, and geographic harms but also sociocultural, economic, political, and organizational factors pertaining to healthy and safe human development.

Understanding the interface between healthy housing and biosafety is an essential basis for healthy public policies and for promoting supportive environments for health, prioritizing risk analysis as the object of study to build safer environments for life that value environmental quality and wellbeing.

Collaborators

Cohen SC (0000-0001-6228-6583)*, Cardoso TAO (0000-0002-5430-7273)*, Navarro MBMA (0000-0003-4408-574X)* and Kligerman DC (0000-0002-7455-7931)* have contributed equally to the development of the manuscript. ■

*Orcid (Open Researcher and Contributor ID).

References

1. Cohen SC, Bodstein R, Kligerman DC, et al. Habitação saudável e ambientes favoráveis à saúde como estratégia de promoção da saúde. Ciênc. Saúde Colet. 2007; 12(1):191-98.

2. Adelaide Recommendations on Health Public Policy. Second International Conference on Health Promotion, Adelaide, Australia, 5-9 abr 1988. [acesso em 2018 dez 8]. Disponível em: https://www.who.int/health-promotion/conferences/previous/adelaide/en/.

3. Declaração de Sundsvall. Promoção da saúde e ambientes favoráveis à saúde. 3ª Conferência Internacional sobre Promoção da Saúde. Sundsvall, Suécia, 9-15 jun 1991. [acesso em 2018 dez 8]. Disponível em: http://bvsms.saude.gov.br/bvs/publicacoes/declaracao_sundsvall.pdf .

4. Cohen SC. Habitação saudável como um caminho para a promoção da saúde [tese]. Rio de Janeiro: Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz; 2004. 167 p.

5. Cohen SC. Reabilitação de favelas: Até que ponto a tecnologia empregada é apropriada? [dissertação]. Rio de Janeiro: Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz; 1993. 376 p.

6. Rojas MC, Peréz CB, editores. Vivienda Saludable, de cara a RIO + 20. Washington: OMS; 2012.

7. Simas MC, Cardoso TAO. Biossegurança e Arquitetura em Laboratórios de Saúde Pública. Rev Pós. 2008; 15(24):108-24.

8. World Health Organization. Housing: implications for health. Report of a WHO Consultation, Geneva, 9-15 June 1987. Geneva: WHO; 1987. [acesso em 2018 dez 10]. Disponível em: https://apps.who.int/iris/handle/10665/59443.

9. Organización Mundial de la Salud. Organización Panamericana de la Salud. Documento de Posición OPS sobre Políticas de Salud en la Vivienda, 1999. Washington: OMS; 1999. [acesso em 2018 dez 8]. Disponível em: http://www.bvsde.paho.org/bvsasv/e/iniciativa/posicion/posicion.html.

10. Almeida ABS, Albuquerque MBM. Biossegurança: um enfoque histórico através da história oral. História, Ciências, Saúde-Manguinhos 2000; 7(1):171-84.

11. Simas CM, Cardoso TAO. Arquitetura e Biossegurança. In: Teixeira P, Valle S, editores. Biossegurança: uma visão multidisciplinar. 2. ed. Rio de Janeiro: Fiocruz; 2010. p. 75-110.

12. Cohen SC, Kligerman DC, Barcelos MRB. Espaços saudáveis e sustentáveis, biossegurança e resíduos. Perspectivas e controvérsias. Rev Bras Promoção da Saúde 2011; 24(3):274-83.

13. Oppermann CM. Manual de biossegurança para serviços de saúde. Porto Alegre: PMPA; 2003.

14. Carvalho APA, Tavares I. Modulação no projeto arquitetônico de estabelecimentos assistenciais de saúde: o caso dos hospitais Sarah. In: Anais do 30 Fórum de Tecnologia Aplicada à Saúde; 2002. Salvador: Universidade Federal da Bahia, Multgraf, 2002. [acesso em 2018 dez 10]. Disponível em: http://bvsms.saude.gov.br/bvs/publicacoes/modulacao_hospitais_sarah.pdf.

15. Câmara Brasileira da Indústria da Construção. Desempenho de edificações habitacionais: guia orientativo para atendimento à norma ABNT NBR 15575/2013. Fortaleza: Gadioli Cipolla Comunicação; 2013.

16. Associação Brasileiras de Normas Técnicas. NBR 15575-1: edificações habitacionais – desempenho – parte 1: requisitos gerais. Rio de Janeiro: ABNT; 2013.

17. Associação Brasileiras de Normas Técnicas. NBR 10152: acústica- níveis de pressão sonora em ambientes internos a edificações. Rio de Janeiro: ABNT; 2017.

18. Brasil. Ministério do Trabalho e Emprego. Portaria nº 876, de 24/10/2018. Altera a Norma Regulamentadora NR 17. Ergonomia. Diário Oficial da União. 25 Out 2018. [acesso 12 dez 2018]. Disponível em: https://enit.trabalho.gov.br/portal/images/Arquivos_SST/SST_NR/NR-17.pdf.

19. McPartland JF, McPartland BJ. Handbook of practical electrical design. 3th ed. New York: McGraw-Hill; 1999.

Received on 04/15/2019
Approved on 09/05/2019
Conflict of interests: non-existent
Financial support: non-existent