Study Protocol

Influence of indoor hygrothermal conditions on human quality of life in social housing

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Significance for public health

This study will contribute to understand how indoor environment relates with quality of life and how improving housing conditions impacts on individuals' health, in social housing neighbourhoods. As so, it is important to share the undertaken methodology carried out by a multidisciplinary team, in order to allow other researchers following comparable studies to adopt a similar approach. The case study results will allow to define building rehabilitation policies, improving residents' quality of life and adding great contribution to public health promotion.

Abstract

Background: Modern societies spend most of their time indoors, namely at home, and the indoor environment quality turns out to be a crucial factor to health, quality of life and well-being of the residents. The present study aims to understand how indoor environment relates with quality of life and how improving housing conditions impacts on individuals' health.

Design and Methods: This study case will rely on the following assessments in both rehabilitated and non-rehabilitated social housing: i) field measurements, in social dwellings (namely temperature, relative humidity, carbon dioxide concentration, air velocity, air change rate, level of mould spores and energy consumption); ii) residents' questionnaires on social, demogaphic, behavioural, health characteristics and quality of life. Also, iii) qualitative interviews performed with social housing residents from the rehabilitated houses, addressing the self-perception of living conditions and their influence in health status and quality of life. All the collected information will be combined and analysed in order to achieve the main objective.

Expected impact: It is expected to define a Predicted Human Life Quality (PHLQ) index, that combines physical parameters describing the indoor environment measured through engineering techniques with residents' and neighbourhood quality of life characteristics assessed by health questionnaires. Improvement in social housing should be related with better health indicators and the new index might be an important tool contributing to enhance quality of life of the residents.

Background

The World Health Organization (WHO), defined Quality of Life (QoL) as an *individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.* There are several factors that may influence QoL such as physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to relevant features of their environment.[1]

As modern societies spend most of their time indoors, namely at home,[2] the indoor environment quality (IEQ) turns out to be a crucial factor to health and well-being of the residents.[3,4] Aspects such as thermal comfort, indoor air quality, acoustics and luminance rely on the design and operation building systems and partake a major influence in IEQ and consequently on peoples' QoL.[5-7]

It has been reported that poor indoor hygrothermal conditions increase the risk of health effects such as respiratory symptoms, asthma and allergy in both adults and children.[5,8] Also, problems of indoor hygrothermal conditions are recognized as important risk factors for human health in both low-income and middle-income countries.[4,9] However, due to methodological problems and administrative and/or governmental obstacles, the effects of housing on health has been poorly studied.[9]

Housing conditions are on top of people's priorities,[6,7] but also very dependent on the economic resources.[9,10] In the context of social housing the substantial costs involved in house improvements comprise an enormous constraint to residents and are dependent on public funding. Therefore, it is expected a higher prevalence of poor indoor hygrothermal conditions in these settings. Poor values of indoor hygrothermal conditions are more likely to occur in houses that are overcrowded and lack appropriate heating, ventilation and insulation.[7,10] Social housing deserves special attention once it is typically occupied by population from lower social strata that may not support the high operating costs associated with technology of indoor and vehicular environmental comfort (HVAC: heating, ventilating, and air conditioning).[7] Thus, in a context of financial restrain, the investment in rehabilitation of the social housing should be proved to be associated with better health indicators.

In the engineering field, one of the most important thermal comfort models is the Fanger's Predicted Mean Vote (PMV), that combines four physical variables (air temperature, air velocity, mean radiant temperature and relative humidity), and two personal variables (clothing insulation and activity level) into an index that can be used to predict the average thermal sensation of a large group of people.[11,12] The PMV seemed to be a better predictor in air-conditioned buildings than in naturally ventilated ones, in part because of the influence of outdoor temperature, and opportunities for adaptation. However, as PMV predictions could result in significant differences according to the setting in which was used,[13-16] some new approaches to measure the PMV have been proposed.[17-19] Grounded in the social housing context, this project aims to assess the relevant variables that should predict the human quality of life based on house and personal variables to ultimately develop a new analytical model for the calculation of a Predicted Human Life Quality (PHLQ) index.

Thus, the present study aims to understand how indoor environment relates with quality of life and how improving housing conditions impacts on individuals' health. To accomplish our project goal, the following specific steps were defined: i) to obtain indoor environmental parameters data, in both rehabilitated and non-rehabilitated social housing; ii) to assess social, demographic, behavioural and health characteristics through structured questionnaires, administered to social housing residents from both dwellings; iii) to conduct interviews with social housing residents from rehabilitated houses, addressing the self-perception of living conditions and their influence in health status and quality of life; iv) finally, to develop a new analytical model for the calculation of a PHLQ index, which relates indoor environmental parameters with human quality of life.

Design and methods

This project combines the expertise areas of engineering, medicine and public health to approach health and housing conditions from a specific population group. Two different institutions were involved in this project: the Faculty of Engineering of the University of Porto (FEUP), Portugal, and the Institute of Public Health of University of Porto (ISPUP), Portugal. The project began with the establishment of partnership between research team and the Porto town hall (Câmara Municipal do Porto, *i.e.* the collegial executive body of Porto municipality that comprises all the departments and services of the municipal administration). As a large social housing rehabilitation program is on-going in Porto, it was decided to focus on both rehabilitated and non-rehabilitated social housing. Support was asked to the municipal enterprise responsible for coordination and maintenance of Porto municipality social housing, DomusSocial, E.M., in order to facilitate the availability of residents to participate in the current project. The research team met with DomusSocial, E.M., and together have defined the most appropriate approach to residents to simplify participation and project development. This project has begun in March of 2014 and it is planned to continue at least for three more years.

Sampling strategy

The *in situ* measurement process will be performed in two social housing neighbourhoods, one rehabilitated and one non-rehabilitated. Both neighbourhoods were built at the same time, sharing the same building structure, and most of the residents from the two neighbourhoods moved there at approximately the same time. Because *in situ* measurements will take one year and it will be required to have thermocouple sensors in all rooms of each house, it is expected to perform these measurements in 50 houses, 25 selected from the recently rehabilitated neighbourhood and 25 from the non-rehabilitated neighbourhood. The selection of the analysed dwellings took different aspects into account, namely physical aspects of the dwellings, number of occupants and demographic composition of the family. The dwellings included in the sample should cover different shape factors, which means that some should be located in the core of the building but others should have a gable wall, be located just below the roof or on the ground floor. Also, at least three dwellings located on the same vertical alignment were selected. The solar orientation was also a concern. The rehabilitated dwellings were homogeneous, with all dwellings holding the same solar orientation. In the non-rehabilitated dwellings, a mix of orientations was selected. Regarding the number of occupants per dwelling the concern was to include different densities in the sample. Very different situations could be found, ranging from five persons in a three bedroom apartment to only one person in a four bedroom apartment. The composition of each aggregate was made so that the demographics were representative of the population under investigation and that similar compositions were present in both neighbourhoods.

Field measurements

Large-scale measurements of indoor hygrothermal conditions parameters in buildings are required for many purposes. Indoor hygrothermal conditions and energy demand will be evaluated in 50 social dwellings, by measuring the following parameters: temperature, relative humidity, carbon dioxide concentration, air velocity, air change rate, level of mould spores and energy consumption.[20] The other experimental measurements will be conducted in the exterior of social housing, namely, temperature, relative humidity, wind velocity and direction, and radiation parameters by a weather station.[21] In order to obtain the key values, the hygrothermal parameters will be continuously monitored during one year in some of the dwellings while in others during shorter but representative periods of more than three weeks in summer and winter.

The values of temperature and relative humidity will be obtained by continuous measurements using HOBO type data loggers. The Blower Door method) will be used in order to measure the building air tightness and estimate ventilation conditions along with the carbon dioxide concentration measurements.[22]

From these case studies data should be reported about energy performance and time series of indoor hygrothermal conditions parameters, from and around the social housing.

Questionnaire (Quality of life and other self-report measures)

The structured questionnaire aims to assess participants' characteristics concerning socio-demographic status, lifestyles and behaviours, and also health characteristics. It is expected the participation of all residents from the monitored social dwellings. All residents 18 or older will be invited to participate in the survey. A trained interviewer will establish a phone connection with the eligible residents, and during the phone call project and objectives will be explained and residents will be asked for participation. Once residents agree to participate, a visit for questionnaire fulfilment will be scheduled, at the time and day considered as more appropriate. Further information about the study will be given verbally, if requested, by the trained interviewers.

Information will be obtained by face-to-face interview. The questionnaire will comprise information on the following domains: i) household socioeconomic and demographic profile (residents' age, subjective social class, job, school education, family income); ii) individual information [social and psychological characteristics such as lifestyles, clinical history; health care visits; medication; respiratory symptoms; quality of life – SF36(23)]; iii) house characteristics (satisfaction, energy consumption, renovations needed/wanted); and iv) neighbourhood characteristics (security, social support).

The 36-item short-form (SF36) is a short questionnaire developed as part of the Medical Outcomes Study and it has been widely used to assess quality of life in public health research. Briefly, it is a generic indicator of health status and includes eight sub-dimensions that assess different areas of health: physical function, physical performance, physical pain, general health, mental health, emotional role, social function and vitality.[23]

Qualitative interviews

A guide for semi-structured interviews will be designed. Interviews will be conducted by trained interviewers in the residents' household. Residents from the rehabilitated social housing will be selected based on gender, age and occupation (employed, unemployed and retired). After the questionnaire fulfilment, respondents will be asked for their interest in being interviewed and will later be contacted by phone to schedule the interview.

The goal of qualitative interviews is to understand the self-perception of living conditions and their influence in health status and QoL, and also, the effect of building restorations on residents' perception of QoL.

Interviews will be conducted through successive visits to neighbourhoods in order to assure the highest number of responses. Contacts will always be done on time and day indicated (in person or by phone) as more convenient for residents.

The interview guide was designed to cover the experience of living in social dwellings. Main topics of the interview will be the experience of living in social housing and neighbourhood, the perception of QoL, indoor environmental conditions, house and building construction solutions.

Data analysis

Quantitative data (field measurements and questionnaire data)

A database for questionnaire registry will be created. In first, a *virtual social housing* database method will be developed and employed to provide a common platform for data storage of field measurements, convenient data access, and comparison with simulation results. Data collected from HOBO data loggers will be analysed using HOBOware Graphing and Data Analysis® software.

Data from questionnaires will be described and analysed using Statistical Package for the Social Sciences 22.0 software (SPSS®) and Data Analysis and Statistical Software 10.0 (Stata®).

Then, both information (from questionnaires and field measurements) will be combined in the same database. From quantitative data analysis it is expected the establishment of the PHLQ index, which will be computed from a weighted combination of the physical parameters that describe the indoor environment, taking into consideration the human associated parameters: social and psychological characteristics, lifestyles, clinical history, health care visits, and quality of life; and variables associated to household socioeconomic and demographic profile. The model will be fine-tuned with adequate analytical expressions that can approximate the correlated results of the field measurements and the questionnaire. Additionally, the predictive model will be applied in a numerical tool that can convert simulation results using the Energy Plus Simulation software, version 8.1.0 and hence automatically calculate the corresponding PHLQ values.

Qualitative data (interviews)

Transcriptions and analysis of interviews will be conducted using NVivo 10 software (QSR International, USA). A content analysis will be performed and major themes will be identified using constant comparison and category building procedures. The information retrieved from interviews and the information obtained from the questionnaires will be combined and results will be published.

Ethics

The project was peer-reviewed and obtained funding support from FEDER and the Operational Programme Factors of Competitiveness - COMPETE and by national funding from FCT - Foundation for Science and Technology (Portuguese Ministry of Education and Science). Additionally, the study protocol was submitted and approved by the Ethics Committee of Institute of Public Health of University of Porto and by the Portuguese Data Protection Authority.

Procedures will be developed in order to guarantee data confidentiality and protection and each participant will be identified with a numerical code. All residents will receive an information sheet with an explanation on the purpose and design of the study and those who agree to participate will provide signed informed consent to data collection and interview recordings.

Expected impact on public health

To our knowledge, there are limited data relating indoor environment physical parameters with residents' and neighbourhood quality of life characteristics. Based on a multidisciplinary approach including engineering, medicine, epidemiology and public health, this study will garner an understanding of the role of restorations of social housing and its impact on QoL and health, and will certainly provide support and knowledge to inform evidence-based building interventions aimed at improving QoL and health.

Data collection had been proved to be difficult in this type of setting. However research team counts on a valuable informal partnership with the municipal enterprise responsible for coordination and maintenance of Porto municipality social housing, DomusSocial, EM.. DomusSocial has introduced the study and the research team to the social housing residents; and therefore residents will be later invited to be interviewed by our research team.

Despite the expected challenges in recruitment and data collection, the results of this project will support the definition of a PHLQ index that can be important for the definition of building rehabilitation policy and used for establishing building performance targets. This new index might be an important tool contributing to enhance quality of life of the residents.

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