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Sub-theme: Active ageing and chronic pulmonary disease

GERIA PROJECT PRELIMINARY STUDY ON INDOOR AIR QUALITY AND HEALTH RELATED QUALITY OF LIFE IN ELDERLY CARE CENTERS

ABSTRACT

Background: The age of the European population is rising and the percentage of adults aged 65 years and older is projected to increase from 16% in 2000 to 20% in 2020. It has been estimated that older persons spend about 19-20 hours per day indoor. In this sense, older persons may be particularly at risk of detrimental effects from pollutants, even at low concentrations due to their common reduced immunological defense and multiple underlying chronic diseases.

Objectives: Six Porto urban area elderly care centers (ECCs), housing a total of 425 older persons, were studied for building indoor air quality (IAQ) and thermal comfort (TC) assessment in both seasons. This paper presents the first IAQ and TC pilot study results in 36 ECCs rooms of a wider ongoing study about respiratory health and related quality of life.

Results: The study areas were all natural ventilated with IAQ winter indoor concentrations within the Portuguese reference values. However, 40% of the participants were dissatisfied with indoor thermal conditions, rating it 'slightly cool'. Summer season show a lower rate of dissatisfied persons (8%), but fungal concentrations exceeded reference levels (> 500 CFU/m³). There were significant differences between seasons on PPD ($P = 0.013$) and PMV ($P < 0.05$) indexes.

Conclusions: To our knowledge, this is the first study in Portugal to assess effects of indoor air contaminants on health status and quality of life in older persons living in ECCs. Although the preliminary results suggest that indoor concentrations of most parameters were within reference values, the results highlight several issues, including the need to improve the balance between IAQ and thermal comfort in ECCs.

STATE OF ART

The air we breathe inside buildings dominates overall inhalation exposure to most air pollutants, whether of indoor or outdoor origin (Corsi et al., 2012). As levels of outdoor ambient pollution have decreased in many geographic areas, the relative impact of indoor air pollution has grown; therefore, indoor air quality (IAQ) has increasingly gained importance for maintaining a health status. It is often thought that indoor environments are among the healthiest and safest places for people to be particularly for older persons, who can have unique health needs and environmental sensitivities. Additionally, thermal comfort (TC) is one of the indoor environment factors that affect health and human performance, thus chiefly determined by temperature, humidity, and air movement. Though thermal environment in homes does not usually cause serious ill health, it has a very significant impact on the general well-being and daily performance of building occupants. Poor thermal environment can also aggravate the impact of air pollutants on occupant's health (Mendes and Teixeira, 2012).

The age of the European population is rising and the percentage of adults aged 65 years and older is projected to increase from 16% in 2000 to 20% in 2020 (Adan et al., 2006). It has been estimated that older persons spend about 19-20 hours per day indoor (WHO, 2003). Moreover, care homes have the potential to influence people's lives socially, physically and psychologically (Bradshaw et al., 2012). As a result, the study of IAQ and thermal environments in the elderly population is becoming an important issue to be addressed by clinical research. In fact, older persons may be particularly at risk of detrimental effects from pollutants, even at low concentrations due to their common reduced immunological defense and multiple underlying chronic diseases. Several health-related effects may be caused (or worsened if already present) by exposure to poor IAQ, including eye irritation, nausea, upper respiratory complications, cognitive impairment, asthma, respiratory infections, cardiovascular disease, chronic obstructive pulmonary disease, and cancer. For residents of elderly care centers (ECCs), IAQ is a special concern and a critical component of their health and quality of life. Moreover, the risk assessment process is often difficult in older persons, involving the identification of multiple factors potentially affecting health and quality of life, the quantification of human exposure to pollutants, and the evaluation of the individual's response to these stimuli. Current evidence suggests the existence of an association between low concentrations of indoor pollutants with increased morbidity and mortality in particular, related to respiratory and cardiovascular disease (Pope and Dockery, 2006; Miller et al., 2007). Health effects of indoor air pollutants have mainly been addressed in studies on other susceptible populations such as children (Neas et al., 1991; Neas et al., 1994; Nafstad et al., 1996; Nafstad et al., 1997; Bruce et al., 2000; Jaakkola, 2000; Jaakkola et al., 2001; Jaakkola and Jaakkola, 2002; Borrego et al., 2008; Madureira et al., 2009;), and only a few have evaluated adults and older people (Xu and Wang, 1993; Moran et al., 1999; Pilloto et al., 1999; Venner et al., 2001; Simoni et al., 2002; Simoni et al., 2003). In this sense, there is still a clear need for more studies on indoor pollution and health specifically targeting adults and older persons. Moreover, evidence is still sparse about the role of indoor pollutants in determining the prognosis of pre-existing diseases. Identification of subgroups

among older persons who are especially susceptible to adverse effects of air pollutants is particularly important to provide the basis to design adequate preventive interventions.

Active ageing means growing old in good health and as a full member of society, feeling more fulfilled, more independent in daily life and more involved as citizens. No matter how old, elderly can still play part in society and enjoy a better quality of life. The challenge is to make the most of the enormous potential that older citizens harbor even at a more advanced age (EU, 2012). Health declines as people grow old, but a lot can be done to cope with this decline. And quite small changes in our environment can make a great difference to people suffering from various health impairments and disabilities. Studies on this specific topic represent an important area of research, taking into account that older persons often present multiple diseases and live in restricted indoor environments at increased risk of exposure to indoor pollutants.

OBJECTIVES AND STUDY DESIGN

The GERIA Project - Geriatric study in Portugal on Health Effects of Air Quality in Elderly Care Centers will examine 20 ECCs chosen among 60 in Porto and Lisbon, each of which will be studied to collect the following data types:

- (i) Building physical and environmental characteristics [IAQ parameters, such as formaldehyde, particulate matter up to 10 micrometers in size (PM₁₀), total volatile organic compounds (TVOC), carbon monoxide (CO), carbon dioxide (CO₂), total bacteria, fungi, temperature, relative humidity (RH) and air velocity, as well as, predicted mean vote (PMV) and predicted percent of dissatisfied people (PPD); and air change rate using tracer gas technique];
- (ii) Health and quality of life questionnaires [BOLD questionnaire to obtain information about the prevalence and burden of Chronic Obstructive Lung Disease (COPD) (Martins et al., 2009), World Health Organization Quality of Life – BREF an international cross-culturally comparable quality of life assessment instrument (WHO, 2004; Liang et al., 2008; Bobic et al., 2009), Mini Mental State (MMS) to indicate the presence of cognitive impairment, such as in a person with suspected dementia or following a head injury cognition (Folstein et al., 1975), Geriatric Depression Scale (GDS) for basic screening measure for depression in older adults (Yesavage et al., 1982) as well as a socio-demographic questionnaire];
- (iii) Exhaled breath condensate and swab samples. This prospective cohort study will provide crucial information about ECCs construction characteristics and prevalence of cardio-respiratory diseases in older persons in Portugal. Table 1 presents the estimate numbers, and their sources, by which the sample size population was calculated. The sample size was also calculated taking into consideration the estimated rate of dementia within the elderly population in order to achieve a representative HRQL evaluation and its correlation with ECCs indoor air parameters. This estimated rate of dementia will be confirmed through the application of the MMS questionnaire.

To our knowledge, this is the first study in Portugal to assess effects of indoor air contaminants on health status and quality of life in older persons living in ECCs. At present 6 Porto ECCs were studied for building IAQ and TC assessment in both seasons. This paper presents the first IAQ and TC preliminary results in 36 ECCs rooms on this ongoing study.

Table 1 Study design estimates

Porto elderly population living in ECCs (No.) ^{a)}	1574
ECCs in Porto (No.) ^{a)}	57
Lisbon elderly population living in ECCs (No.) ^{a)}	3646
ECCs in Lisbon (No.) ^{a)}	95
Estimated elderly dementia (%) ^{b)}	53
Estimated sample size population with 95% CI in Porto (No.) ^{c)}	309
Estimated sample size population with 95% CI in Lisbon (No.) ^{c)}	348

Sources: a) Carta Social, 2010 [<http://www.cartasocial.pt>]; b) Estimated based on data provided by the ECCs managers; c) OpenEpi, Version 2.3.1, 2011 [www.OpenEpi.com] (Dean et al., 2001)

MATERIAL AND METHODS

Walk-through Survey

A building characterization of the ECCs was performed including the following assessment: type of building construction (concrete, masonry, etc.); thermal insulation of the building; characteristics of building envelope (structural type of the windows and doors – with weather-strip or not, sliding windows or casement windows, etc.); ventilation system (natural, mechanical, hybrid, etc.); materials used for finishing; use of gas burning appliances that could influence the IAQ; evidences of dampness and mould at the building envelope; ventilation practices of the occupants (opening windows or not).

Indoor Air Monitoring and Thermal Comfort Assessment

IAQ was measured twice a year, during winter 2011 and summer 2012, so to take into account the influence of outdoor pollution and atmospheric conditions on IAQ and ventilation. IAQ evaluation considered the chemical parameters including CO₂, CO, formaldehyde, TVOC, PM₁₀; biological contaminants such as bacteria (total counts) and fungi (total counts and identification); as well as TC parameters according ISO 7730:2005 International Standard assessing PMV and PPD indexes, relative humidity (RH), temperature and air velocity. The monitoring was performed within dining rooms, drawing rooms, medical offices and bedrooms. Ambient air samples were also collected for comparison to the indoor measurements. All the active sampling and its analytical measurement were performed in replicate and duplicate. The

monitoring work was developed in the Environmental Health Department of National Health Institute where these methodologies are accredited by NP EN ISO/IEC 17025:2005 "General requirements for the competence of testing and calibration laboratories".

The monitoring phase included air sampling during daytime (starting at 10 a.m) for, at least, a 4 hour period during ECCs normal activities but conducted in a discreet fashion in order not to disturb occupants' normal behaviour. Sampling devices were placed at a height of about 0.6-1.5 metres above the floor, approximately at the breathing zone level of elderly. All monitoring data were collected as close as possible to the centre of the main area of the room with the sampling points no closer than 1 meter to a wall, a window, a door or and an active heating system.

PM₁₀ were collected using Polytetrafluoroethylene (PTFE) filters on Personal Environmental Monitors (PEM) attached to Gilian personal pumps at a flow rate of 2.0 L.min⁻¹ according Environmental Protection Agency (EPA) 10-A Method 'Determination of Respirable Particulate Matter in Indoor Air Using Size Specific Impaction' (Winberry et al., 1992). These sampling pumps were calibrated and checked daily prior and after each sampling with Gilian Gilibrator-2 Air Flow Calibrator. Each filter was weighed under controlled conditions of temperature (20°C ± 1°C) and relative humidity (50% ± 5%) before and after the sampling. Filters were analyzed gravimetrically for particle mass using an electronic microbalance Sartorius (Sartorius M5P with 0.001 mg of sensibility). In order to obtain good precision, static charges were eliminated using a non-radioactive, ionizing air blower (EXAIR, Model No. 7907). Concentrations were calculated based on the weight difference between "after sampling" and "before sampling" filters and sampled air volume.

TVOC samples were collected by drawing air through a stainless steel sampling tube (Tenax TA) using a personal air sampling pump (SKC Pocket pump) at a flow rate of 0.05 L.min⁻¹ for a period of 45 min. These pumps were calibrated and checked daily prior and after each sampling with Gilian Gilibrator-2 Air Flow Calibrator. Analysis of volatile organic compounds (VOCs) was performed by automatic thermal desorption coupled with capillary gas chromatography using Perkin Elmer equipment ATD 400 and AutoSystem GC fitted with flame ionization detector (FID) and one apolar column, according to the International standard ISO 16000, part 6 and an internal method (ECA, 1997).

Formaldehyde was collected by active sampling with 2, 4 dinitrophenylhydrazine-coated glass fiber filters in a Millipore Swinnex-13 filter holders with personal pumps (SKC AirChek 2000) at a flow rate of 0.8 L.min⁻¹ (calibrated and checked daily prior and after each sampling with Gilian Gilibrator-2 Air Flow Calibrator) and determined by high-performance liquid chromatography (HPLC) according the method reported by Levin et al. (1986) and the method from the National Institute for Occupational Safety and Health (NIOSH) 2016:2003.

During normal occupancy conditions CO₂ and CO concentration were determined using a portable monitor of IAQ (GasData, model PAQ). Short-term measurements (30 min average for each room) were conducted sequentially recording the respective duration. After equipment

stabilization, reading values were registered and transferred to an informatics system using PCLogger 32 V3.0 software.

TC (temperatures, RH and air velocity) evaluation was performed using a Delta Ohm HD 32.1 - Data logger. After equipment stabilization (25 minutes) in each room, reading values were registered (during 10 minutes in each sample point) and transferred to an informatics system using DeltaLog10 Version 1.30 software. According to the ISO 7730 and through observation of the elderly daily activity it was considered a metabolic rate of 1.0 met and a thermal insulation of clothing of 1 clo (Summer) and 1.3 clo (Winter).

Microorganism air sampling were carried out with a microbiological air sampler (Merck Air Sampler MAS-100), working at a constant air flow rate of 100 liters per minute, and using the following culture media: *Tryptic Soy Agar* (TSA) for total bacteria and *Malt Extract Agar* (MEA) for fungi. One volume of air were collected both indoor and outdoor (250 L), in duplicate and with one field blank, per culture medium, per day. It was followed the NIOSH 0800 Method - Bioaerosol Sampling (Indoor Air). For quantification of fungi, the set of collected samples were incubated at 25°C. Identification of fungal colonies was based upon phenotypic characteristics and followed standard mycological procedures. The culture media for bacteria quantification were incubated at 37°C. For each room and analysis, the total number of colonies was plotted against volumes of air. Results are expressed as colony-forming units per cubic meter of air (CFU/m³).

Data Processing and Analysis

Descriptive analyses were used to obtain insight into the ECCs characteristics and environmental monitoring. Paired t-tests were used to test for differences within indoor/outdoor measurements and for seasonal effects. Uncertainty was reported as 95% confidence intervals based on error propagation of multiple samples, experiments and an analysis of instrumental uncertainty. A 0.05 level of significance was used for all analyses. All data were analyzed using SPSS 16.0.

RESULTS AND DISCUSSION

Elderly Care Centers Characterization

The studied ECCs were located in an urban area housing a total of 425 older persons. They were located in antique buildings adapted to the actual purpose, with a mean age up to 60 years. Eighty-nine percent of these buildings have close proximity of roads with heavy traffic. The studied areas were all natural ventilated, had a mean floor area of 30 m², and the following mean occupancy rates per room during monitoring: dining rooms (3.8), drawing rooms (7.2), medical offices (1.5) and bedrooms (0.4). All studied ECCs were smoke free. Stone masonry was the main building characteristic between ECCs, as well as, single pane glass windows (78%). The floor covering materials were mainly wood, tile/stone or PVC, according to the

ECCs. Table 2 present the overall building characteristics of the ECCs participating in this study. Only 33% had thermal insulation on the roof and walls and most of the buildings had leaks (67%) and condensation (56%) with visible fungi and molds. During monitoring tasks carried out in Porto the mean ambient air temperatures ranged from 16°C to 28°C in the summer season and from 4° C to 14°C in the winter season.

Table 2 ECCs building envelope characteristics (%)

Stone masonry	78
Insulation	33
Wooden frames	67
Single glass	78
Power supply for heating	
Electricity	56
Gas	67
Visible fungi and molds	
Condensation	56
Leaks	67

Environmental Monitoring

CO and TVOC parameters preliminary results (Table 3) indicate mean concentrations are within the Portuguese reference values and International references in both seasons. Nevertheless, TVOC indoor levels are 3 times higher indoors possibly indicating a prevalence of indoor sources. According to Spengler et al. (2001) VOC indoor concentrations are generally higher than outdoors depending on type of sources such as construction materials, furniture, cleaning products, cosmetics, combustion processes and varnishes (Martínez and Gómez, 2007). CO outdoor levels are higher (1.3) than indoors possibly translating the traffic pollution (89% ECCs near main roads).

It were also analyzed several samples (n=66) of formaldehyde indoors which show concentration values below the method limit of quantification (0,0002 mg.m⁻³). Paustenbach et al. (1997) in their comprehensive review concluded that hypersensitive groups (elderly people, asthmatics and children) could not be identified, nor could they identify any indication of sensitization by exposure to formaldehyde. This has been supported by comprehensive reviews during the last decade. Increased sensitivity is not considered biologically plausible. No studies on formaldehyde have been reported that show elderly people to be more susceptible; on the contrary, the elderly are generally less sensitive to sensory irritation, possibly decreasing after the age of 60 years (WHO, 2010). Also this result is coincident with the average age of the studied buildings (up to 60 years) decorated with antique furniture and no immediate sources of formaldehyde such as plywood, carpets and environmental tobacco smoke.

Indoor PM₁₀ mean concentration is within the Portuguese reference, but when related to the 24 hour average WHO guideline this value is 1.4 times above. This WHO guideline gives

interim target related to outdoor air pollution nonetheless, progress towards this guideline value should be the ultimate objective in order to achieve significant reductions in risks for acute and chronic health effects from air pollution. In one of the studies, Simoni et al. (2002) showed an association of relatively low levels of indoor pollutants, such as particulate matter (PM) with acute respiratory symptoms and reduced peak expiratory flow, in elderly residences. Our finding is consistent with this trend in what concerns PM10, TVOC, Formaldehyde and CO. In fact, these parameters are within the reference levels however this issue justifies further studies due to older person's susceptibility to pollutants, even at low concentrations.

CO₂ mean indoor concentration levels are within the Portuguese reference but 1.05 above the international reference. Indoor levels are higher than outdoors both in summer (1.5) and winter (1.7) seasons reflecting the occupation rate within the analyzed areas. In developed countries, pollutant concentrations indoors are similar to those outdoors, with the ratio of indoor to outdoor concentration falling in the range 0.7-1.3 (Thade Project Report, 2004). The Finnish Society of Indoor Air Quality and Climate suggests 1300 for 'very good', 1650 for 'good', and 2200 mg/m³ for 'satisfactory' indoor air quality (Säteri, 2002). At these concentrations, CO₂ is not harmful; however, it is an indicator of other airborne pollutants and ventilation rate.

Airborne bacteria in the indoor environment are the confirmed or presumed causative agents of several infectious diseases, and their components are linked to the development and exacerbation of chronic respiratory illness including asthma (Peccia et al., 2008). The biological IAQ parameters pilot results (Table 3) point out to summer and winter results within the recommended levels except from fungi concentrations exceeding both reference levels in the summer (> 300 and 500 CFU/m³). These pilot results also point out to a prevalence of the following mold species in the analyzed samples: *Cladosporium species* (41%), *Penicillium species* (24%) and *Aspergillus fumigatus* (8%). This last one is known to cause invasive infection in the lung and represents a major cause of morbidity and mortality in susceptible and immunodeficiency individuals such as elderly. Moreover, according Ayanbimpe et al. (2010) the presence of toxin-producing fungi like *Aspergillus fumigatus* indoors should be a cause for concern considering the potential risk of mycotoxicosis. Inhalation of infectious microorganisms discharged by people and animals is a primary mechanism of contagion for most acute respiratory infections. In indoor environments characterized by reduced ventilation and increased use of untreated recirculated air concentrations of microorganisms may increase (Thade Project Report, 2004).

Analyzing the bacteria and fungi correlation with CO₂ by season and by room the results present a significant correlation between summer ($P = 0.004$) and winter ($P = 0.003$) indoor bacteria and CO₂ as represented in Figure 1. In our study the total bacteria concentration is below the reference levels, however the indoor concentration is 2 times higher than outdoor concentrations which is in accordance with Hospodsky et al. (2012) revealing that human occupancy is a dominant factor that contributes to the concentration of indoor airborne bacterial

genomes during occupancy. Both resuspension from carpet and direct human shedding contributed to significantly elevate bacterial concentrations above background concentrations. Similarities between indoor air populations and bacteria associated with the human skin microbiome point to the important contribution of human microflora. Furthermore, high ECCs bacteria concentrations are positively correlated with the increase of CO₂ in the studied rooms. Humans are the major source of CO₂. As people exhale CO₂, they also exhale and give off a wide range of bioeffluents which include bacteria, gases, odors, particulate, and viruses. Due to poor ventilation rates these bioeffluents are allowed to build up in space (Mendes and Teixeira, 2012).

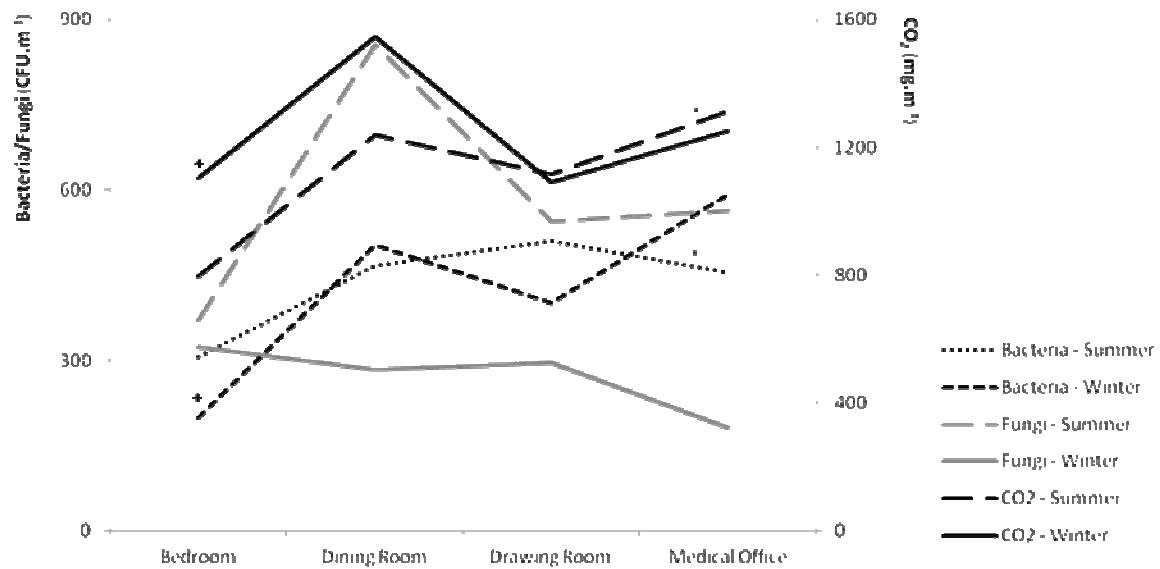


Figure 1 Bacteria, Fungi and CO₂ concentrations by room and season (* $P < 0.004$; + $P < 0.003$)

The overall TC winter results indicate that 42% of the residents were dissatisfied (PPD) with indoor thermal conditions, rating it 'slightly cool' (PMV=-1.2) (Figure 2). Summer results show a lower rate of dissatisfied persons (PPD=8%) reflecting a 'neutral' PMV index (PMV=-0.03) (Figure 2). Temperature and TC are also major issues for the elderly population (Raymann and Van Someren., 2008). Studies show an influence between cardio-respiratory mortality and ambient temperature (Halonen et al., 2011) and also with indoor climate (Bøkenes et al., 2009). The PPD index analyses by room (Figure 3) present the medical office (Winter: 49%; Summer: 10%) and the bedrooms (Winter: 47%; Summer: 9%) as the areas with higher percentage of dissatisfied residents in both seasons opposite to the dining rooms and drawing rooms most likely due to higher mean occupancy rates per room during monitoring. Notwithstanding, there was significant differences between seasons of the PPD ($P = 0.013$) and PMV ($P < 0.05$) indexes.

Table 3 IAQ chemical and biological measurements parameters results (indoor and outdoor) and references comparison

Parameter	Season	Indoor		Outdoor		Indoor reference levels	
		Average	SD (Range)	Average	SD (Range)	Portuguese ^{a)}	International
Formaldehyde (mg.m ⁻³)	Summer	<0,0002	-	-	-	0.1	0.1 ^{b)}
	Winter	<0,0002	-	-	-		
TVOC (mg.m ⁻³)	Summer	0.07	0.09 (0.03-0.5)	0.04	0.01 (0.02-0.06)	0.6	0.2 ^{c)}
	Winter	0.1	0.07 (0.02-0.32)	0.02	0.01 (0.01-0.03)		
PM ₁₀ (mg.m ⁻³)	Summer	0.07	0.04 (0.02-0.2)	0.08	0.02 (0.05-0.11)	0.15	-
	Winter	0.07	0.07 (0.01-0.43)	0.05	0.03 (0.02-0.12)		
CO (mg.m ⁻³)	Summer	1.3	2.47 (0.01-10.4)	1.2	1.61 (0.01-4.8)	12.5	7 ^{b)}
	Winter	0.5	0.68 (0.01-4.08)	0.8	0.81 (0.01-2.56)		
CO ₂ (mg.m ⁻³)	Summer	996	436 (512-3568)	669	91 (512-951)	1800	1080 ^{d)}
	Winter	1196	512 (512-3842)	712	344 (457-3751)		
Bacteria (CFU.m ⁻³)	Summer	397	237 (6-830)	166	126 (68-336)	500	500 ^{b)}
	Winter	329	280 (32-996)	52	20 (30-84)		
Fungi (CFU.m ⁻³)	Summer	525	533 (6-2224)	476	726 (20-1314)	500	300 ^{c)}
	Winter	296	263 (90-1218)	225	146 (114-478)		

a) DL 79/2006, 4th April 2006; b) WHO, 2010; c) ECA, 1997; d) Burton, 1995; e) Robertson, 1997

In general, elderly seem to perceive TC differently from the young due to a combination of physical ageing and behavioral differences (Hoof and Hensen, 2006). The effects of gender and age can be accounted for by model parameters such as activity and clothing level (Havenith, 2001; Korhonen et al., 2003). On average, older adults have a lower activity level, and thus metabolic rate, than younger persons which is the main reason why they require higher ambient temperatures (Havenith, 2001; Tsuzuki and Iwata, 2002). Studies by Enomoto-Koshimizu et al. (1997) and Turnquist and Volmer (1980) suggested that, also psychologically, the 20- 24°C comfort zone is not warm enough for older adults and found an optimum temperature of 25.3°C for sedentary older adults, which is within the current comfort range.

The previous information, along with our PPD and PMV preliminary results, lead us to one explorative issue of how maintain comfortable indoor temperatures with good IAQ to these susceptible populations, particularly in the winter season. Individual differences are too large to draw an unequivocal conclusion on the requirements of older adults regarding their preferred thermal environment. More research is needed on thermal preferences of older adults, for example through field studies in which older adults are given personal control options over their thermal environment (Hoof and Hensen, 2006).

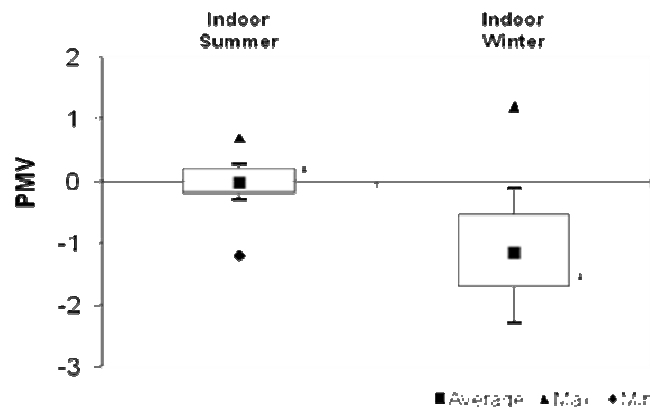


Figure 2 Overall PMV indexes (* $P < 0.05$)

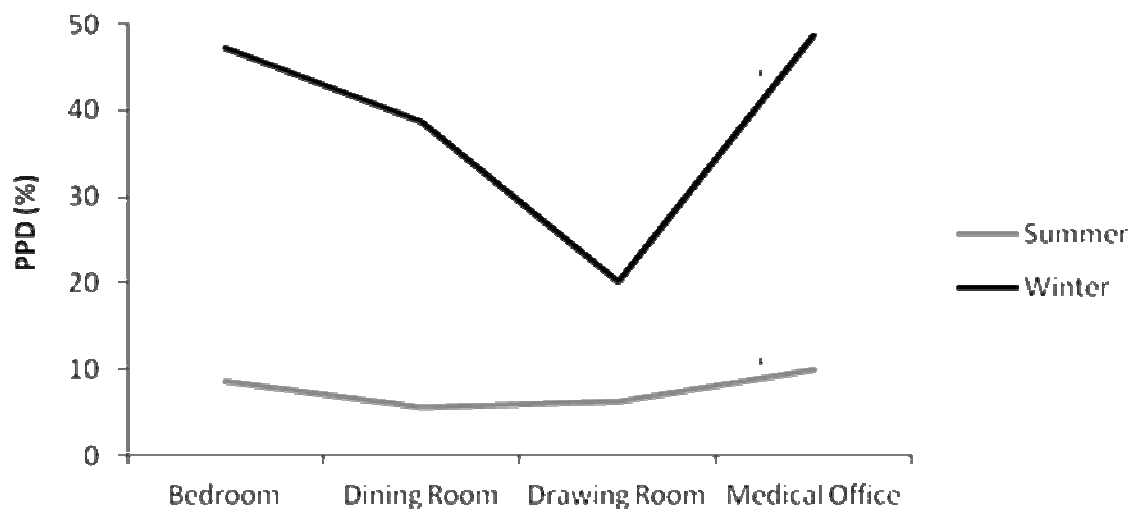


Figure 3 PPD by room and season (* $P = 0.013$)

Currently, very little published data exist on IAQ and TC in ECCs in developed countries. The integration of indoor air science with residential environmental characterization has revealed new insights into the sources and origins of indoor air pollutants and their health effects in humans. According Simoni et al. (2003) there is a clear need for more studies on indoor pollutants and health in the elderly, with focus on improved exposure assessment, various types of short-term and long term health outcomes, and identification of characteristics associated with susceptibility to the adverse effects. The potential role of indoor pollutants as a prognostic factor determining the development of a pre-existing disease may be an important new area for research. Quantitative monitoring of indoor and outdoor ECCs air will be analyzed and correlated with the clinical tests and health related quality of life questionnaires. In this sense, this paper contributes to a preliminary characterization and understanding of the possible health effects due to IAQ and TC variables and its potential balance to improve the wellbeing of our elderly population.

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