



European Network on New Sensing Technologies for Air Pollution Control and
Environmental Sustainability - *EuNetAir*
COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

Copenhagen, Denmark, 3 - 4 October 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 2: 2013-2014 (*Ongoing Action*)

GERIATRIC STUDY IN PORTUGAL ON HEALTH EFFECTS OF AIR QUALITY IN ELDERLY CARE CENTERS



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CONTEXT: IAQ AND HEALTH

 People spend 80-90% time indoors

 Indoor environments have changed enormously with often bad IAQ:

- Outdoor air, building fabric failures, human activities, soft furnishings, fitted carpets, equipments and mechanical air ventilation systems
- Decrease of the rate at which indoor air is exchanged for fresh air

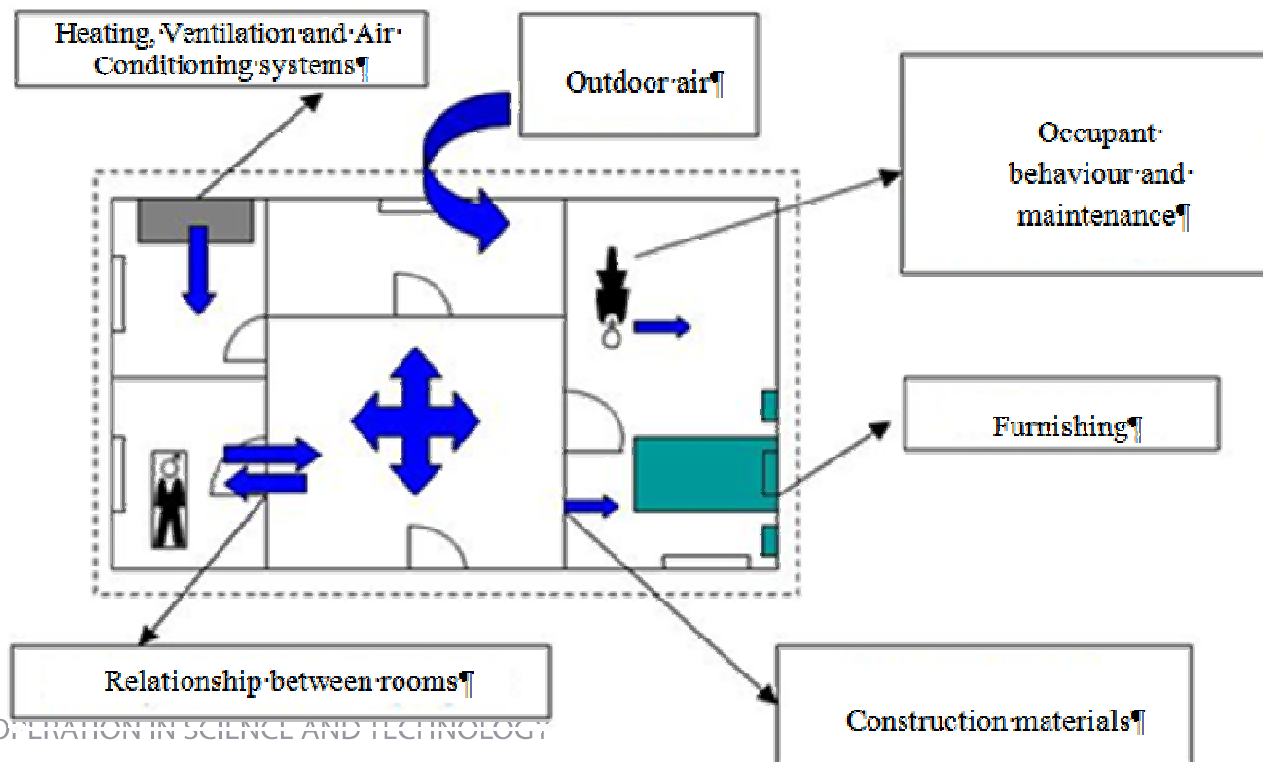
 Evidence of IAQ related health effects particularly in susceptible individuals



BACKGROUND

$$\text{Indoor Air} = \text{Outdoor Air} + f(\text{Building}) + \varphi(\text{Activities})$$

Buildings – kind of ‘diodes’ or special controlling (controlled?) barriers to allow for a specific environment



BACKGROUND



Thermal comfort (TC) and indoor air quality (IAQ) are INDOOR ENVIRONMENT FACTORS that affect HEALTH PARTICULARLY IN SUSCEPTIBLE INDIVIDUALS SUCH AS ELDERLY.



This population is particularly at risk of detrimental effects from pollutants, EVEN AT LOW CONCENTRATIONS, due to REDUCED IMMUNOLOGICAL DEFENCES AND MULTIPLE UNDERLYING CHRONIC DISEASES.



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 INDOORS.



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.



PROJECT STUDY DESIGN

1st Phase

22 ECC Porto
33 ECC Lisbon

BUILDING CHARACTERIZATION

- Type of building construction
- Thermal isolation of the building
- Characteristics of building envelope
- Ventilation system
- 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

HEALTH AND QUALITY OF LIFE QUESTIONNAIRES

- WHOQOL-BREF Questionnaire
- BOLD Questionnaire
- Mini Mental State Examination
- Geriatric Depression Scale GDS-15

2nd Phase

20 ECC Porto and Lisbon

INDOOR AIR QUALITY ASSESSMENT

(AUTUMN/WINTER-SPRING/SUMMER)

- PM10 (INDOOR/OUTDOOR)
- PM2.5 (INDOOR/OUTDOOR)
- Formaldehyde (INDOOR)
- Total Volatile Organic Compounds (INDOOR/OUTDOOR)
- Carbon Dioxide (INDOOR/OUTDOOR)
- Carbon Monoxide (INDOOR/OUTDOOR)
- Temperature (INDOOR/OUTDOOR)
- Relative Humidity (INDOOR/OUTDOOR)
- Bacteria (INDOOR/OUTDOOR)
- Fungi (INDOOR/OUTDOOR)
- Thermal Comfort Indexes (INDOOR)

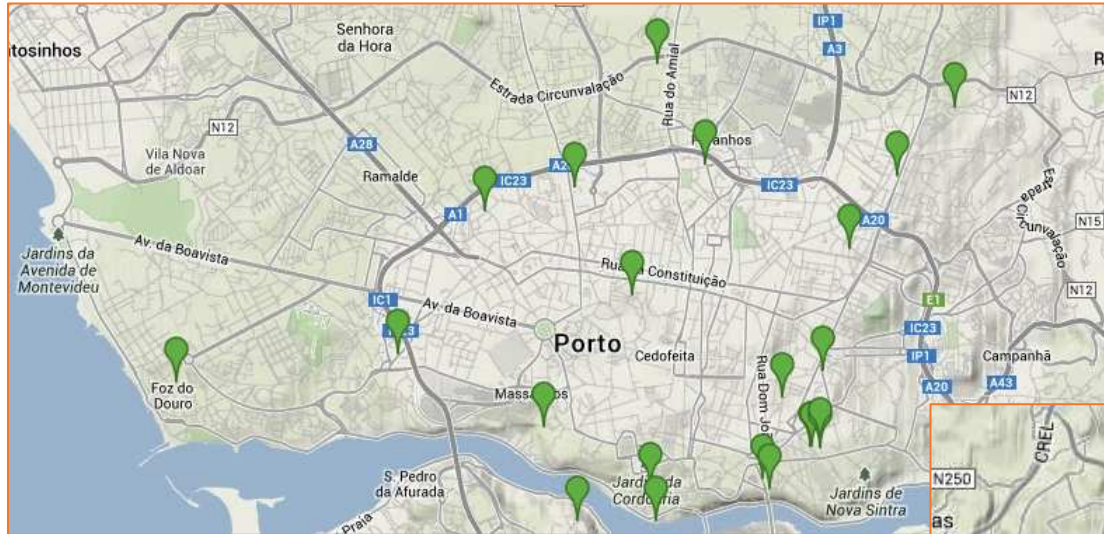
CLINICAL TESTS

- Nasopharyngeal swabs for virus characterization
- Exhaled breath condensate
- Spirometry

VENTILATION ASSESSMENT

- Tracer Gas Technique PFT
- Ventilation modeling

PROJECT SAMPLE DISTRIBUTION





PILOT STUDY RESEARCH AIM

-  Evaluate the association and impact of Indoor Air on Health-related quality of life among the elderly population



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METHODS ECC BUILDING CHARACTERIZATION



The form is titled 'Inventário das Características Construtivas do Edifício e da Habitação do residente senior' and is associated with the GERIA project. It contains several sections with checkboxes and input fields:

- 1. CARACTERIZAÇÃO DO EDIFÍCIO**
 - Tipos de Edifício: Edifício independente, Edifício plurifamiliar
 - Implantação: Interior, Exterior
 - Obliquação do telhado: Sim, Não
 - Em relação a outras habitações: Em terraço, Em sótão
- 2. RESISÃO CONSTRUTIVA**
 - Construção do solo: Grupo Construtivo (Indicar em qual dos subgrupos)
 - Tipos de Paredes: Não são feitas de blocos cerâmicos, Sim, com isolamento, Sim, sem isolamento
 - Tipos de Janelas: Não são de vidro / plástico ou vidro de plástico, Sim, com isolamento, Sim, sem isolamento
 - Tipos de Portas: Sim, com isolamento, Sim, sem isolamento
- 3. CARACTERIZAÇÃO DO AMBIENTE EXTERNO**
 - Equipamento: Não instalado, Instalado
 - Temperatura: Não medida, Medida

🌸 n = 22 ECCs in Porto (41N11.8W36), urban area

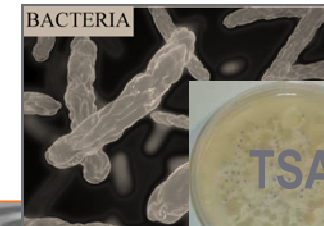
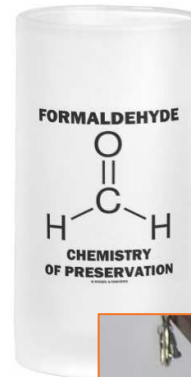
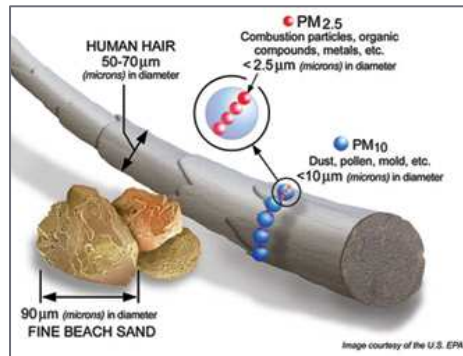
🌸 Winter & Summer season IAQ & TC Assessment

🌸 141 rooms assessed within dining rooms, drawing rooms, medical offices and bedrooms, including the bedridden subgroup

🌸 Outdoor monitoring for comparison

🌸 Building Characterization Questionnaire

METHODS IAQ ASSESSMENT | ACTIVE SAMPLING



naked eye count



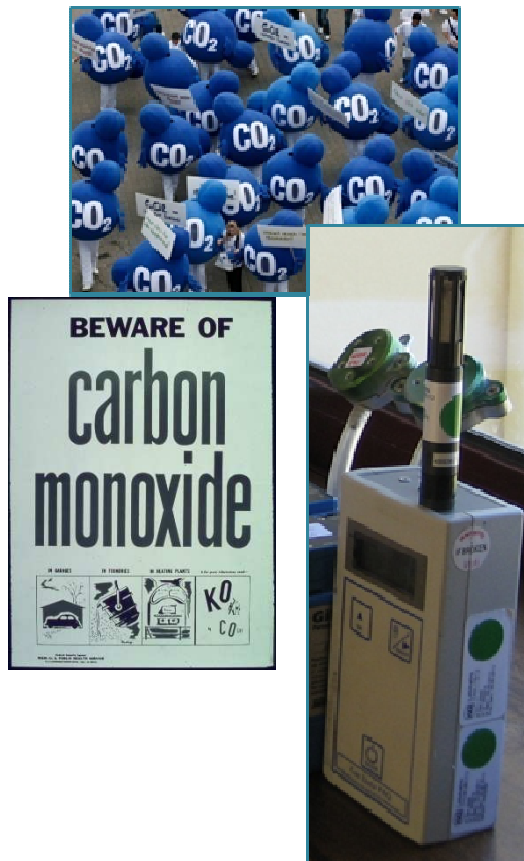
METHODS IAQ ASSESSMENT | DIRECT READING

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55)

TC indexes following ISO 7730:2005

PMV: Predicted Mean Vote

PPD: Predicted Percent of Dissatisfied People



moderate environments (class C – comfort standard)



MATLAB® Software

Delta OHM HD32.1

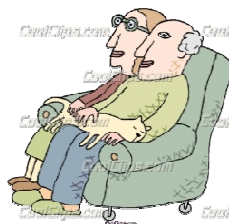
0.60 meters above the floor (sitting - abdomen level)

25 minutes EQUIPMENT STABILIZATION in each room

10 minutes MEASUREMENTS

METABOLIC RATE (Table B.1 - Annex B): 1.0 met (seated, relaxed)

CLOTHING INSULATION (TABLE C.1 – ANNEX C): 1 *clo* Summer
1.3 *clo* Winter



RESULTS POPULATION CHARACTERIZATION



Table 1 Elderly sample characterization

ECCs Sample	39% (n = 22) Total in Porto = 57
Elderly living in ECCs Sample	54% (n = 716) Total in Porto = 1323
HQoL Questionnaires Sample	20% (n = 143) out of 716
Age (years)	84 [68 – 103]
Gender	Female = 85% Male = 15%

RESULTS ECC BUILDING CHARACTERIZATION







Table 2 ECC building characteristics



Building age (Years)	62 [8 – 191]
Close proximity to roads with heavy traffic (%)	89
Occupants per building (Range in No.)	7 - 138
Adapted to ECC (%)	64
Insulation (Walls & Ceiling) (%)	32
Single pane glass (%)	85
Stone masonry (%)	40
Central heating systems (%)	50
Natural ventilation ONLY (%)	14
Mixed Ventilation (%)	86
Windows frames (%)	WOOD: 40 ALUMINIUM: 35 PVC: 25

RESULTS IAQ ASSESSMENT | CHEMICAL PARAMETERS ⁽¹⁾







Table 3. ECCs main descriptive statistics and variables (Chemical parameters 1)

mg/m ³							REFERENCES		OUTDOOR (MEDIAN)
							P ^a	I	
PM ₁₀ SUMMER ^b	0,04 [0,01 - 1,7]	0,05 [0,01 - 1,7]	0,03 [0,01 - 0,3]	0,04 [0,01 - 0,4]	0,03 [0,01 - 0,2]	0,02 [0,01 - 0,1]	0,15	0,15 ^c	0,04
PM ₁₀ WINTER ^b	0,05 [0,01 - 0,4]	0,05 [0,01 - 0,3]	0,04 [0,01 - 0,4]	0,05 [0,01 - 0,4]	0,04 [0,01 - 0,2]	0,06 [0,02 - 0,09]			0,05
PM _{2.5} SUMMER ^b	0,03 [0,01 - 2,1]	0,04 [0,01 - 0,3]	0,04 [0,01 - 1,4]	0,03 [0,01 - 0,3]	0,02 [0,01 - 2,1]	0,25 [0,02 - 0,6]	-	0,035 ^c	0,05
PM _{2.5} WINTER ^b	0,03 [0,01 - 0,9]	0,04 [0,01 - 0,2]	0,04 [0,01 - 0,6]	0,03 [0,01 - 0,9]	0,01 [0,01 - 0,1]	0,01 [0,01 - 0,1]			0,04
TVOC SUMMER ^b	0,05 [0,01 - 2,5]	0,06 [0,03 - 0,7]	0,04 [0,01 - 2,5]	0,06 [0,02 - 0,9]	0,04 [0,02 - 0,1]	0,04 [0,03 - 0,2]	0,6	0,2 ^d	0,03
TVOC WINTER ^b	0,08 [0,01 - 0,9]	0,08 [0,01 - 0,7]	0,08 [0,03 - 0,9]	0,06 [0,02 - 0,8]	0,06 [0,03 - 0,3]	0,2 [0,02 - 0,2]			0,02

^a Portuguese references: DL 79/2006 ^b median [min - max] ^c EPA, 2012 ^d ECA Report, 1997







RESULTS IAQ ASSESSMENT | CHEMICAL PARAMETERS ⁽²⁾

Table 4. ECCs main descriptive statistics and variables (Chemical parameters 2)

mg/m ³							REFERENCES		OUTDOOR (MEDIAN)
							P ^a	I	
Formaldehyde SUMMER ^b	< 0,0002	< 0,0002	< 0,0002	< 0,0002	< 0,0002	< 0,0002	0,1	0,1 ^e	-
Formaldehyde WINTER ^b	< 0,0002	< 0,0002	< 0,0002	< 0,0002	< 0,0002	< 0,0002			-
CO ₂ SUMMER ^b	724 [538 - 2313]	791 [595 - 2313]	724 [553 - 1583]	710 [538 - 1221]	649 [543 - 984]	697 [640 - 842]	1800	1300 ^f	565
CO ₂ WINTER ^b	999 [541 - 2697]	1253 [563 - 2374]	1029 [541 - 2009]	954 [579 - 2697]	1251 [678 - 1590]	1325 [581 - 2113]			596
CO SUMMER ^b	0,1 [0,01 - 7,1]	0,1 [0,01 - 4,5]	0,1 [0,01 - 5,4]	0,3 [0,01 - 7,1]	0,02 [0,01 - 5,3]	0,2 [0,01 - 1,2]	12,5	10 ^e	0,44
CO WINTER ^b	0,3 [0,01 - 2,9]	0,2 [0,01 - 2,3]	0,3 [0,01 - 2,6]	0,4 [0,01 - 2,9]	0,1 [0,01 - 1,9]	0,1 [0,01 - 0,8]			0,72

RESULTS IAQ ASSESSMENT | BIOLOGICAL PARAMETERS

Table 5. ECCs main descriptive statistics and variables (Biological parameters)

CFU/m ³							REFERENCES		OUTDOOR (MEDIAN)
							P ^a	I	
Bacteria SUMMER ^b	258 [6 - 2282]	358 [92 - 1414]	302 [36 - 2282]	192 [6 - 1386]	240 [58 - 1052]	303 [84 - 650]	500	-	132
Bacteria WINTER ^b	192 [14 - 996]	212 [14 - 996]	274 [44 - 838]	156 [20 - 630]	242 [40 - 618]	214 [30 - 820]			228
Fungi SUMMER ^b	210 [6 - 2224]	244 [8 - 2224]	208 [38 - 1010]	208 [6 - 1128]	181 [34 - 640]	297 [36 - 824]	500	500 ^g	50
Fungi WINTER ^b	186 [18 - 2812]	234 [38 - 2812]	213 [26 - 784]	184 [18 - 1218]	159 [18 - 502]	162 [80 - 284]			170

^a Portuguese references: DL 79/2006

^b median [min-max] ^g WHO,2009

RESULTS IAQ ASSESSMENT | BIOLOGICAL PARAMETERS | FUNGI MAIN SPECIES

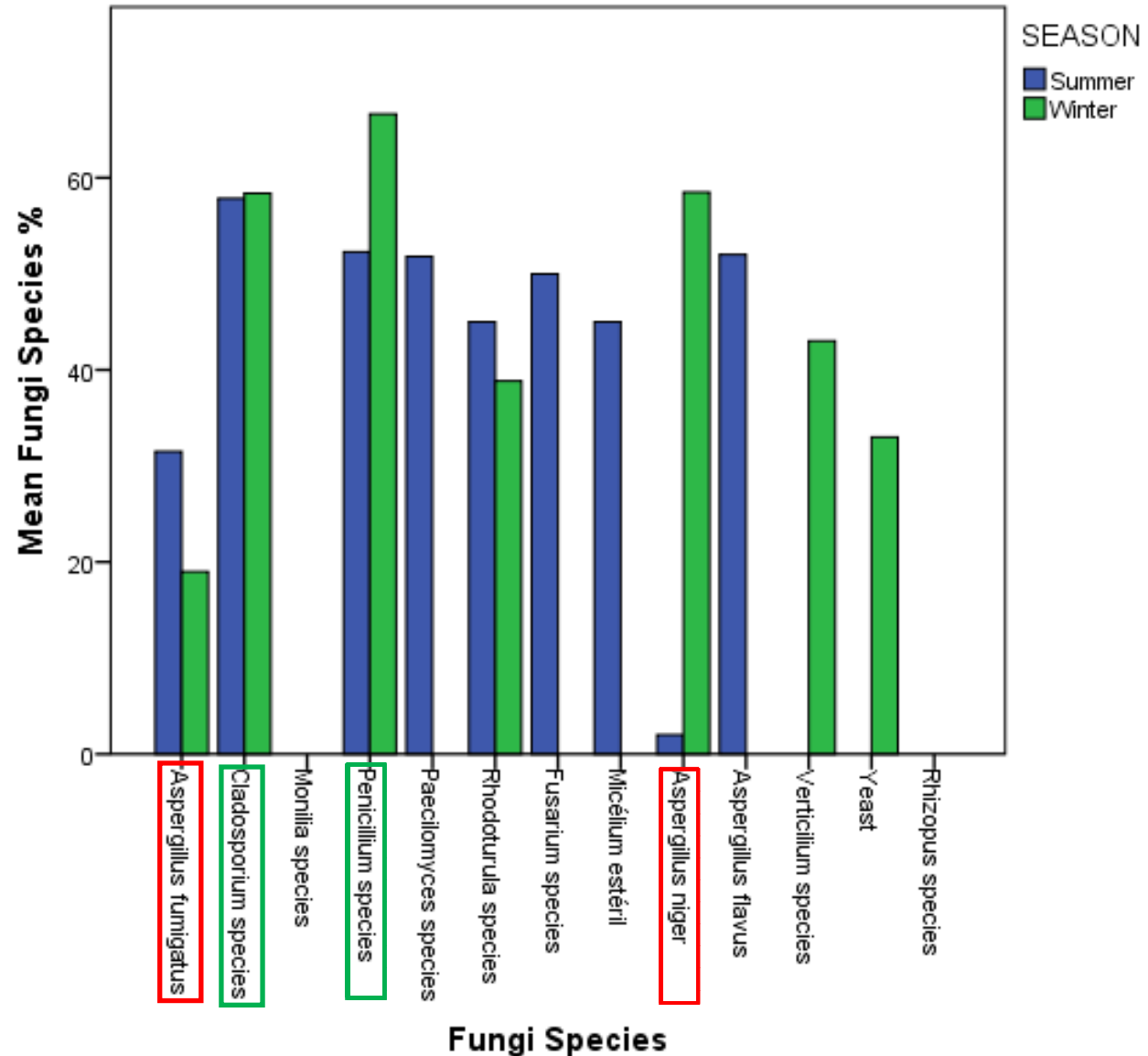


Figure 1. ECCs Fungi main species (prevalent species)

RESULTS IAQ ASSESSMENT | PHYSICAL PARAMETERS

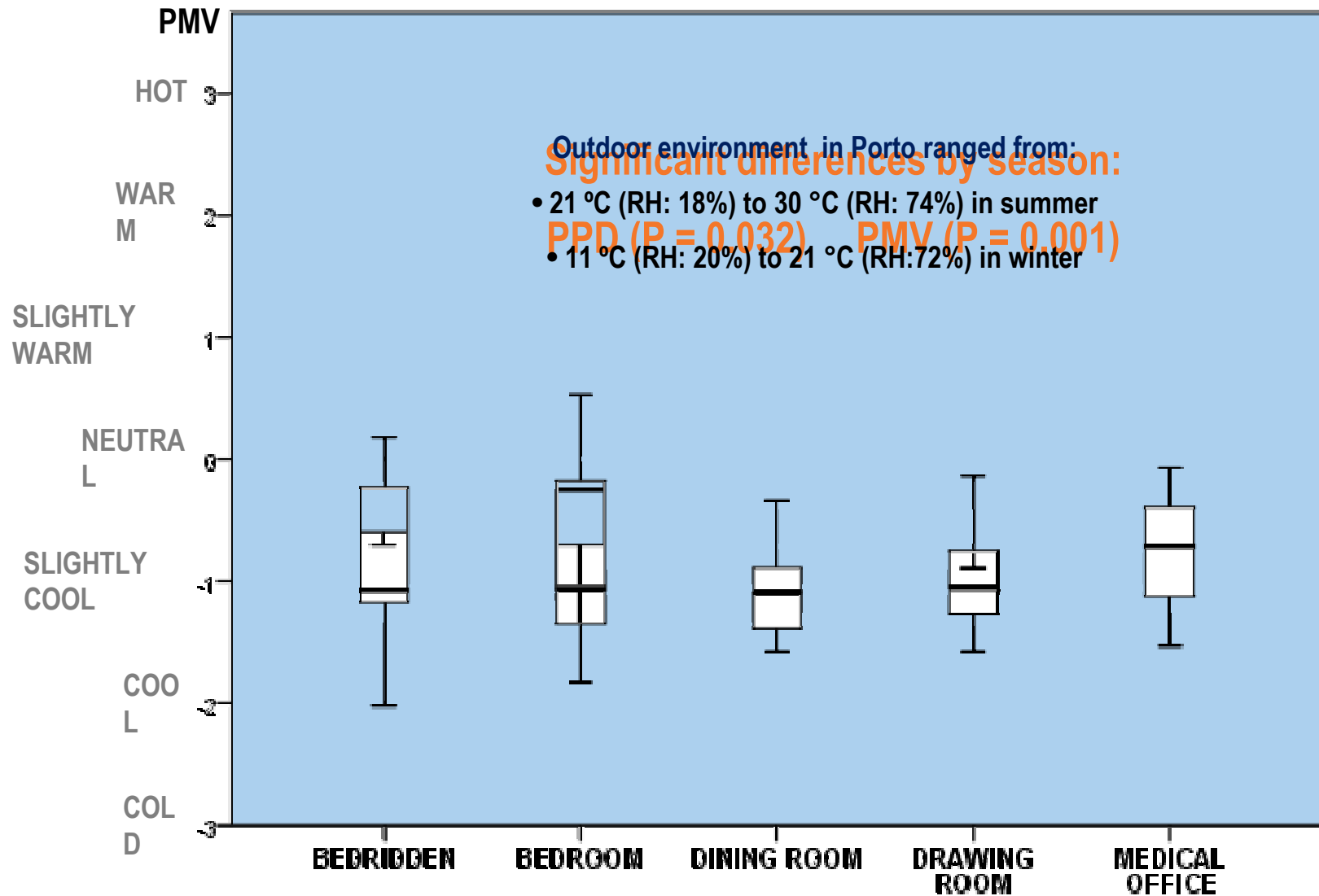


Figure 2. Winter season PMV distribution by room

DISCUSSION

✿ Although IAQ PARAMETERS ARE WITHIN REFERENCES VALUES both in Summer and Winter season, the IAQ reference values are NOT SPECIFIC FOR SUSCEPTIBLE POPULATIONS.

✿ Prevalence of indoor sources;



✿ TC parameters and indexes in WINTER SEASON ARE NOT WITHIN THE REFERENCES from ISO 7730:2005;

DISCUSSION

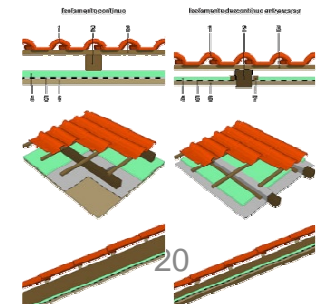
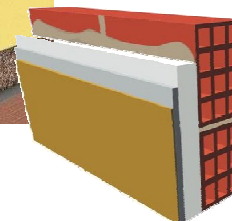
TC IS A MAJOR ISSUE FOR THE ELDERLY AND CAN BE ASSOCIATED WITH CARDIO-MORTALITY DUE TO LOW TEMPERATURES IN POOR INSULATED HOUSES

;

NATURAL VENTILATED ENVIRONMENTS WITH POOR INSULATION IS A CHALLENGE in the maintenance of comfortable indoor environment



INSULATING CEILINGS, WALLS AND WINDOWS COULD PROVIDE HEALTH BENEFITS TO ECCS RESIDENTS, without giving up the natural and passive ventilation solutions that are very common in Portugal due to the advantage of the region's generally mild weather.



FURTHER DEVELOPMENTS

- ✿ Evaluate the IMPACT OF IAQ & TC VARIABLES ON HEALTH-RELATED QUALITY OF LIFE AMONG THE ELDERLY POPULATION;
- ✿ PRODUCE GUIDELINES on remedial measures and recommendations to ECCs in order to improve the wellbeing of our elderly population.



VS



VS



PROJECT RESEARCH TEAMS & FUNDING



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